1. Course Material

Chapter 1—Course Material

Information for NRCS and Non-NRCS Participants

This information is intended to help you prepare for the week you will be spending at the West-Wide Snow Survey Training School. It is an intense, rigorous, outdoor-oriented course that you should find to be an enjoyable and rewarding experience if you know what to expect in advance and come prepared to participate.

You must be able to get around in the snow on foot. Cross-country skis or snowshoes are required. Ski equipment should be available for rental at the lodge (call to be sure), or you may bring your own gear. Make your travel arrangements in order to arrive early enough to get your equipment fitted properly and not be late for the lessons. If you intend only to snowshoe, you must bring snowshoes with you.

One of the most important portions of the training is the overnight exercise. After a morning of classroom instruction, you and a partner(s), will spend the afternoon constructing a snow shelter. You will then be required to spend the night in whatever it is that you have built. The more care and attention to detail that you use, the more comfortable you will be.

Following is a list of items that you MUST BRING WITH YOU for this exercise.

- Shovel—avalanche and scoop shovels do nicely. Military trenching tools are unacceptable.
- Hatchet—necessary for cutting trees used in shelter construction and for making a bough bed.
- Rope—minimum of ten feet, used in the shelter and for tethering gear.

- Ground cloth—many trainees bring construction plastic or space blankets. You will need a minimum of one 8 x 10 foot piece, of at least 4 mil in thickness. Additional pieces are useful in constructing the shelter.

- Sleeping bag—a winter weight bag and sleeping pad are a necessity. Closed-cell foam or ensolite pads work well, however, ensolite, tends to shatter in very cold temperatures.

- Backpack—you will carry everything you need to the bivouac area for the over-night exercise. You will ski or snowshoe about half a mile, so the backpack must be large enough to handle the necessary gear, yet still allows balance and freedom of movement. Day packs and military rucksacks are not acceptable.

Information

NOTE—Make arrangements to bring this equipment to the school with you. You will not be allowed to participate without it. If you do not have this equipment, talk to your supervisor, Data Collection Office, or Water Specialists Office so they will bring what you need. If you are not an NRCS employee, you will need to make your own arrangements to obtain the equipment.

If you have a snow sampling set and are driving to the school, bring your set. Otherwise, make sure that the Data Collection Office Supervisor for your area is aware of your need, so that one can be provided.

The afternoon sessions are mostly conducted outside. Winter-weight clothing including boots, pants, coats, sunglasses, gloves or mittens, and hats are required because temperatures may fall well below freezing. It is a good idea to have more than one pair of gloves or mittens, and gaiters come in handy in powder snow.

In contrast, make sure you bring a bathing suit because the facilities usually have a sauna and hot tub. Check your letter from the National Employee Development Center (NEDC) to find out. Examine the list of "things to bring" that is included in your packet of materials. Most are necessary and some are optional. Having them with you will make your stay a more enjoyable and memorable experience.

Suggested List of Things to Bring

1. * Outdoor clothing—clothing that can be worn in layers that can be added or removed according to activity.

_____shirts _____jacket or parka
_____pants _____mittens or gloves (2 pairs)
_____socks _____windbreaker
_____gaiters _____wind pants
_____boots _____long underwear
_____hat

2. Indoor clothing—comfortable and casual

3. Off-hours recreation

_____swim wear _____down-hill ski equipment
_____ice skates _____camera and film

4. Outdoor equipment

_____*sleeping bag—winter weight _____*sleeping pad
_____*ground cloth _____*backpack
_____*rope _____*hatchet
_____*flashlight (with extra batteries) _____*shovel
_____*sunglasses or goggles _____*water bottle (1 quart min.)
_____*small tarp or plastic sheet 8'X 10' _____+snowshoes
_____+cross-country boots _____+cross-country ski equipment
_____candle _____metal cup
_____matches _____sun screen
_____space blanket

*Required
+must have either skis or snowshoes

Pre-Course Information

Snow Survey Physical

NRCS personnel must have a snow survey physical completed before attending the session (see page 1.9).

Non-NRCS personnel must have certification that they are in good enough physical shape to complete the cross-country and bivouac portions of the school (see page 1.9).

First Aid

All personnel should have completed a basic First Aid course and a CPR course and be prepared to show a certification card.

Travel Authorization

You will need to request travel authorization through your state office to attend the Snow Survey School.

Ski Instructions

Please refer to your letter from the NEDC to see if ski lessons will be offered.

Pre-Course Assignment

These questions are designed to guide you through the book and help you understand the material. Upon completion of the school, you should be able to fully answer these questions as a post-test.

Physical Fitness Certification

I certify that I have passed a physical examination which determined (or I personally determined (non-NRCS employees)) that I am physically capable of ski or snowshoe travel in deep snow with field pack, at high altitude, and I am capable of an overnight, outdoor bivouac in a snow-covered environment. Additionally, I will have completed a basic first aid course before attending the West-Wide Snow Survey Training School and am current in CPR. I understand that I may be asked to present actual proof of certification.

____________________________________ ____________________

Name Date

____

Signature

Please mail the completed form ASAP to:

Attn: Jo Huelshoff
Water Supply Forecasting Staff
Natural Resources Conservation Service, WNTC
101 S.W. Main St., Suite 1700
Portland, OR 97204-3225

If you have any questions, please contact Jo Huelshoff at (503) 414-3031.

Pre-Course Assignment

Name: ______________________________ Date: ____________

Location: ____

Please complete the following questions by reviewing the enclosed training workbook.

Avalanche

1. Name two types of avalanches.

   a. ____

   b. ____

2. List five important factors affecting snow stability.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

3. If you become trapped in an avalanche, you have about a _____ percent chance of survival after being buried for 30 minutes.

Mountain Medicine—Safety

4. What are three factors that can lead to hypothermia?

   a. ____________________

   b. ____________________

   c. ____________________

5. What are three symptoms to look for if you suspect a member of your group is becoming hypothermic?

   a. ____________________

   b. ____________________

   c. ____________________

6. Name two methods of treatment for hypothermia.

   a. ____________________

   ____

   b. ____________________

   ____

7. When should you use snow as a treatment for frostbite?

   ____

   ____

Data Collection

8. What are the three major components of the standard Federal Sampling Set?

   a. ______________________________

   b. ______________________________

   c. ______________________________

9. What are two good reasons for carrying site maps on snow surveys?

   a. ______________________________

   b. ______________________________

10. Why are SNOTEL ground truth measurements taken?

    ____

    ____

11. The maximum allowable deviation in density between sample points when measuring a snow course is _____ percent.

Preparedness

12. Who is responsible for initiating search and rescue operations in your local community?

    ____

13. What is the best clothing to wear for:

    a. Cold and dry conditions? ______________________________

    ____

    b. Cold and wet conditions? ______________________________

    ____

    c. Cold and windy conditions? ____________________________

    ____

    d. Helicopter travel? _____________________________________

    ____

14. What three items which should always be included in a trip plan?

    a. ____

    b. ____

    c. ____

15. What are two ways to control excessive perspiration?

    a. ____

    b. ____

Survival in Snow

16. List three types of survival shelters.

    a. ______________________________

    b. ______________________________

    c. ______________________________

17. What are four factors you should consider in deciding whether or not to bivouac?

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

18. List three ways to start a fire in a survival situation.

    a. ______________________________

    b. ______________________________

    c. ______________________________

19. In an emergency, is it a good idea to eat snow if you become thirsty? Why?

    ____

    ____

    ____

Travel—Over Snow

20. Name three methods of over snow travel.

    a. ______________________________

    b. ______________________________

    c. ______________________________

21. What advantages do large snow cats have over small snowmobiles?

    ____

    ____

Travel—Air

22. From which direction do you approach a helicopter when boarding?

    ____

    ____

23. What is the significance of NOMEX?

    ____

    ____

24. Name three modes of travel used by snow surveyors which require the use of helmets?

    a. ______________________________

    b. ______________________________

    c. ______________________________

Equipment Maintenance

25. What are two methods used to keep snow from sticking to the snow tube?

    a. ______________________________

    b. ______________________________

26. What are the two most frequent maintenance problems associated with snowmobiles?

    a. ______________________________

    b. ______________________________

Uses of Information—General

27. What percent of water in the western states comes from snow?

    a. 25%

    b. 50%

    c. 75%

    d. 90%

28. What two significant accomplishments are attributed to Dr. James Church?

    a. ______________________________

    b. ______________________________

29. List at least five applications for snow survey data other than for water supply forecasting.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

Assembly of Notebook Binder

Please assemble your notebook binder prior to attending the West-Wide Snow Survey Training School. YOU MUST BRING THIS MANUAL WITH YOU TO THE SESSION. The following suggestions should be of help to you:

Inside your opened notebook binder:

- Insert one of the 8.5" x 11" plastic document protectors in the front and at the back of your notebook binder.
- Remove the plastic shrink-wrap from your training manual and insert it into the binder. Chapters in your binder are as follows:

Chapter 1—Course Material
Insert your course agenda, participant's letter, etc.

Chapter 2—Welcome and Course Overview
Includes History of Snow Survey

Chapter 3—Avalanche Hazard Recognition, Evaluation, and Rescue

Chapter 4—Mountain Medicine
This is the support section for your copy of the booket, "The National Sky Patrols Outdoor Emergency Care."

Chapter 5—Data Collection

Chapter 6—Preparedness

Chapter 7—Survival

Chapter 8—Travel-Surface

Chapter 9—Travel-Air

Chapter 10—Equipment Maintenance

Chapter 11—Use of Information

Please Note...

Customized West-Wide Snow Survey Training School inserts for the outside plastic sleeves and spine of your notebook binder will be given to you at the session.

Course Objectives

The overall objectives of this week's training is to impart to participants the knowledge and skills needed to conduct snow surveys in a safe, efficient, and technically sound manner. To attain this objective you will be instructed in three principal categories—Safety, Sampling and Travel. You will also receive instructions in how snow survey data are used, how forecasts are made, and how (and what) information is provided to interested data users and the public.

Safety is the paramount concern of all snow surveyors and your instructors this week. At the conclusion of this week's training, you should have a working knowledge of safety hazard assessment and avoidance. mechanics of snow avalanches. and emergency rescue procedures. You will have been instructed in mountain medicine and first aid principles and procedures. You will have constructed an emergency shelter in the snow and survived for a night without benefit of a furnace, electricity, telephone or television. You will understand the proper and safe way to function in and around snow machines and aircraft.

Travel over deep snowpacks to, from, and along snow courses is an obvious necessity for any snow surveyor. Many of you are unfamiliar with snowshoeing or cross-country skiing. Others may be experts. The instruction has been structured so that all levels of ability will receive beneficial training.

Snow sampling is what this week and your winter work assignment is all about. Good sampling information will be your product. To assure the continued integrity of snow survey data, you will be instructed and participate in proper techniques of sampling, recognition of errors in the data, and note keeping.

Your instructors this week are all experts in the various facets of snow surveying, oversnow travel, safety, forecasting and public information. Most are Natural Resources Conservation Service (NRCS) professional hydrologists, safety officers, and line managers. The services of other government and private sector experts have been obtained to bring you the highest degree of expertise possible. Their combined experience amounts to tens-of-thousands of snow surveys; hundreds of snow avalanche studies; many medical cases; countless miles on skis, snowshoes, and snowmachines; thousands of aircraft hours; and scores of nights in snow caves (some unplanned). Do not hesitate to ask questions, recount experiences, or otherwise take the opportunity to benefit by their presence.

Chapter 2—Welcome and Course Overview

Welcome to the West-wide Snow Survey Training School. You will not only benefit from this activity-filled week of learning, you will enjoy every second of it. Come prepared to work hard, ask questions, do hands-on field and classroom activities, and, above all, learn. This course could save your life someday; so plan to be an active participant.

The overall objective of the West-wide Snow Survey Training School is to impart to you the knowledge and skills needed to conduct snow surveys in a safe, efficient, and technically sound manner. To attain this objective, you will receive instruction in three principal categories:

- Safety
- Sampling
- Travel

You will also receive sufficient instruction so that, following the training, you will be able to:

- Describe how snow survey data are used.
- Explain how forecasts are made.
- Provide forecast information to interested data users and the public.

Safety is the paramount concern of all snow surveyors and instructors at the West-wide Snow Survey Training School. At the conclusion of the training you will be able to:

- Make safety hazard assessments and practice the avoidance mechanics of snow avalanches.

- Describe and carry out emergency rescue procedures.
- Perform simple mountain medicine and first aid principles and procedures.
- Construct an emergency shelter in the snow and survive for a night without benefit of a furnace, electricity, telephone, or television.
- Explain the proper and safe way to function in and around snow machines and aircraft.

Travel over deep snowpack to, from, and along snow courses is an obvious necessity for any snow surveyor. Many of you are familiar with snowshoeing or cross-country skiing. Others of you may be experts. Instruction has been structured so that all levels of ability will receive beneficial training.

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The combined experience of these experts amounts to:

- Tens-of-thousands of snow surveys.
- Hundreds of snow avalanche studies.

- Numerous medical cases.
- Countless miles on skis, snowshoes, and snowmachines.
- Thousands of aircraft hours.
- Scores of nights in snow caves (some unplanned).

Do not hesitate to ask questions, recount experiences, or otherwise take the opportunity to benefit from the presence of these experts.

History of Snow Surveys

We Have Always Sought the Unknown

Since the dawn of early history, mankind has desired to see beyond today, tomorrow, or even years to come. This applies as much to meteorological phenomena as to love, security, or other personal and social problems.

By successfully reading, in advance, the riddle of nature's annual patterns of participation and temperature distribution over the globe, it is not out of reason to believe that cropping systems, flood control, and other practices could solve some of our major problems of today and the future.

Much attention has therefore been given to so-called weather cycles and to probabilities of repetition in the future of meteorological behavior of the past.

Ancient Forecasters

In the written record 2,300 years ago, from India (Arthasastra by Kantilya, translated by Shamasastry) is found the following passage:

> "Quantities of rain that falls in the Country of Jargala is 16 dronas... The forecast of such rainfall can be made by observing the position, motion, and pregnancy of the Jupiter, the rise and set motion of Venus, and the natural or unnatural aspect of the sun... Hence, .i.e. according as the rainfall is more or less, the superintendent shall sow the seeds which require either more or less water."

Thus it appears, by implication at least, that thousands of years ago the earliest forecasters were attempting to serve the water users.

More Recent History

In more recent history, the science of snow surveying for the forecasting of water supplies was first practiced in europe in connection with snow density studies. In the eastern United States, in 1905, Charles Mixer begin surveying the snowpack in his studies of runoff from watersheds.

Early Pioneer

The most important early pioneer in snow surveying was Dr. James Church, a professor at the University of Nevada. In 1906, Dr. Church laid out what is considered to be the first western snow course. This snow course on Mt. Rose was used as a basis for predicting seasonal fluctuations in levels of nearby Lake Tahoe. **Again, modern-day forecasters were attempting to serve the water user**.

The first effort at snow surveying merely determined the depth of the accumulated snowfall. In eastern United States, snow samples were melted to determine water content. The present method of weighing samples to determine water content was developed in the western United States. **Dr. Church pioneered this effort by developing the Mount Rose Sampler**.

California Becomes Interested in Forecasting

When the success of Dr. Church's methods in forecasting became known, the State of California recognized the great value that forecasts could be to the irrigation interests in the Sacramento and San Joaquin valleys. Therefore, in 1917, the Department of Engineering was authorized by the California State Legislature to engage in snow surveys and forecasting.

Nevada Cooperative Snow Surveys

About the same time, significant events with respect to snow surveys were taking place in other states in the west:

- The establishing of the Nevada Cooperative Snow Surveys in 1919.
- Start of the Jackson Lake, Wyoming, snow surveys in the same year.
- The beginning of snow surveys by the Washington Water Power Company in 1920.
- Establishment of the Utah Cooperative Snow Surveys in 1923.
- The beginning of the Oregon Cooperative Snow Surveys in 1928.

Modified Snow Sampler

Also, in the early 1920's, while the Utah Cooperative Snow Survey was being established, Professor George D. Clyde of the Utah Agricultural College, developed a modified snow sampler. This sampler was somewhat lighter than the Mt. Rose type and had a cutter with a cutting diameter of 1.485 inches. This enabled him to use commercial scales, since a cylinder of water 1.485 inches in diameter and one-inch long weighs just exactly one ounce.

First Western Snow Conference

The first Western Snow Conference was held in Reno, Nevada, in 1933. The organization became associated with the American Geophysical Union and, in later years, evolved to its present status as a separate professional and scientific society.

1934 Drought Causes Call for Federal Snow Survey

The following year, as a result of the unprecedented western drought of 1934, there developed a general realization throughout the west of the value of the snow survey to agriculture. Irrigation interests, in particular, called for a federal program to provide reliable information on potential water supplies so they could plan their farming operations around known water supplies for irrigation.

As a result, the U.S. Congress appropriated a modest $36,000 to the Bureau of Agricultural Engineering in USDA to conduct snow surveys for the purpose of forecasting irrigation water supplies, and to develop uniform equipment and methods for snow surveying and water supply forecasting.

These water supply forecasts experienced almost instant popularity. Water users found the information provided was of significant value in planning their operations. By 1935, at least nine independent and uncorrelated snow survey networks were operating in the west.

Newly Formed SCS Gets Federal/State Cooperative Snow Survey Program

On July 1, 1939, the Division of Irrigation of the former Bureau of Agricultural Engineering was transferred to the Soil

Conservation Service (SCS), Research Division. The California network was not included in this package as California was far ahead of the other states in developing its own program and in realizing its full significance at state level. In 1953, research activities were transferred to the Agriculture Research Service (ARS), but the Federal/State Cooperative Snow Survey Program was retained in the SCS.

Present Network

Snow survey information is presently collected from a network of over 550 automated SNOTEL sites, 900 manual snow courses, and other miscellaneous data sites including aerial snow depth markers, storage precipitation gages, and other moisture monitoring sites.

Program is a Cooperative Effort

The program, as presently constituted, is a cooperative effort. SCS, now NRCS (Natural Resources Conservation Service), bears the basic responsibility under PL-46 and is assisted and partially funded by other federal agencies, state agencies, and public and private water management interests. NRCS has about 50 full-time professional snow hydrologists, computer specialists, water supply specialists, and para-professionals at national, center, and state levels. About 200 NRCS employees (such as you) and employees from other agencies do most of the field work of collecting snow data.

Hydrologists and water supply specialists and their staffs analyze, record, and use these data in preparation for and publication of state water supply outlooks.

Distribution of Reports is Extensive

More than 8,000 individuals receive one or more of the state reports. Annually, more than 40,000 copies of these reports are issued. Several states issue a fall summary report. The Water Supply Forecasting Staff issues monthly West-Wide Reports January 1 through June 1 to approximately 1,000 recipients. Extensive dissemination of the measurements, forecasts, and other water supply outlook information is accomplished through newspapers, radio, and television.

SNOTEL

In the late 1970s, the NRCS began installing automatic data-sensing equipment and radio telemetry systems to bring data from remote areas. The move to automation was taken in order to get better coverage, more frequent data, and more kinds of information. This reduces hazardous and expensive travel to remote sites. The NRCS system is called SNOTEL, short for "SNOw TELemetry".

The SNOTEL system includes two base stations, one central computer facility, and over 550 remote data transmitting stations. ***For the first time in history, complete real-time data describing the building and melting away of our mountain storehouse of water is available to NRCS and water users.***

We've Come a Long Way

Cost of Snow Surveys and Water Supply Forecasting Programs has risen since its inception in 1935 because of program expansion and inflation. The implementation of SNOTEL has brought our program costs up to nearly $5 million annually. The 1935 program totaled $36,000.

Benefits of Snow Surveys and Water Supply Forecasting

Benefits of the present snow surveys and water supply forecasting program are many and varied; only a few lend themselves to dollar valuation.

Non-monetary or esthetics benefits include:

- Preservation of human life.
- Improved recreation.
- Enhanced fish and wildlife resources.
- Improved water quality.
- More efficient management of water supplies for multiple uses.

We have values only for irrigated agriculture. With the advent of SNOTEL, we expect to operate at a resultant benefit-cost ratio for snow surveys of about 20 to 1, assuming full utilization of water supply forecasts by agricultural water users.

The benefit of water supply forecasts to irrigated agriculture alone has been estimated at $45 million annually.

You Play an Important Part

There are many uses for the information that you snow surveyors will be helping to gather in the mountains of the west.

For NRCS, snow survey information constitutes an important part of our assistance to landowners and operators within local conservation districts. Helping these individuals in planning the use and treatment of land is our time-honored basic mission.

Congress is Aware of Importance of Snow Surveys

Snow surveys are recognized by members of Congress. In a Senate Committee Hearing several years ago, one of our western senators said, "Snowpack and moisture content, the anticipated runoff both in terms of quantity and timing, are highly significant for the entire economic livelihood in our section of the country."

Short Snow Survey History is Colorful

The relatively short history of snow surveys has been colorful and marked by the efforts of many innovative and enduring people. The present is an era of transition from manual methods of sampling and data analysis to automatic data processing, remote data sensing, snow telemetry, and satellite snow cover observation.

A Future Filled with Improvement

We expect the future to be one of continued improvement of techniques, equipment, remote data gathering systems, and forecasting methods.

Snow surveys and water supply forecasting are critical to the management and wise use of our vital mountain water resource. This effort will grow and develop in accord with the population and resource development of the western United States.

References

Work, R A., Administration and Organization of Snow Surveys, 1954.

Johnson, W. M., Snow Surveys—Success and Challenges, 1977.

USDA, SCS, Program Evaluation Committee, An Evaluation of The Snow Survey and Water Supply Forecasting Program, February, 1977.

3. Avalanche

Chapter 3—Avalanche Hazard Recognition, Evaluation, and Rescue

(Prepared by Doug Fesler and Jill Fredston[1])

Objectives

Upon completion of this lesson, participants will be able to:

- Describe the procedures to follow if you witness an avalanche accident.
- Explain the correct plan of action if you respond to an avalanche accident that has been witnessed by someone else.
- Describe the proper procedure to follow if you are caught in an avalanche.
- List and describe four types of avalanches.
- Explain how to evaluate snow stability and avalanche hazards
- Describe the route selection principle for reducing risks.

Student References

West-Wide Snow Survey Training School Workbook

Time

Classroom: 5 hours, 30 minutes

Field: 1 hour, 15 minutes

[1]Avalanche Hazard Consultants, Alaska Mountain Safety Center, Inc., 9140 Brewster's Drive, Anchorage, Alaska, 99516, Phone/ Fax (907) 345-3566.

Introduction

Perhaps you are thinking that you do not need to read this article, that avalanches are not a threat where you work and travel. But first, consider these facts. Roughly 50% of all fatal avalanche accidents in the United States happen on slopes that are less than 300 feet high, little booby trap slopes, steep creek banks. A 9 year old boy in Homer, Alaska was killed playing on a bank that was only 65 feet high. One snow surveyor in Nevada was killed, on the job, traveling during a storm on a summer road exposed to several avalanche paths. Other snow surveyors have been caught. Many snow survey sites have been hit. We have numerous examples of accidents that happened in places where people thought avalanches could never occur, accidents that did not need to happen. Avalanches are often called "unpredictable" but the truth of the matter is that most avalanche accidents can easily be avoided.

We will start off by addressing avalanche rescue, but the bottom line is that avalanche rescue does not work very well. Things have already gone wrong, you are "behind the eight ball". Statistically, one out of every three people who gets caught and buried in an avalanche will die. Most of this article will focus on how not to get caught in the first place, for that is the very best way to survive.

What do you do if you're caught in an avalanche? Or if someone else is caught?

> "At first, I was not really worried about the situation because the slab had broken off just above us and I thought it would go under and leave us on the slope, but as I was tumbled over I looked up the slope and saw another huge slab turn loose and come down. At that moment, I thought it was all over for us. I am not sure of much that happened from then until the slide stopped, but we seemed to gain momentum and the waves of snow grew larger. I don't think I was ever completely covered with snow but at one time I felt that my

face was being pushed down in the snow. I started to struggle to get my arms in front of my face so that I would have a little more air space when the slide stopped. The next sensation I had was of being thrown violently backwards and a terrific pull on my legs. Then everything was still and I was lying in a trough in the snow looking at a wave of snow about 5 feet high that probably would have covered me completely if the slide had continued further."

Report of Dale Ashby, Snow Surveyor (Logan, Utah),
The Snow Surveyors Forum, Western Snow Conference,
1955-56.

Back Country Self-Rescue Procedures

The information contained in this rescue section addresses what to do if:

- You witness an avalanche accident.
- You respond to an avalanche that has been witnessed by someone else.
- You are caught in an avalanche.

Background Information

Rescue Phases

For tactical purposes, any avalanche rescue (whether it is a back country or a 'formal' rescue), can be divided into three phases: the initial response, the primary search, and patient management.

- *Initial Response*—From the time the rescuer first sees or hears about the accident until he or she arrives at the scene. Includes: initial notice and if necessary, call-out, preparation, and transportation to the scene.

- *Primary Search*—From the time the rescuers arrive on the scene until the victim is dug out. Includes: Interviewing witnesses, checking and marking clues, spot probing, searching with beacons, setting up probe lines (if necessary), and pinpointing and digging out the patient.

- *Patient Management*—From the time the patient is found until he or she is delivered to the hospital (if necessary). Includes: Patient assessment, first aid, and evacuation.

Baseline Data

Statistically, the average depth of burial in the U.S. for all victims is 26.5" (.67 m). In order to get "first air" to the victim, approximately 1 m^3 of snow (on the average) needs to be removed.

- Observation—With a small shovel, it usually takes one person approximately 10 minutes to remove 1 m^3 of snow.

- Observation—With no shovel, it generally takes about 50 minutes for one person to remove the same quantity.

- Every member of a back country party must carry an avalanche rescue transceiver (beacon), probe, and shovel and know how to use them.

- Statistically, an avalanche victim has roughly a:

  — 60% chance of survival after 25 minutes of burial

  — 50% chance of survival after 30 minutes

  — 40% chance of survival after 1 hour

  — 20% chance of survival after 2 hours

These are not good odds! Some victims have been dug out dead after five minutes, others have survived for many hours. The leading causes of avalanche deaths are suffocation, mechanical injuries, and hypothermia.

Rescue Response Goal

In order to have better than even odds of finding a person alive, speed is of the essence. A successful rescue depends upon having a rescue plan that is formulated *before* the accident. Your chances of performing a successful rescue are limited if the first time you are thinking about avalanche rescue is after the accident has happened.

If You Witness an Avalanche Accident

Do not go for help; you are the help!

A person buried under the snow needs air immediately, not many minutes or hours later. If you go for help, you're going for a body recovery, not a rescue. In essence, you are dealing with a drowning person. *You are the help!*

Exceptions—If help can be summoned without depriving the victim of your immediate help (e.g., calling for help on a radio), then do it. Keep in mind that "help" generally takes hours to arrive on the scene.

Be calm and methodical; use the *"STOP and GO"* approach:

- *Stop* what you are doing.
- *Think* about what needs to be done.
- *Observe* the situation carefully.
- *Plan* your response.
- *Go* into action A.S.A.P.
- *Organize* your resources efficiently.

Risk Assessment

Before entering the avalanche path to search for the victim, evaluate the potential hazard from secondary slides and take appropriate action (outlined below). Do not make a bad situation worse by putting rescuers at risk.

- If the avalanche was human-triggered or occurred on a small slope, rescuers can probably go into the slide area safely if they enter the path on snow that has already slid.
- If nearly all of the starting zone has released and no loading is taking place, it is unlikely that a secondary release will occur.
- If nearly all of the starting zone has released, but significant loading is taking place, there is likely to be a window of a couple of hours before the probability of a secondary release is high.
- If a significant portion of the starting zone has not yet released and if significant loading is taking place, the probability of a second release is high.
- Be careful of situations where multiple release zones funnel into a single runout zone, or of the possibility of accidental releases triggered by people approaching from above. The possibility of a secondary release is high for both scenarios, all things being equal.
- Any slopes that could potentially release and bury rescuers should be stabilized (by using explosives or some other means) *prior* to sending in rescuers. When in doubt about the potential hazard, have the slope assessed by an avalanche specialist.
- If required, establish a predetermined escape route and post an avalanche guard to:
  - — Alert rescuers of a second release.
  - — Assist in the rescue of those rescuers who are caught.

— Note: if you *have* to post an avalanche guard, maybe you should not even be there.

Determining the Primary Search Area

If you can limit the likely search area, you greatly increase the chances of a successful rescue. Follow the trajectory of the victim downslope:

- Carefully observe and mark in your mind the location of the victim when he or she is first caught.
- Observe the victim as he or she is carried down the slope and mark in your mind the last seen point or, more realistically, the last seen area. The line between the location when caught and the last seen area determines the downslope trajectory of the victim.
- Follow the fall-line downslope from the last seen position carefully searching all likely catchment areas and checking out and marking all clues. Spot probe[2] likely places, for example:
  - — Areas around clues.
  - — Snow piled against protruding boulders or trees.
  - — Benches, dips, bowls, or bends where snow has come to rest.
  - — Places where the slope angle decreases and snow debris has piled up or areas where debris deposits are suspiciously thick.
- If you see the victim disappear beneath the moving snow, watch the snow as it travels downslope. As the snow comes to rest, check that area first. The victim may be just beneath the surface.

- — Note: if the victim was wearing an avalanche rescue transceiver (beacon[3]), begin a beacon search as soon as possible in the primary search area.
- — Note: with a witnessed search, there is approximately a 98% probability of encounter if rescuers follow the fall-line from the last seen area. About 75% of all victims are found in the toe of the debris.

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[2]*Spot probing* means searching for a buried victim by pushing an avalanche probe vertically into the snow in likely places. The procedure is random in the sense that no particular grid pattern is used, but search efforts are concentrated in the most likely catchment areas. Probes are generally 8-10' long and are made in sections that can be fitted together. Some ski poles also double as avalanche probes. If probes are not available, skis, ski poles, branches, etc. may be used although they are not as effective.

[3]An *avalanche rescue transceiver*, or beacon, is a small electronic device capable of transmitting and receiving an alternating signal within a range of approximately 50'–100'. For the duration of a trip in avalanche terrain, each member of the group wears their beacon in "transmit" mode. Should an avalanche bury a member of the party, survivors switch their beacons to "receive" mode, spread out across the debris, and begin the search for their partners using a standard search pattern. Once a signal is picked up, the location of the buried beacon can usually be pinpointed within two minutes. Beacons are not safety talismans—people wearing beacons have been killed by avalanches and beacons are little more than a body locator if all members of a party are buried. However, they offer the greatest chance of recovering a completely buried person alive.

Initial Response Search

The initial response effort (also known as hasty search) involves:

- A **visual search** for surface clues in the debris with emphasis on:
  - *Checking* out each clue (i.e., pulling on them to see if they are attached to the victim).
  - *Leaving* clues in place and marking them if possible. (Note: In formal rescues, clues are marked with survey flagging. In back country rescues, clues may be turned upside down.)
  - Note: Clues may be very subtle, e.g., entry or exit tracks, drops of blood, a piece of hair, the tip of a ski pole basket, a muffled scratching sound, the family sitting in one location, etc. Look and listen carefully. When in doubt, check it out!
- **Spot probing** all likely catchment areas.
- A **beacon search** of the entire deposition area, unless it is positively known that the victim(s) were not wearing beacons.

If a careful beacon search has been conducted and no beacon signal has been picked up, continue with the visual search and spot probing until the area of debris has been searched thoroughly. If there are still no results from this initial search, it is time to set up a coarse probe line[4] with all available personnel in the most likely area. If you are the only survivor, continue to spot probe likely catchment areas until no hope exists. Be sure the *entire* deposition zone is checked for clues.

- **Working fast, efficiently, and quietly. Don't give up; you are the victim's best chance of survival**. Continue searching until all hope is lost or until the hazard to rescuers is too great (e.g., exhaustion, hypothermia, increasing avalanche hazard, etc.) Darkness alone is not a reason to call off a search.

If You Respond to an Avalanche Accident which has been Witnessed by Someone Else

The witness is the most important person you have regarding the number of victims and their last seen locations. If at all possible, *return to the accident with the witness.*

Determine from the witness:

- What happened, how many people were caught, and how long ago the accident happened.
- His or her location when the avalanche occurred.
- The relative location of each victim when the avalanche occurred.
- The last seen area of each victim.
- Whether or not the victim(s) were wearing avalanche beacons.
- Any other pertinent information.

Do not make a bad situation worse; tend to any immediate, potentially life-threatening needs of your witness.

Proceed as outlined above under "If you Witness an Avalanche Accident," page 3.6 (risk assessment, initial search, etc.)

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[4]A *coarse probe line* is a method of probing where rescuers stand side by side (with probes 30" apart), advancing (24") upslope. This grid spacing of 30" x 24" yields a 76% probability that a victim will be found on the first pass. The probability of encounter increases slightly with each additional pass. By contrast, a fine probe (with a grid spacing of 12" x 12") has nearly a 100% probability of encounter, but the process takes approximately four times longer to complete. When looking for a live person, it is nearly always best to use the coarse probe method, even if the process has to be repeated several times.

What are the Elements of a Successful Rescue?

Common mistakes in avalanche rescues[5]:

- *Poor organization*—e.g., no plan, divided or uncertain leadership, lack of proper equipment.
- *Mishandling the witness*—e.g., failure to hold and question the witness, inaccurate information concerning the last seen area, number of victims, etc.
- *Inadequate initial (hasty) search*—e.g., not doing one, not searching the entire area, not knowing how to use avalanche beacons, not locating clues, not probing likely spots.

Summary of the necessary components of a successful rescue:

- *Speed* tempered with *safety*
- Leadership
- Communication
- Having a plan
- Efficient allocation of manpower
- Qualified personnel—knowing how and where to search
- First aid/evacuation
- Self-help!

Now, let's turn the tables.

[5]Taken from information synthesized by Dale Atkins, Colorado Avalanche Information Center in Avalanche Rescue Fundamentals, Hotchkiss, Gallagher, and Atkins, 1991, The Twelfth National Avalanche School Handbook, pp 44-51.

If You are Caught in an Avalanche, Immediately...

- Try to get off to the side of the avalanche by jumping, skiing, or by whatever means possible.
- Yell to alert your partners of your situation, then keep your mouth closed to avoid choking on snow.
- You will probably be knocked off your feet almost instantly and tumbled down the mountain. If you are lucky, you will be on your feet. It is unlikely that you will have time to remove your pack, skis or snowshoes, or ski poles, but try to jettison something. Unfortunately, these items will serve to drag you underneath the surface of the moving debris.
- Try to stay on top of the snow by swimming, rolling, jumping and kicking. *Fight!* This is your best chance of staying on the surface. Try to keep your head upslope and your feet downslope.
- Keep your eyes open and pay attention to what is coming up below you, so that you can try to "maneuver" your way around objects like trees and cliffs. If you are "stuck" in the moving snow, you will not be in control and thus, face a higher probability of being injured or buried as the snow moves downslope.
- If you are completely buried, try to cup one hand near your mouth or your arm around your head, while trying to reach the other arm skyward. This may enable you to have a small air pocket and/or an airway along your arm.
    - The snow around you will "set up" very fast once it comes to rest, thus, you generally have only a few seconds to make an air space. If possible, try to expand your chest during this time. Remember that approximately 70% of the "snow" is composed of air.
- Try to relax; you will use less oxygen.

- If you are completely buried and do not have an air pocket, your chances of survival are slim. You will probably slip into unconsciousness within a minute or so. Given a *worst case* situation, after four minutes without oxygen you can expect the early stages of brain damage. After 8 minutes without oxygen, you will probably be a "vegetable" for the rest of your life, which usually is short lived. After 15 minutes without oxygen, your life will end.

- Given a *best case* situation—plenty of air, warm clothes, and a strong mental attitude—victims with large air pockets have survived five or more days buried in the snow.

- Once completely buried, your primary chance for survival rests with your partners. Hopefully, all members of your party are outfitted with (and know how to use) beacons, probes, and shovels. This equipment could save your life!

Your chances of survival are obviously greatest if you do not get caught in an avalanche. *So, how do you avoid avalanches? What is an avalanche?* First, the basics.

Avalanches

Types of Avalanches

By definition, an *avalanche* is simply a mass of snow, rock, and/ or ice moving down an inclined slope. Sometimes, the terms "snowslide" and "snow avalanche" are used interchangeably with the term avalanche, unless otherwise qualified as a "landslide" or some other mass-wasting event. Four types of avalanches are of particular interest to snow surveyors and other back country travelers: point releases, slab avalanches, cornice breaks, and ice avalanches.

- *Loose snow avalanches,* also called *point releases,* generally initiate from a point in loose, cohesionless snow and widen as they entrain additional unconsolidated snow along their descent.

— Most commonly observed on steep slopes in new snow which has not yet settled, in recently warmed surface layers that have lost their cohesiveness, or in very wet, unconsolidated snow. Loose snow avalanches generally pose the least risk to facilities and structures (but a much higher risk to skiers and climbers).

- *Slab avalanches* occur when a cohesive layer or layers of snow fail as a unit (i.e., *a slab),* and release simultaneously across a broad plane, becoming detached at all of the slab boundaries.

  — These boundaries include the *crown face or fracture line* at the top, the flanks along the sides, the *stauchwall* at the bottom, and, most importantly, the *bed surface* upon which the slab rests.

  — Slab avalanches generally pose the greatest potential risk to snow surveyors and back country recreationists because they can fail catastrophically across an extensive area, encompass a great mass of material, and attain high velocities in their descent.

- *Cornice breaks* refer to the failure of overhanging "drift" deposits of wind-transported snow which are generally found along ridgecrests and creek banks in windy areas.

  — Cornices generally fail under the weight of additional loading from new wind-deposited snow or from weakening due to warm temperatures and melt. But they also collapse under the weight of people and, because of this, can pose a serious potential threat to people traveling along corniced ridges.

- *Ice avalanches* result from the collapse of large blocks of "teetering" ice, *called seracs.*
  - Found on the steep slopes of hanging glaciers and at the face of large glaciers, these seracs pose a potential threat to people working in their path.
  - Unlike other avalanches, ice avalanches are unpredictable (although the hazard is easy to recognize) and can occur at any time, summer or winter. Additionally, they are capable of traveling long distances at high speeds.

Slab Avalanche Characteristics

Most avalanche accidents involve human-triggered slab releases. Because slab avalanches pose the greatest risk to snow surveyors and other back country travelers, most of the discussion in the remainder of this outline relates to assessment and failure of slab avalanches. Like animals, slab avalanches vary in their size, destructive force, and characteristics. The information below paints a picture of the nature of the beast:

- *Slab thickness:*
  - Natural releases: 1/2 inch to 35 or more feet thick.
  - Human-triggered slides: Generally less than 5' deep with most less than 2'. (How deep does a slab have to be to be dangerous? It all depends upon where you are standing, that is, what the consequences are of getting caught. Mountaineers, in exposed terrain, have been killed by slabs only 4 inches thick.)
  - Typically, the crown face (fracture line) is 90' to the bed surface.
- *Fracture length*—Several feet to more than 1.5 miles long.
- *Bed surface area*—Roughly 100 times larger than all of the other boundary regions combined (i.e., the crown face, flanks, and stauchwall).

— This is important because once this surface fails in shear, the other boundary regions are not usually strong enough to hold the slab in place.

- *Slab consistency*—one or more layers varying in density from a low of 60 kg/m^3 (6% water equivalency) to a high of 700 kg/m^3 (70% water equivalency), from seemingly unconsolidated, soft powder to very hard, old windslabs, and from very wet, relatively warm water-saturated slabs to cold, dry, soft slabs.

- *Slab age*—minutes to years old.

- *Velocity:*

  — Wet snow avalanches: 10–35 m/s

  — Dry snow avalanches: 20–70 m/s

- *Motion*—Sliding, tumbling, flowing, mixed motion, airborne, turbulent powder blast (wave of displaced air with a suspension of fine-grained snow particles that often precedes fast-moving, particularly dry, avalanches).

What is stability evaluation?

Evaluating Snow Stability

Definition of Terms

Avalanches do not happen by accident; they happen for particular reasons. The interrelationship of three critical parameters, the terrain, the snowpack, and the weather, determine whether or not avalanches are possible. A fourth factor, the presence of man, determines whether a hazard exists. Each of these factors in some way influences the delicate and constantly changing balance between stress and strength found within the snowpack.

Of critical importance is the concept that *when stress equals strength, failure occurs.* In other words, when the combined stresses of slope angle, snow load, a skier or explosive charge, etc. equal the combined strength of settled snow layers, the bonding between these layers, or the anchoring capability of the terrain and/or vegetation holding these layers, the slope will avalanche.

When strength significantly outweighs stress, the snowpack is said to be *stable*—that is, avalanching is unlikely or impossible.

When stress is nearly equal to strength, the snowpack is termed *unstable* (i.e., the instability is such that avalanching is possible or likely).

When the snowpack is unstable, any additional increase in stress or decrease in strength may result in failure.

Stability evaluation, then, is the process of determining whether a snowpack is capable of avalanching. Having data relating directly to the balance between stress and strength is essential to evaluating the stability of the snowpack and assessing potential hazard.

The stability evaluation process starts with the first snowfall of the season and lasts until the last melt of summer. It is an ongoing process which continues during each step of a climb, each turn of the ski, and every hour of the day and night.

How do changes in the snowpack affect stability?

Snow Characteristics

Snow as a Material

The mountain snowpack is a fascinating phenomena. Each winter, storm and wind events deposit new snow in layers of variable depth. Some of these layers are strong, while others are weak. What is important in terms of avalanche potential is how well neighboring layers are bonded and where the weak and strong layers lie in relation to each other.

Snowpack layers are constantly changing in response to deposition, erosion, sublimation, settlement, melting, viscous flow, and metamorphism.

These changes affect the balance between strength and stress (i.e., the stability of the snow) by altering snow hardness, density, grain structure, thermal state, and the bonding ability of layers.

The type and rate of change within a layer or layers of the snowpack is primarily dependent upon the effect of three variables: stress, temperature, and structure.

Stress Effects

The way in which the snowpack responds to stress (i.e., physical pressure, force, or load) depends upon the intensity of the force and the rate at which it is applied.

- The stress affecting the snowpack is derived from three primary sources: slope angle, applied load, and shock:
  - *Angle:* As the slope angle increases, the stress exerted on the snowpack increases.
  - *Load:* As the weight of new snow, rain, people, etc. increases, the stress exerted on the snowpack increases.

   - *Shock:* Any shock—a falling cornice or person, an earthquake or an explosion—results in stress being applied to the snowpack. The greater the shock, the greater the force.

- The snowpack can only absorb a certain amount of load (i.e., stress) and only at a limited rate of speed.

   - The snowpack responds to *slow* loading in a *viscous* fashion, that is by flowing, bending, and deforming through creep and settlement[6]. Sustained creep can dissipate stress through plastic flow.

   - The snowpack responds to *fast* loading in an *elastic* fashion. The sudden release of stored elastic energy takes place as brittle failure (this is the driving force for propagating fracture lines).

- *Structure Effects*—Over time, the snowpack settles and densifies, becoming generally harder and stronger in the process. Certain snow types are susceptible to change while others are much more resistant:

   - The more unconsolidated the snow layer, the more susceptible it is to deformation (i.e., densification). Examples: unconsolidated new snow, melt-freeze snow in the melt phase.

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[6]*Settlement* refers to the compressive internal deformation of the snowpack on a horizontal plane under the influence of gravity and load. As snow settles, it becomes denser and stronger. An inclined snowpack will also settle and densify in response to compressive stress but it is also subject to creep and glide. *Creep* is the internal deformation of the snowpack in response to shear stress. *Glide* is the downslope slip of the snowpack in relation to the ground.

— Likewise, the denser a given snow layer is, the more resistant it is to further densification. Examples: Hard old wind slab, well developed faceted snow, and frozen corn snow (melt-freeze snow in the freeze phase).

- *Temperature Effects*—The warmer the temperature, the faster the rate of change; the colder the temperature, the slower the change. The primary changes affected by temperature are:

  — Deformation (settlement and creep): All things being equal, snow deforms (densities) faster at warmer temperatures and much slower at colder temperatures.

  — Metamorphism: Any change in the snowpack takes place faster at warmer temperatures and slower at colder temperatures, regardless of type. This is known as the "Betty Crocker" principle: You can cook a cake at 200°, but it will cook a lot faster at 400°.

  — The primary means by which temperature changes are transmitted to the snowpack are through conduction, convection, and solar and terrestrial radiation.

Metamorphism

Snow metamorphism is the term given to describe changes in snow structure that take place within the snowpack. Three types of metamorphism occur: rounded grains (also known as equilibrium form), faceted grains (also known as kinetic growth form), and melt-freeze[7]. Each develops according to a different set of conditions and each, in turn, affects the strength of the snowpack. Also importantly, different types of metamorphism may be occurring in various layers of the snowpack at a given time. Again, the rate of change, that is, the speed at which any type of metamorphism occurs, depends on the average snowpack temperature. The warmer the temperature, the faster the metamorphism takes place. The colder the temperature, the slower the rate.

- *Rounded grains* develop when the temperature in a layer is fairly uniform, that is, there is no significant temperature gradient. While individual grains become smaller and rounder, bonds or necks between grains are developed. This bonding process is known as *sinteting* and increases the strength of a layer. Thus, the equilibrium form process produces fine, rounded, well bonded grains and the result is a relatively strong layer, with moderate to high density.

  — Do not confuse the terms strong and stable. Strong snow makes good slab material because it is cohesive enough to be able to propagate a fracture. It is the *relative* cohesiveness of the layers that helps determine slab avalanche potential. The critical question is: What is that cohesive layer of snow sitting on top of and how well is it bonded?

  — Favorable conditions or habitat for the development of rounded grains are cloudy, warm weather or a thick snowpack. Every metamorphic process has an early, intermediate, and advanced stage. The more advanced the equilibrium form process, the smaller, rounder, and better bonded the grains will be.

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[7]The two types of metamorphism which take place in cold, dry snow have been know in recent years as equitemperature (ET) and temperature gradient (TG) metamorphism. The international terminology was revamped in 1990 and two parallel classifications were developed to describe metamorphic types by process and by morphology (shape and structure) of the resulting grains. ET snow is now called equilibrium form or more simply, rounded grains (rounds). TG snow is called kinetic growth form or faceted grains (facets). The presence or absence of a temperature gradient determines whether or not rounded or faceted grains develop within a given layer. The third type of metamorphism is known as melt-freeze (MF) or wet grains.

- *Faceted grains* develop when a significant temperature gradient (variation in temperature over distance) exists within or between layers. In most areas, the temperature at the ground/snow interface is warmer than the air temperature. Thus, the shallower the snowpack, the greater the temperature difference or gradient within the snowpack. Deep snowpacks tend to dampen this difference by adding many layers of "insulation" between the relatively warm ground and cold air.

  — A significant gradient in a snowpack where the average temperature is close to 0°C (32°F) is 1°C per 10 cm (4 in). In very cold areas, such as continental and arctic climates, where the average snowpack temperature is usually much colder than 0°C, it takes more of a gradient to drive the kinetic growth process.

  — The trend of the kinetic growth process is to produce large, angular grains which are poorly bonded and weak, especially in shear.

- The longer the gradient exists and the process continues, the larger, more faceted, and more persistent the grains. Advanced faceted grains are also known as *depth hoar or sugar snow.*

- Favorable conditions for the development of faceted grains are cold weather and/or a thin snowpack. Also, because temperature gradients are likely to develop on either side of ice crusts, these are likely habitats for faceted grains.

- These grains also need relatively low density (high porosity) snow in order to have room to grow.

  — If a temperature gradient is introduced within a dense, hard wind slab made up of small, rounded grains, the kinetic growth process may be activated, but because of the constricted pore spaces between the grains, the process will be so inhibited that it is unlikely the existing structure of the layer will be altered.

- Rocks, tree wells, brush, and exposed ribs are likely spots for faceted grains to develop, partly because they have plenty of open or pore space around them and partly because they are often areas of shallow snow.

- *Melt-freeze* metamorphism occurs during midwinter thaws or in the spring, when melt water or rain enters the snowpack and the snowpack temperature reaches 0°C (32°F). The trend is toward the production of coarse, rounded grains and with repeated cycles of melting and refreezing, these grains become larger and larger.
  - Melt-freeze or wet grains are also known as corn snow.
  - In the freeze phase, these grains are well-bonded and strong although the resulting ice crusts can make good potential bed surfaces for slabs subsequently deposited.
  - In the melt phase, wet grains weaken rapidly and form an unstable surface layer which can be easily triggered by travelers.

Other Weak Layers

Surface hoar, the wintertime equivalent of summertime dew, is formed at the snow surface during cold, clear weather. Surface hoar crystals are loose, feathery, and poorly bonded.

Surface hoar is a potentially deadly weak layer once buried because it persists for a long period of time, can form a thin shear plane that is difficult to detect if you are not looking for it, and can produce long-running fractures.

Another significant weak layer is *unmetamorphosed new snow.* This is snow that may have fallen during a cool or windless period of a storm and then had denser, heavier snow deposited on top of it.

Whether or not you remember the different types of metamorphism or can definitively identify unmetamorphosed new snow as opposed to early faceted grains is unimportant. What is critical is that you are able to recognize relatively strong and weak layers in the field. However, if you do learn something about the conditions that produce different kinds of layers, you will be better able to anticipate changes in snow stability before you even reach the trailhead.

What conditions are required to have a slab avalanche?

Slab Failure

Criteria

In order for *slab failure* to occur, the following requirements must be met:

- *The terrain must be suitably steep and smooth.* (See section titled "Critical Data," "Terrain," page 3.26–3.27 for more details.)
- *The snowpack must be unstable.* In other words the snowpack must be made up of a slab, a weak shear layer, a bed surface (i.e., a sliding surface), and most importantly, the stress exerted upon the boundary regions of the slab must be *nearly equal* to their strength.
    - — This state of near-equilibrium balance is typically attained by either increasing stress or by decreasing strength. For example, stress on the snowpack generally becomes greater as slope angles increase or as load increases (e.g., the added loading resulting from snow storms, rain, or deposition of wind-transported snow).
    - — Remember, the circumstances which lead to the development of a slab also contribute to the stored elastic energy held within the slab.

— Stress and strength are not uniform across a given slope. It is common to have areas of stress concentration (e.g., steeper slope angles, rollovers, etc.). It is also common to have weak zones where the snow is much more tender (e.g., shallow or bushy/rocky spots where weak layers may be well developed). Often, fractures are initiated in these areas and then are propagated into stronger snow.

- *A trigger of sufficient force is required* to tip the balance on the scale and complete the ingredients needed for slab failure. In other words, when the stress exerted on the snowpack is nearly equal to the strength, all it takes is the additional stress of a trigger to cause the slope to fail. People are common triggers.

  — Once a localized failure occurs, the sudden release of stored elastic energy acts to drive the failure across a broader plane.

What information is considered important when evaluating avalanche hazard?

Critical Data

Seeking Information

Just as you look and listen both ways to check for oncoming traffic before crossing a busy intersection, no snow surveyor should think of traveling across or below a steep snow-filled slope without first seeking the answers to these four critical questions:

- Is the terrain capable of producing an avalanche?

- Has the weather been contributing to instability?

- Could the snow fail?
- Do better alternatives exist?

The key to evaluating avalanche hazard is having access to reliable information. The interrelationship of four variables: terrain, weather, snowpack, and man, determines the degree of avalanche hazard present, but within each of these areas exists critical information that must be considered.

Start the evaluation process by formulating an opinion based, in part, upon the data parameters outlined in this section. By choosing information that provides a high degree of certainty in its message and by seeking a variety of clues and test results that either reinforce or refute the message, you can quickly make an educated evaluation based upon meaningful information. The key to this process is going for the 'bull's eye" data, the information which gets to the heart of the problem and then listening to the message. No one clue tells the whole story; information must be integrated from a variety of sources. Hazard evaluation is not an event; it is an ongoing process. Thus, new opinions must be continually formulated based upon new data as summarized.

Terrain

Is the terrain capable of producing an avalanche?

- *Slope Angle*—Concept: *the greater the slope angle, the greater the stress exerted on the slab boundaries* (i.e., the crown face, flanks, stauchwall, and bed surface/slab interface). To reduce uncertainty, measure slope angles with an inclinometer; don't guess. Remember:

  — Prime time starting zones generally range between 35° and 45° or higher. These should not be taken as absolute numbers, but as an approximate range that varies with snow climate.

— Human-triggered avalanches can be initiated from a slope of any angle as long as some portion of the connecting slope has at least a 25° slope angle component. This is roughly the angle at which sufficient stress is exerted upon the boundary regions of a slab to allow it to fail.

— Different types of instabilities tend to fail at different slope angles. Pay attention to which angles and aspects are failing when a cycle starts. What may have been a safe slope to traverse yesterday, may not be safe today.

— Slabs rarely adhere to slopes steeper than 60° because the slope angles are so steep that snow generally sluffs off repeatedly during storms. Again, the angle at which this happens depends upon snow climate.

- *Slope Aspect*—Observation: *Leeward, shadowed,* or *extremely sunny slopes are potentially more unstable, all things being equal.* Why?

  — *Leeward:* because wind-transported snow makes good slab snow and adds stress to the snowpack. Remember, the snowpack can adjust to only a certain amount of load and only at a limited rate. Fast loading rapidly increases instability.

  — *Shadowed:* because of the greater propensity for the development of weak, faceted crystals and the reduced rate of strengthening through settlement (due to the absence of beneficial warming by the sun and generally colder temperatures). Thus, instabilities persist longer on shadowed slopes.

  — Extremely sunny exposures: because of the rapid weakening of the bonds between snow grains caused by warming from solar heat and by the percolation of meltwater into and between snowpack layers.

- *Slope Configuration (roughness/shape)*—Concept: *Anchor points not only provide holding ability for the snowpack, but they can act as points of stress concentration* (i.e., trees, rocks, etc. act as immovable objects surrounded by an otherwise flowing snowpack). Remember:

  — Slabs frequently fracture just below convexities and between anchor points because these are the areas of greatest tensile stress.

  — Rough irregular surfaces, such as boulder fields or heavy vegetation, generally provide better anchoring for a snowpack than smooth surfaces such as grassy or tundra-covered slopes.

  — As snow depth increases the effectiveness of anchors decreases.

  — Trees have to be almost too close together to ski through to ensure that an avalanche cannot fracture through them.

  — Avalanches can occur on *all* steep, snow-covered slopes, given the proper conditions of instability, regardless of slope shape or roughness.

Weather

Has the weather been contributing to instability?

- *Precipitation* (type, rate, and amount)—Concept: *Increased weight from snow or rain causes increased stress.* How much new stress is the snowpack capable of handling and how well is the new snow layer bonding to the old snow surface? Check it out.

  — Generally, warmer, more consolidated snow layers on top of colder, less cohesive layers tend to increase instability. Conversely, warm snow falling over warm snow tends to bond well and strengthen rapidly through settlement, all things being equal.

- Unlike snow, rain provides no additional strength through bonding, only weight and lubrication.

- As an example, a storm resulting in 18" accumulation during one day is more likely to result in increased instability than one which deposits 18" in three days, all other things being equal. Record measurements of new snow depth vs. time (i.e., precipitation intensity).

- *Wind* (wind speed, direction, amount of snow transported)— Concept: The *snowpack can only adjust to a certain amount of stress (i.e., load), and only at a certain rate.* Wind speed/direction along with the amount and type of snow available for transport determines the depth and distribution of a newly deposited wind slab.

  - Snow transported from windward slopes can rapidly increase instability on leeward slopes due to the inability of the snowpack to adjust to the new weight. A layer or bond between layers with little internal strength may not be strong enough hold the weight of the newly deposited snow load. Also remember that slab formation is enhanced in wind-deposited snow.

  - Each snow type has a wind threshold speed (i.e., the speed at which snow starts to move), thus low density, unconsolidated snow is more susceptible to wind action than older, harder snow. How much snow is actually being loaded and how much is being sublimated? Do not assume loading rates; measure them if possible.

    - One method of measuring how much snow is available for wind transport is the "boot penetration" method; essentially, the depth of a footprint is available for transport.

- *Temperature* (max/min, trend, and freeze line)—Concept: *The warmer the snowpack temperature, the faster internal changes take place.* What effect are current and projected temperature changes going to have on the snowpack? How will these changes affect snow stability?

  — Remember that snowpack temperatures are often a much slower reflection of air temperatures, thus temperature trends are particularly important.

  — As snowpack temperatures warm, the rate of deformation (both creep and glide) increases and, thus, flow stress may be accelerated.

  — Warmer snow temperatures also mean faster rates of metamorphism, regardless of the type of change. Remember: it is the presence or absence of a temperature gradient that determines the type of metamorphism, but it is the average temperature of a layer that determines the rate of metamorphism.

  — Rapid or prolonged warming of the snowpack often results in increased instability. Conversely, cooling of a warm snowpack usually results in a more stable condition, all other things being equal.

  — Preexisting instabilities in cold, dry snowpacks have the ability to persist for long periods of time (weeks or months, depending upon the nature of the instability), thus the possibility of delayed action avalanches, particularly human-triggered avalanches, must be taken into consideration.

Snowpack

Could the snow fail?

- Slab Configuration (depth, distribution, and structure): Question No. 1: *Do you have a slab?*

  — If so, what is the depth and distribution of this slab across the slope? Where is it likely to fail? What are its boundaries? One way to measure slab depths and distribution is by probing.

- *Bonding Ability*—Question No. 2: *How well is the slab bonded to the layer beneath?* What is the nature and distribution of "tender spots" (i.e., again, these are micro areas of more unstable snow that, when triggered, rapidly propagate failure to a broader plane)? Often tender spots consist of areas of shallower and weaker snow such as those found around wind-scoured convexities and ribs or boulder areas.

  — Confirm the nature of the weak layers by probing, by digging quick exploratory pits (armhole pits), by performing shear tests[8], by seeking major clues to instability, and by examining fracture and flank profiles from previous avalanches in the area to determine the cause of failure. Record the nature of the structure and pertinent measurements for future reference.

  — Poorly bonded layers come in all types and sizes so do not be fooled by appearances; test the layers for shear strength. Weak layers have one thing in common, they all fail easily if you find the right spot.

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[8]*Shear tests,* such as shovel and ski shear tests, rutschblock, and banzai tests are a means of applying a known amount of force to a fixed sample size to determine the depth and ease with which the sample fails in shear. (See *Snow Sense, A Guide to Evaluating Snow Avalanche Hazard,* by Fredston and Fesler, 1988, pp 15–24 for more details.)

— Be aware of the fact that you may not be able to detect instability using tests alone, some tender spots are hard to find and dangerous to approach. Use extreme caution in your choice of test sites. Avoid exposure.

- *Sensitivity to Force*—Question No. 3: *What kind of force will it take to make the slab fail?* What are the shear test results? What are the clues to instability? Concept: Stability is relative to the force you apply to it. For example, deep slab instability often requires greater force to initiate failure.

  — Constantly think *safety* when performing field tests. Some weak layers such as surface hoar or young faceted snow are notorious for their ability to propagate "zipper fractures" long distances up-slope, across-slope, and down-slope. Make sure your test sites will give you realistic information but are bombproof.

  — Integrate results from a variety of tests and clues and interpret the message.

  — Snow stability tests include: jumping, trundling, ski cutting, rutschblock (shear block), testing with explosive charges, performing shovel and ski shear tests[9].

[9]Again, for detailed test procedures see: Snow Sense: A Guide to Evaluating Snow Avalanche Hazard, Fredston and Fesler, 1988, pp 15–24.

The Human Factor

Do better alternatives exist?

Attitude/Physical and Mental State

When you are considering traveling in risky terrain under marginal conditions, what you are really talking about *is "What's your attitude toward life?"* A strong physical and mental state is as likely to contribute toward an avalanche accident as a weak one, if your attitude is that of a "high risk taker."

- People with high-risk taking attitudes generally filter information about hazard and draw unrealistically optimistic conclusions which lead them to push the fine line even finer.

- People who are generally conservative by nature tend to use information to further justify their conservative approach.

- Keep in mind that Mother Nature doesn't care what you think. Conditions need to be evaluated objectively on their own merit. Thus, it is important for you to "tune in" to how your own attitude may bias your judgment. **When traveling in avalanche terrain, you need to think like an avalanche.**

Skill Level/Preparedness

Generally two categories of people tend to get into trouble with avalanches: novices and experienced travelers.

- Novices fall within the category of "ignorance is bliss." When an accident happens, they are usually totally surprised and unprepared. They simply haven't learned the basics of avalanche hazard recognition, evaluation and rescue.

- Experienced back country travelers, on the other hand, are often faced with the problem where, for example, their ability to ski steep terrain often far exceeds their ability to evaluate snow stability. For the most part, experienced people tend to overestimate their ability to travel through potentially hazardous terrain.

Assumptions and Consequences

The bottom line question in the hazard evaluation process is "What are the consequences if something goes wrong?" Usually our decision to "proceed" is tempered by certain assumptions about our presumed safety.

- Ask yourself: *Will I be caught? Buried? Killed? Am I prepared for the worst? Is it worth it? Do better alternatives exist?* Also ask: *On what assumptions am I basing my decision? Always* identify and check out your assumptions. Some examples of false assumptions:

  — We need to go because we have to be back by 5 p.m. (Note: Mother Nature does not care.)

  — It must be safe, because there are already tracks ahead of us. (Again, the tracks don't mean anything, what is Mother Nature saying? Slopes with over 150 tracks on them have slid.)

  — It's probably okay, because the snow ranger said the avalanche hazard was low/moderate. (Note: Make your own stability evaluations, hazard forecasts are regional, not site specific.)

  — Hey, its a beautiful blue sky day and the powder is great. What could possibly go wrong? (Note: While most natural avalanches happen during storms, most *human-triggered* avalanches occur on the blue sky days after storms.)

  — I've skied this place a hundred times before and never seen an avalanche. There's nothing to worry about. (Note: Most of the time, the snow is stable so we get "negative reinforcement," that is, we begin to think of an area as "safe." If the spot is avalanche terrain and if we travel there enough times, sooner or later we will be there when the snow is unstable.)

Risk Assessment

Each piece of information carries with it a certain level of risk based upon the hazard potential of the data. These levels of risk can be thought of as green lights, yellow lights, and red lights. *Green* means it is "Okay; no hazard exists." Yellow means "use caution; potential danger exists." And *red* means "Stop, danger, a hazardous situation exists." For example, if the terrain is red (e.g., 37°, leeward), the snowpack is red (e.g, 12" of new and wind-deposited snow, poorly bonded to the old snow surface), and the weather is green (e.g., blue sky, no wind), do you go or no go? The answer is a resounding "no go." In the same scenario, if the snowpack was green, you could have a safe day on avalanche terrain.

Taken by itself, each piece of information portrays an important, but incomplete, view of the whole. When integrated together, however, a more complete message starts to appear. The important thing is to assign a level of risk to the overall message and then take appropriate action to reduce or eliminate the risk.

You can travel on or near steep slopes safely but it is a matter of timing. When the fish are running, some people like to go fishing. When the avalanches are running, it is more important than ever to carefully evaluate snow stability and choose good routes every step of the way.

What are the major clues to instability?

Major Clues to Instability

Reducing Uncertainty

Typically, evaluating snow stability is like trying to see through a frosted window on a cold morning. In order to clearly see the view, the window must be defrosted. In evaluating snow stability, the "defroster" consists of critical data derived from clues and test results. Generally when an unstable snow condition exists, the preponderance of information from clues and tests will reinforce the message that conditions are unstable on certain aspects, at certain elevations, and within a certain range of slope angles. Conversely, the absence of any clues or test results indicating instability is usually a pretty sound message that the snowpack is stable. Because some degree of uncertainty will always be present, an extra margin of safety is required. This is particularly true during periods of unsettled weather when snow stability is likely to be changing rapidly. Some of the major clues to instability are listed below.

Nature's Billboards

- *Recent avalanche activity*—No better clue to instability exists than the presence of recent avalanche activity. Slopes of similar elevation and aspect should be considered suspect.

- *Collapsing snow* (i.e., "whumphing" noises)—These sounds, caused by the sudden collapse of a weak subsurface layer, are indicative of extreme instability in the area. They are literally Mother Nature screaming in your ear to be cautious. This usually means picking routes across gentle slopes of less than 25° and avoiding the runout zones of steeper slopes.

- *Shooting cracks*—Shooting cracks are a form of brittle failure caused by the sudden release of stored elastic energy. These cracks indicate the presence of a tender slab and thus, high instability. As a "rule" (most rules lie, but this one does not), the longer the crack, the more serious the instability.

- *Hollow sounding snow*—Hollow, sometimes drum-like sounds indicate the presence of a less consolidated, potentially weak layer over-capped by a denser layer. Be careful, you may be traveling on wind slab deposited over unmetamorphosed new snow or faceted snow.

- *Pluming, wind transport*—Wind pluming (wind-generated snow clouds), resulting from the erosion of snow from windward slopes and the rapid deposition of new snow on leeward slopes is a major clue that conditions are changing for the worse on leeward slopes. If wind-loading persists, the period of instability is usually followed by repeated cycles of avalanche activity and reloading. If a wind-loading event has terminated, evidence of wind slab (surface texture patterns and hollow sounds) should be present in the area.

- *Storm activity*—Like wind events, storms tend to make conditions more unstable because of the rapid loading that takes place. These periods of instability will *generally* be of shorter duration in warmer snow climates, but persist for longer periods of time in colder climates. Examples of typical weather patterns resulting in unstable snow conditions are listed below:

  — Major prolonged precipitation events (lasting several days) with significant quantities of rain or snow. Result: Increased stress due to loading.

  — Heavy accumulations of snow or rain during a short period of time (less than a day). Result: Rapid loading. Insufficient time for the snowpack to adjust.

  — Clear weather with strong winds resulting in significant snow transport to leeward slopes. Result: Development of wind slab, cornices (i.e., possible triggers), as well as rapid loading of leeward slopes.

  — Long periods of cold, clear weather, followed by heavy precipitation and/or wind. Result: Development of a consolidated slab over a weaker, less consolidated layer.

- — Storms that start out cold and end warm. Result: Development of an "upside-down layer cake," instability is usually of short duration, but highly sensitive.
- — Warm storms (with temperatures near the freezing level) that follow long periods (several days or weeks) of cold weather. Results: same as above.
- — Rapid and prolonged rises in temperature following long periods of cold weather. Results: If deep slab instability was a preexisting condition, avalanche activity is likely. If the snowpack was previously stable, some surface instability may persist until temperatures cool.
- — Prolonged periods of above freezing temperatures and overcast skies following periods of colder weather. Results: same as above. Deep slab failure could be triggered, often by surface sluffing.
- — Intense solar radiation, particularly with a thin layer of clouds above. Results: Surface layer(s) are likely to become rapidly unstable as bonds between grains melt. Loose snow and soft slab avalanches involving surface layers are likely. If deeper instabilities preexisted, larger, deep slab avalanches could be triggered, often by surface stuffing. In the spring, deeper slab releases become more possible after several days and nights when the snowpack does not refreeze (this is encouraged by cloudy, warm weather).

- *Shear test results*—Easy shears and very easy shears obtained from properly executed shovel or ski shear tests, rutschblock tests, loaded column tests, ski cutting, and banzai jump tests are indications of instability. The question is, "How widespread is the instability and what hazard does it present?" Negative shear results, on the other hand, do not necessarily mean that conditions are stable. It could be that the tests were conducted in nonrepresentative areas. Seek to corroborate the results by integrating additional information from a variety of sources. Remember: No one test will tell all.

- *Results from explosives*—Many ski areas use explosives to "control" avalanches and the results from these activities can provide useful feedback concerning how sensitive or active the snowpack is in a particular area. Control results can often be obtained by contacting the Snow Safety Director of the ski area or the local avalanche information hot line. But again, your evaluation of the overall hazard should be based upon a wide variety of sources and not just explosive results.

Important Caution: Every avalanche cycle must have its first avalanche. Every period of instability must have its first "whumphing" noise or shooting crack or avalanche. Sometimes, human triggered avalanches occur well before the natural avalanches start to roll. Sometimes, the threat of human-triggered avalanches lingers long after the naturals have run. The major clues to instability may not always be obvious with certain instabilities or at times when snow and weather conditions are rapidly changing from stable to unstable (but there are, almost always, *some* clues). Be careful and, when in doubt, be conservative.

How do you travel when the snow instability is high?

Route Selection Principles for Reducing Risk

The tenets of safe route selection are based upon these four principles:

- Prepare for the worst.
- Use the terrain to your advantage.
- Minimize exposure time.
- Make informed decisions regarding risk.

Prepare for the Worst

Research your route beforehand. Identify potentially hazardous areas as well as safety zones.

- Utilize air photos, maps, and local knowledge.
- View the route from many perspectives on the approach if possible. Identify your route alternatives.

Check the current and forecasted weather before you leave. Ask about expected precipitation (e.g., types, amounts, storm duration), freeze level, wind speeds and direction, and temperature trends. Call the National Weather Service Forecast Office and if possible, someone living near the area for site specific, real-time observations.

Know the capabilities of your group. Are your partners capable of doing the trip? Don't be afraid of reconsidering your plan. If necessary say, "No, I don't think we should follow this route because..." Equally important, learn to accept a "no" from another group member. A "no" based upon facts is a very powerful tool with which to save lives.

- Is everyone physically fit? Any medical problems?
- Does each member have the traveling skills necessary for the job?
- Is everyone sufficiently "mountain savvy" for the conditions?

Carry the necessary equipment. Anticipate your equipment needs and bring the essential items:

- Travel gear—snowshoes? Skis and climbing skins? Repair kit?
- Survival gear—extra clothes? Emergency shelter? Camp stove and fuel? Fire starter? Extra food? Headlamp? Radio and batteries?

- Avalanche rescue equipment—one shovel, avalanche probe, and beacon *per person*.

File a trip plan with a responsible person before leaving. Leave a reasonable amount of time for bad weather.

- Answer—Who, what, when, where, and how.
- When delayed for whatever reason, don't get caught in the trap of trying—against all odds—to make it back by "the deadline." Fear that a search will be launched, is not justification for exposing a group to risk.

Use the Terrain to your Advantage by Selecting:

- *Ridge routes*—Travel on the windward side of ridges, well away from cornices and steep slopes.
- *Broad valleys*—Travel well away from the runout zones of avalanche paths and do not stop until you are in a safety zone.
- *Dense timber*—Although dense timber is no guarantee that avalanches do not affect the area, it is a good indication of the frequency of events. Look for flagging (i.e., broken branches) on the uphill sides of trees. Remember if the trees are spaced far enough apart to easily ski through, it is possible for the slope to fracture provided it is steep enough.
- *Gentle ramps and benches*—Utilize low angle slopes as routes rather than steeper slopes with greater exposure. Measure the slope angles!
  - Remember: You can trigger an avalanche on a gentle slope as well as a steep one, as long as what you are standing on is connected to a slope of sufficient steepness and sensitive instability exists.

- *Avoid exposure to hazardous areas* such as:
  - — Steep, smooth, leeward, loaded slopes (the classic avalanche path).
  - — Gully routes: gullies and narrow valley floors are known as "death routes" because victims, when caught, are usually buried deeply. Slopes which spread out onto alluvial fans generally produce a shallow burial.
  - — Corniced ridges: not only do cornices often break off much further back than expected, but it is common for cornice crevasses (tension cracks) to form on the windward side. These are often bridged over by new or wind-drifted snow and represent a serious hazard to anyone who should fall into them.
  - — Sun-exposed slopes during warming events: intense solar warming results in the formation of an unstable surface layer of well lubricated snow grains. Once triggered, this type of snow acts like a concrete slurry from which escape is often difficult or impossible. Timing can be very important. Sometimes in the spring, a slope will be hard and stable in the morning and very weak later in the afternoon.
  - — Avalanche path runout zones: not good places to stop or camp for obvious reasons.
  - — Other terrain traps: avoid steep creek banks, convex rollovers, and small bowls. They may seem innocent, but all can be deadly under the right circumstances. Avoid skiing above cliff bands or other areas where the consequences of getting caught in even a small slide are serious.

Minimize Exposure Time

Know your route.

- Carry a map and compass and know how to use them.
- Be in *good shape* and travel fast; in other words, minimize your exposure time by keeping on the move through hazardous areas.
- Be skilled in your method of travel. High skill levels can help you minimize your exposure time (e.g., fewer delays due to inexperience).

If you need to move through avalanche terrain, try to travel during stable weather and snow conditions. Eighty percent of all *natural* avalanches happen during or shortly after storms. Remember, however, that the typical accident happens when the terrain and snowpack are "red," but the weather is "green" (i.e., a nice blue sky day with beautiful snow after a storm).

Make Informed Decisions Regarding Risk

Identify the problem and formulate an initial opinion about the level of hazard anticipated based upon available information.

Examine the critical data from snow, weather, terrain, and human parameters. Seek first that information which will *do the most* to clarify your situation and reduce existing uncertainty.

Integrate additional information from a variety of sources that will either reinforce or refute your opinion and pay attention to the central message.

Identify your alternatives, their consequences, and the assumptions upon which they are based. Then develop a plan of action which takes into account the probability of success versus the likelihood of failure.

Always be willing to reevaluate your opinion based upon new information. Remember, hazard evaluation is an ongoing evolutionary process, not an isolated event.

The purpose of this article is *not* to make you paranoid about traveling and working in the back country. It is possible to travel safely in the mountains even when the snow is unstable. Keep in mind that most avalanche accidents do not need to happen. The clues are there if you are looking, listening, thinking, and paying attention to them. Have fun!

Chapter 4—Mountain Medicine

Objectives

Upon completion of this lesson, participants will be able to:

- Describe symptoms of altitude illness, explain what causes mountain illness, and describe how to prevent it.
- Describe why water should be warm before drinking and explain how to disinfect mountain water before drinking.
- Describe symptoms of hypothermia, explain what causes hypothermia, and describe how to prevent it.
- Describe symptoms of frostbite, explain what causes frostbite, and describe how to prevent it.
- Describe the procedure to follow if a member of your survey party is injured during a remote survey.

References

Outdoor Emergency Care, Third Edition, Warren D. Bowman, M.D., National Ski Patrol System, Inc.

West-Wide Snow Survey Training School Workbook

Time

Classroom: 4 hours, 15 minutes

Field: 1 hour, 15 minutes

Altitude Related Illnesses
Water Borne Infections and Water Disinfection
Hypothermia
Frostbite

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Altitude Related Illnesses

Incidences

Everest	43%	1-2%	1:2000
McKinley	50%	2-3%	1:625
Rainier	70%	<1%	? 0
Colo. Ski Resorts	17-25%	0.1%	? 0

Causes

Acute Mountain Sickness (AMS)

High Altitude Pulmonary Edema (HAPE)

	Onset	Clinical	Treatment	Prevention
AMS	4-6 hrs > 6000 ft	Headache, insomnia fatigue, irritable, nausea vomiting, SOB on exercising	Rest, fluids Tylenol, ASA Compazine DESCENT Gamow Bag	1,000 ft/day Diamox 125 mg 2/day Decadron 4 mg 4/day
HAPE	2-3 days > 8000 ft	1) Fatigue, cough. 2) SOB at rest, worse cough, pink sputum, confusion. 3) Stupor, coma. 4) May progress rapidly.	DESCENT Oxygen Rest Nifedipine Gamow Bag	1,000 ft/day 500 ft/day if over 22,000 ft

Water Disinfection

Heat

Giardia—inactivated by bringing water to a boil

Bacteria—at elevation, boil for 3 to 4 minutes

Viruses—same

Iodine

The best halogen for small volume disinfection.

- **Tablets**

	Clear	Cloudy
Warm water	1 tab x 15 min.	2 tabs x 20 min.

- **Crystals**

- Place 4-8 grams of I_2 in a 1 oz (30 cc) glass bottle. Fill with water.
- Warm glass bottle in pocket prior to use until crystals are all dissolved.
- Warm the water to be disinfected to 20°C (68°F). This may be done by placing water in direct sunlight.
- Add 30 cc (contents of 1 oz bottle) to 1 qt warm water.
  — Clear: wait 15 min.
  — Cloudy: wait 30 min.

Filters

Organism	Smallest Size
Viruses	0.01 microns
Bacteria	0.2 microns
Giardia cysts	5.0 microns
Parasites	30 microns

First Need
0.4 microns .... $45.00 .... 12oz. 1pt/min

Water One
0.5 microns .... $40.00 .... 16oz. 1pt/min

Katadyn
0.2 microns .... $210.00 .... 24oz. .... 1 qt/min

Hypothermia

Insidious

"Killer of the Unprepared"

Progressive Clinical Presentations

Core Temp (°F)	Clinical Symptoms and Signs
98.6	"Normal"
97	Metabolic rate increases to make up for heat losses
95	Maximum shivering
93	Conscious, responsive, normal BP
91	Impaired fine motor coordination, usually oriented but lethargic
90	Consciousness clouded, walking difficult, shivering stops, pupils dilated but react to light
86	Progressive loss of consciousness; low BP, respiratory rate and pulse; muscles rigid
82	Ventricular fibrillation increasingly likely
80	Lose voluntary motion, pupils not reactive, no reflexes
78	Unconscious
68	Cardiac standstill
64.4	Lowest documented accidental hypothermic victim to recover
48.2	Lowest artificially cooled hypothermia patient to recover

Predisposing Factors

Wind, wet, low temp, prolonged exposure, alcohol, exhaustion, dehydration

Treatment

ANTICIPATE, PREVENT

Recognize the condition
Prevent further heat loss
Warm central areas (chest, neck, groin, arm pits)

Frostbite

Treatment

Thaw quickly— 105°–110° F

Do not refreeze

Use sterile dressings for local wound protection

NSAID (ibuprofen) or Aspirin, 2–3 tabs 3/day

Chapter 5—Data Collection

Objectives

Upon completion of this lesson, participants will be able to:

- Describe four common types of data sites and explain two types of descriptive site maps.
- Describe the types of snow sampling equipment used in data collection.
- Describe and demonstrate five methods used for data observations.
- Prepare notes in accordance with standard NRCS procedures.
- Describe the impact of data collection accuracy in relation to water supply forecasting.

Materials

Agriculture Handbook No. 169

SCS NEH Section 22

West-Wide Snow Survey Training School Workbook

Time

Classroom: 2 hours, 25 minutes

Field: 4 hour, 45 minutes

Data Collection Outline

I. Introduction

II. Explanation

   A. Data Site Descriptions

      1. SNOTEL Site
      2. Snow Course
      3. Aerial Marker
      4. Storage Precipitation Gage
      5. Descriptive Site Maps

         a. Location Map
         b. Detail Site Map

            1) Snow course and aerial marker
            2) SNOTEL

   B. Types and General Description of Snow Samplers

      1. Mt. Rose Sampler
      2. Utah Sampler
      3. Federal Sampler
      4. Bowman Sampler
      5. McCall Sampler
      6. Adirondak Sampler

   C. Methods of Measurement

      1. Manual Snow Sampling Observations

         a. General Snow Sampling
         b. Shallow Bulk Snow Sampling
         c. Deep Dense Snow Sampling
         d. Special Conditions

2. Aerial Marker Observations
3. SNOTEL Theory and Operation
4. SNOTEL Observations
    a. Groundtruth
        1) Manometer
        2) Snow Pillow Groundtruth Observation
        3) Thermometer
    b. Telemetered
5. Precipitation Gage

D. Notekeeping
1. Manual Snow Course Notes—ENG. 708 Form
2. Aerial Marker Notes—For SCS-166
3. SNOTEL Site Data
    a. Manometer
        1) Precipitation
        2) Snow Pillow
    b. Snow Pillow Groundtruth
    c. Air Temperature Readings
4. Manual Precipitation Gage Notes—SCS-ENG-2

E. Importance of Accuracy
1. Effect of Sampling Error on Streamflow Forecasts
2. Economic Effects of Data Collection Error
3. Consistency in Data Record

III. Summary

Introduction

Precipitation information has been collected for many centuries. In the western United States, snowpack information began being collected early in the 1900's. Recently, automated sites called SNOTEL, for SNOw TELemetry, have begun to replace some manual snow courses. SNOTEL sites provide daily information on a near-real time basis with snow-water content, total precipitation, temperature, and other hydrometeorologic information. Accurate, timely readings, taken safely and responsibly along with the SNOTEL information, will continue to provide the information necessary to generate reliable streamflow forecasts.

In this lesson, you will cover four types of data sites, various types of equipment used in data collection, the proper method of measuring and recording information, and why the accuracy of the measurements is so critical to the water user.

Explanation

Data Site Descriptions

SNOTEL is an acronym that stands for SNOw TELemetry. A SNOTEL site is a location where hydrologic and climatic data is collected and transmitted by telemetric signal. A SNOTEL site consists of two main areas: (1) the data collection and transmission area and (2) a buffer zone surrounding the SNOTEL site.

The primary site is located in the high runoff producing areas and is, generally, in a small meadow or in scattered timber with a very slight slope. Exposure to solar energy is important for recharge of batteries using solar panels.

The data collection and transmission area is usually no more than 200 feet in diameter and contains the physical components of the SNOTEL site. These components include:

- Snow Pillow—A device for measuring snow water equivalent by pressure sensing.
- Storage Precipitation Gage—A straight wall, missile type storage gage used to collect precipitation. This gage can be 6 to 26 feet tall and is surrounded by a wind shield. The diameter of the gage is 12 inches.
- Instrument Shelter—A shelter 8 to 16 feet tall is used to house the radio equipment, batteries, transducers, manometers, and other components needing protection from the weather.
- Air Temperature Sensor—A sensor mounted outside the instrument shelter and above the maximum snow depth used to record ambient air temperature that is used in the calculation of maximum, minimum, and average daily air temperature.
- Antenna Tower—A free standing, triangular tower, usually 20-feet high, to which the radio antenna and solar panels are usually attached.
- Antenna—The device through which interrogation signals and data are received and transmitted.
- Solar Panel—Panels which convert solar energy to electricity needed to recharge batteries which are used to power the meteorburst transceiver.
- Transceiver—The electronic package that obtains sensor data, performs calculations using that data, and stores the information for transmission when the site receives a request from the master station.

- Transducers—The devices that measure the pressure created by weight of the snowpack or precipitation gage fluid and converts that pressure to an equivalent electrical voltage.

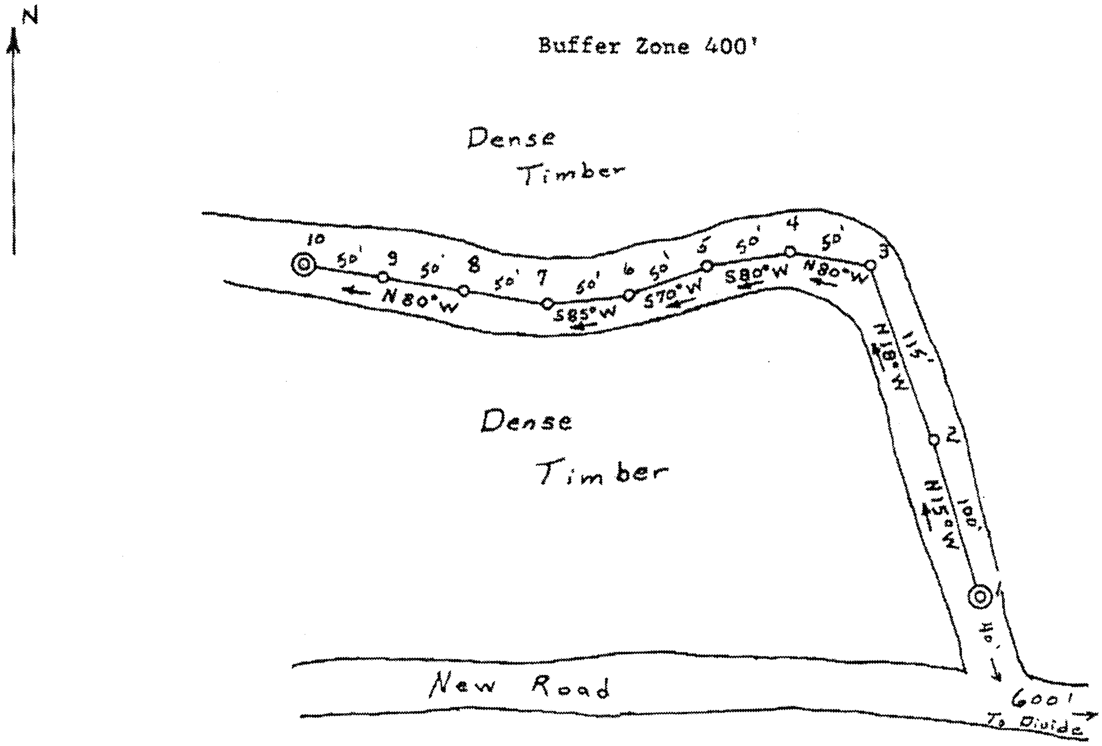
- Fencing—Fencing is used to protect the snow pillows or the entire site from animal or human damage.

A buffer zone is established to protect the SNOTEL site from logging or other activities which could alter the hydrologic characteristics of the site. Typically, a 400 foot zone surrounding the data site is adequate.

Snow Course

A snow course is a pre-selected location where manual snow measurements are taken at certain times during the winter season and used to determine the actual depth and water content of the snowpack. A snow course that is only measured one time during the winter season is referred to as a Basin Index Point. The selection of a snow course is based on elevation, aspect, vegetation, and other hydrologic parameters so that the water-producing areas of the basin are represented. Snow courses typically consist of 5 to 10 individual sample points, but can consist of any number. The course is generally laid out in a straight line with evenly spaced intervals between each sample point. This, however, can also vary from site to site. Some are in a "dog leg" or "L" shape while others may be of some other shape. In short, almost any configuration may be encountered. The spacing between each sample point may vary from a few feet to several hundred feet. Snow course beginning and ending points are generally identified by standard snow course marker signs mounted on steel pipes or trees. Intermediate sampling points may also be identified by markers on trees or posts. If not, the sampling points are located by measuring from the end markers. A typical snow course layout can be found in figure 5.1. A snow surveyor measures the depth and determines the water content at each sample point each time the course is measured. The average depth and water content of all sample points represent a single snow course reading.

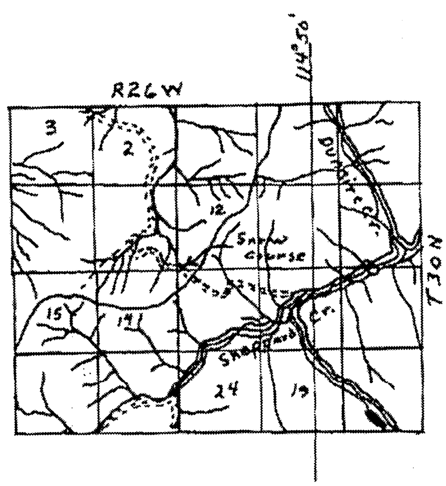
Figure 5.1 Typical Snow Course Map



Mileage Log

Snow Course	-	0.0
Turn off Sheppard Creek Rd.	-	3.2
Sheppard Creek Junction	-	3.3
Star Meadow R. S.	-	9.0
Star Meadow Ranch	-	10.8
Logan Creek S. C. Turnoff	-	13.3
Logan Cr. Campground & Jct.	-	18.4
Kalispell	-	43.4

Kootenai National Forest
Sec. 12; T30N; R26W
Montana Principal Meridian
Lat. 48-22; Long. 114-52
Elevation 5000'
Course Length 565'
Sample Interval As Noted
No. Samples 10
Scale 1" = 100'



MONTANA COOPERATIVE SNOW SURVEYS
BRUSH CREEK (ROAD)
No. 14A04
Columbia River Drainage
Est. 9/2/36 by J.C. Marr
Remarked 8/56 by A.R. Codd & N. Nelson
Relocated 7/14/65 Farnes

Aerial Marker

Aerial markers are used in remote mountainous locations that are difficult to reach by over-snow travel. The criteria for site selection is identical to that of a snow course, with one additional requirement. The marker must be in a position which can be readily observed from the air without undue hazard to the aircraft. The marker consists of a vertical pipe of known height, generally, 3 to 4 feet more than the maximum expected snow depth. Horizontal crossbars are placed at 1-foot intervals on the vertical pipe. Crossbars on the even foot increments (i.e., 2, 4, 6, 8, etc.), are 6 inches wide and 24 to 36 inches long while crossbars on the odd foot increments are 2-inches wide by 12 inches long. An alternative design may have diagonal members in lieu of the smaller crossbars (see figure 5.2). Markers are painted with bright orange enamel paint similar to that used for highway signs so they can be easily seen from the air. Snow depth readings are made by flying over the marker and counting the number of visible crossbars. Refer to METHODS OF MEASUREMENT for more information about making aerial observations.

Precipitation Storage Gage

Precipitation storage gages should be located where they will receive a catch representative of precipitation over the general area. The best sites are in medium-size openings surrounded by trees of sufficient height to block or minimize the effect of wind. The tops of the trees should be high enough to intersect a line drawn from the top of the precipitation gage at an angle of 30 degrees from the horizontal, but not tall enough to intersect a line drawn at 60 degrees from the horizontal. Even deciduous trees will offer some wind protection. A wind shield on the gage also helps. The gage should not be located under overhanging trees, in areas exposed to high velocity winds, on ridge crests, on lee slopes where wind might deposit above normal precipitation, or in any other place that would be non typical. In areas where wind is a factor, a Wyoming wind shield could be used (see figure 5.3).

Precipitation gages may be located at different elevations on a watershed to represent the vertical distribution of precipitation. Some areas do not offer good sites for measuring precipitation. In these cases, obtain the best catch possible.

Descriptive Site Maps

A location map shows the placement of a data site in relation to natural and man-made landmarks in the general area. A location map may be constructed from a U.S. Geological Survey quadrangle, a Forest or Park Service map, a state road map, or any other general area map. The purpose of this map is to document the route and distance that must be traveled to reach the site. Although not a part of the location map, a mileage-log identifying distance and road junctions may accompany the map. Prominent landmarks should be named, a map scale shown, and the title block of the service map should be included.

Figure 5.2 Aerial Marker

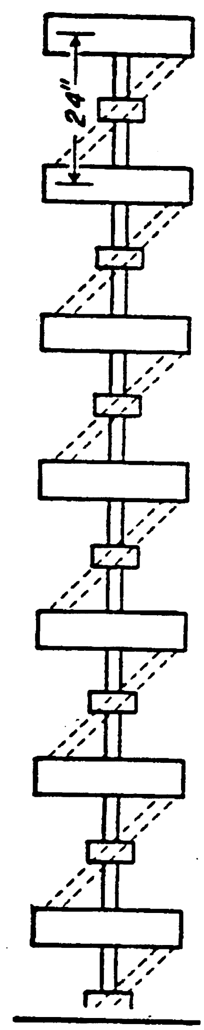


Figure 5.3 Wyoming Windshield

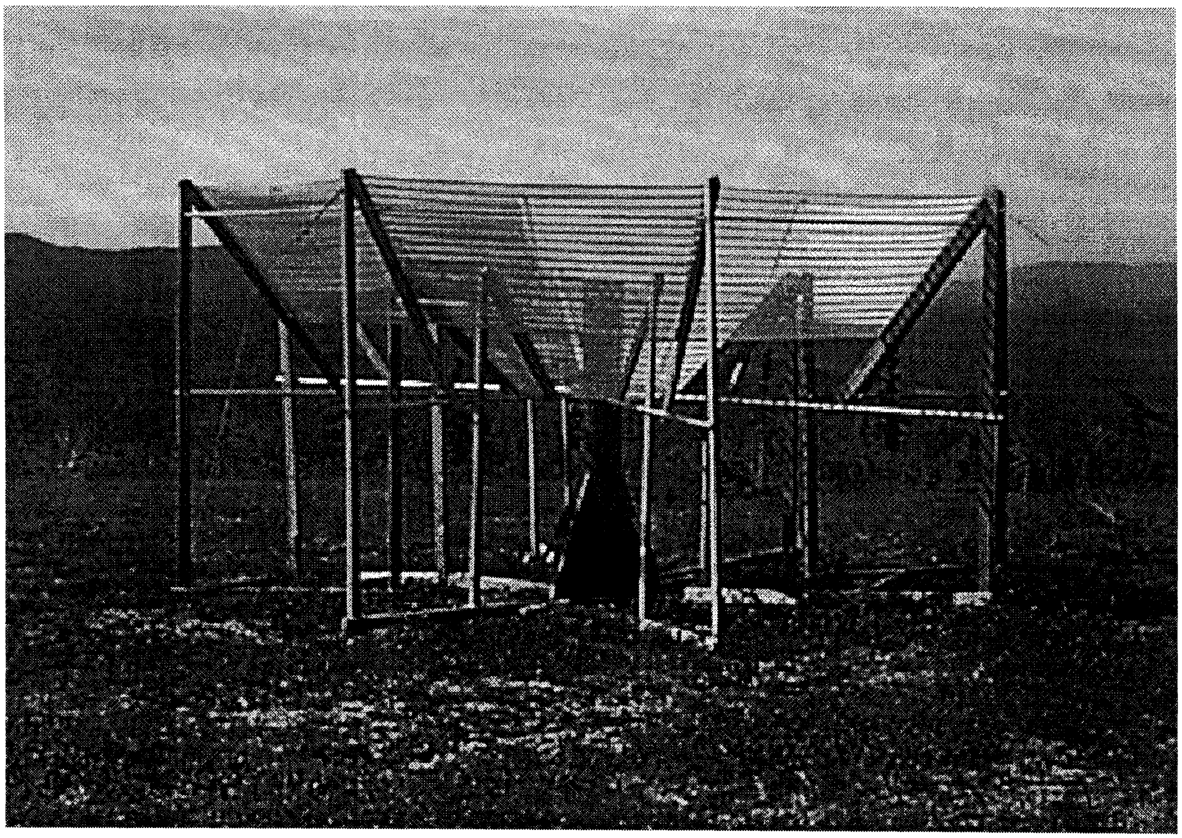
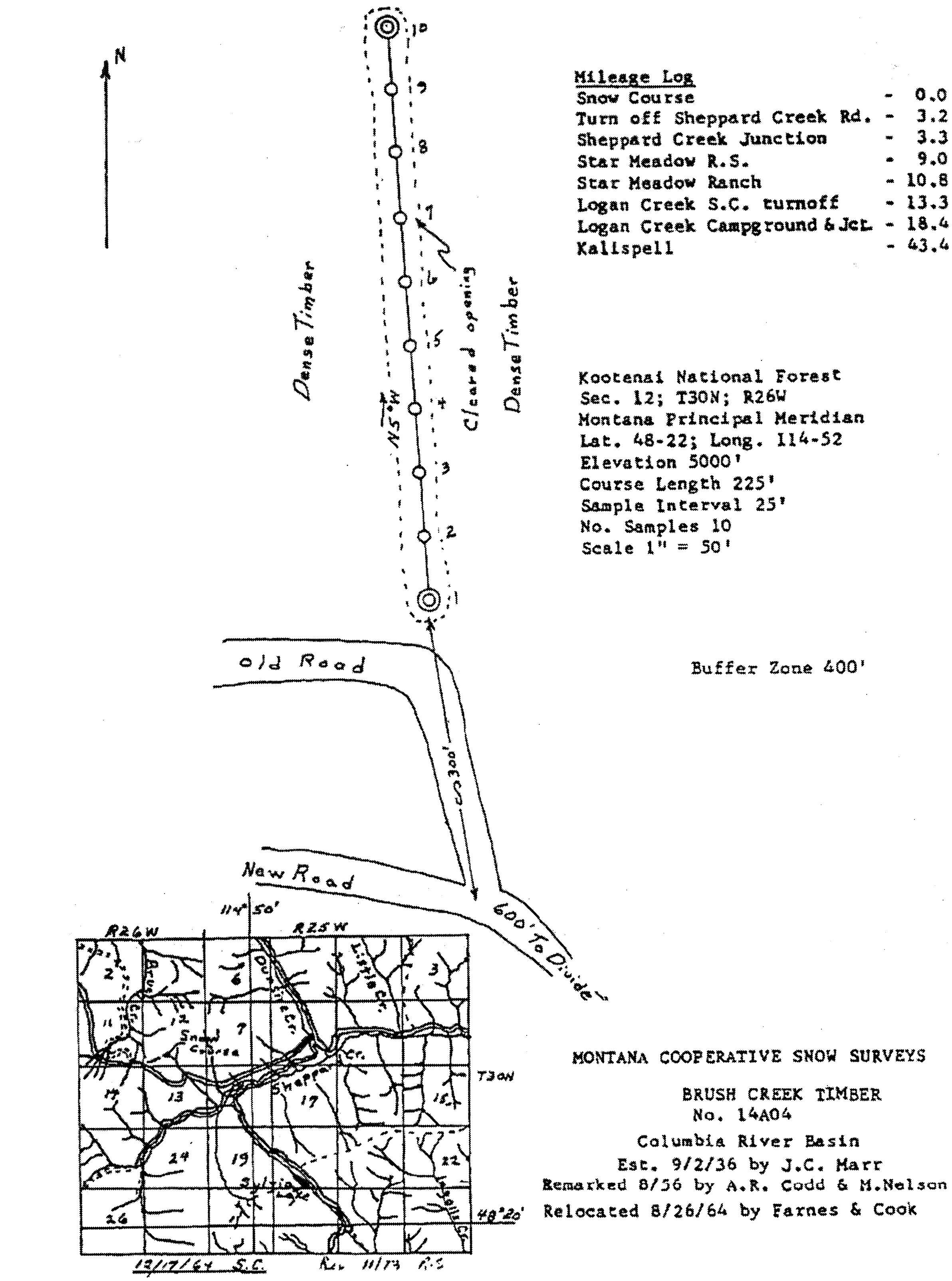


Figure 5.4 Detailed Site Map



Detailed Site Map

Figure 5.4 is an example of a detailed site map. The title block should show:

- Name of site
- Identification number
- Type of site
- Date established
- Location (latitude and longitude; section, range & township)
- Elevation
- Aspect
- Individual who established site
- River basin

The main features of the data site will be shown in symbols with a short word description. The symbols and words used will vary depending on the type of data site being described.

All site maps will have:

- True or magnetic north arrow—labeled.
- Type of vegetative cover on and around the data site.

Snow course, precipitation gage, and aerial marker maps will have the following:

- General bearing of the course in reference to north, preferably with the actual bearing printed along the course.
- Location of end of course signs.

- Location of sample points and their sequence numbers.
- Interval distances between points.
- Number of points identified.
- Prominent natural and man-made landmarks in the immediate vicinity.
- Location of precipitation gages or instruments.
- Location of aerial marker with or without an associated snow course.

SNOTEL site maps will show:

Location, orientation, and distance between all major installation components.

- Pillows
- Shelter house
- Precipitation gage
- Antenna tower and antenna
- Fences
- Any other prominent feature or landmark

SNOTEL sites on snow courses will have a combined map.

Types and General Description of Snow Samplers

The earliest procedures for sampling snow at a snow course involved vertically cutting and withdrawing a core from the natural snow cover with a tube similar to a stovepipe. The volume of snow removed could be computed from pipe dimensions. Its water equivalent was determined by weighing the snow core or, more often, by melting it in a container and measuring the depth of water with a graduated dipstick.

Mt. Rose Sample

To measure deep snow, Dr. J. E. Church developed the Mt. Rose sampler about 1909-1910. His original steel sampler tube was approximately 1.7 inches inside diameter and the inner diameter of the cutter point was 1.5 inches. The tubing was in lengths up to about 10 feet. Later the length of these steel tubes was reduced to 30 inches and several lengths were coupled in the field by threading them together. The tube, with its snow content, was weighed on a specially calibrated Chatillon balance. A tare adjustment for the empty tube simplified the reading of the water equivalent.

Utah Sample

The Mt. Rose snow sampler remained essentially unchanged until George D. Clyde developed the so-called “Utah type” sampler in the late twenties. Clyde used aluminum for the tubes, couplings, and scales. He machined the inside diameter (ID) of the steel saw-toothed cutter to 1.485 inches, thus establishing the weight of 1 inch of water-equivalent snow in the tube at 1 ounce. Any scale weighing in ounces could be used, but Clyde designed a simple tubular, aluminum barrel, spring-actuated scale.

Federal Sample

The Soil Conservation Service (SCS) adopted Clyde’s basic design in 1935 and, with some minor changes, produced the Federal snow sampler now used almost universally in the West and in many foreign countries. The modified snow sampler has tubing made of duraluminum, with an outside diameter (OD) of 1-3/4 inches, an ID of 1-11/16 inches, and is made in sections 30 inches long. Each section has a graduated 1/2 inch interval scale on its side. It has a steel cutter bit that is cold shrunk to fit inside the lower end of the first, lower section. The cutter bit has an inside diameter of 1.485 inches, which is about three-sixteenths of an inch smaller than the inside diameter of the tubing. This difference permits easier sampling and removal of the snow-core. The tube sections are assembled by threaded couplings to lengths of 300 inches or more. The slots spaced alternately along the tube sections are provided for observing the length of core. Snow water equivalent is determined by weighing the tube and its snow core on a tubular spring scale. The weighing cradle holding the snow tubes is attached to a spring clip on the bottom of the tubular scale. The scale come in three sizes, i.e., for snow depths of 12.5 feet, 20 feet, and 30 feet. All scales weigh in ounces. Since the cutter point of the sampler cuts a snow core 1.485 inches in diameter, each ounce of core is equivalent to 1 inch of water. We refer to the weight as inches of water.

Spanner wrenches are used to unscrew the sections that may tighten in place when sampling. The driving wrench is clamped on the tube to drive it into deep, hard, compact snow and to cut through layers of ice. Federal snow sampling specifications are available from the Data Resources and Field Support Team at the National Water and Climate Center (NWCC). Figure 5.5 shows the sampling tubes and other pertinent items usually included in this type of snow sampling set.

The federal sampler tends to over-measure snow water equivalent by 10 to 12 percent with a standard factory cutter bit. If the teeth of the cutter bit are sharpened to the inside, the over-measurement is reduced to about 6 percent.

Bowman Sample

Dr. Charles Bowman, Montana State College, developed a plastic sampler with an improved ice cutting tip. This is an excellent shallow snowpack sampler, but is not presently available.

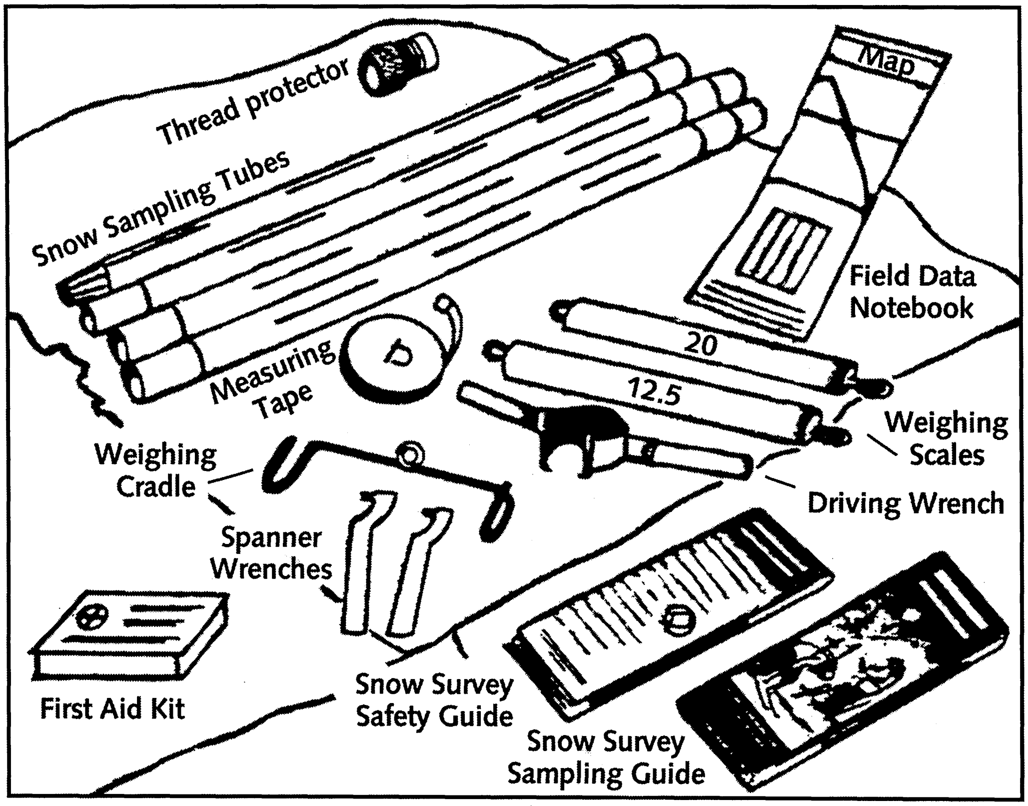
McCall Sample

Another variation of the Federal sampler is the McCall sampler developed primarily for extremely deep snowpacks. This sampler has thick smooth outer walls and internal couplings for added strength and to facilitate easier penetration through the pack. Disadvantages of this sampler are added weight and cores that are often hard to remove. This sampler also requires a special heavy duty scale.

Adirondack Sample

The snows of the northeastern and Midwestern United States rarely attain either the depth or maximum density found in western mountain snowpacks. Thus, a snow sampling device commonly called the Adirondack sampler became popular in the Northeast. This sampler, formerly made of galvanized iron but now constructed of fiberglass or thin wall aluminum tubing, has a smooth sharp cutting point, about 3 inches ID. It is extensively used in the eastern states and Canada. The sampler is 5 feet long and is weighed on a specially calibrated scale.

Figure 5.5 Snow Sampling Kit



Sampling Techniques

Manual Snow Sampling Observations

The most important part of the snow surveyor's mission begins upon arrival at the snow course. The data obtained by sampling will be used by many cooperators and agencies. It is imperative that surveyors do their best to obtain accurate measurements while at the snow course.

General Snow Sampling

Snow sampling is determining the snow depth and amount of water contained in the snow, usually referred to as water content or snow-water equivalent. Sampling equipment includes duraluminum tubes in 30-inch sections, weighing scales, and other items. Snow measurements are made at designated areas called snow courses. Usually, there are 5 to 10 sampling points at a snow course.

Generally, snow sampling is not difficult. People from all walks of life have become good snow surveyors. However, there are some "do's" and "don'ts" which must be observed.

The "Snow Survey Sampling Guide," Agricultural Handbook No. 169, gives detailed steps and illustrations of sampling procedures and the recording of notes. Read it if you are a novice. Review it, periodically, even if you are an experienced snow surveyor. Each snow sampling kit should contain a copy of this guide book. The SCS National Engineering Handbook, Section 22, Snow Survey and Water Supply Forecasting, is also an excellent reference. Each snow surveyor should have a copy of this publication.

Before leaving the office, make sure you have enough SCS-ENG-708 Snow Survey Note forms to complete your surveys. Be sure that your sampling equipment is properly maintained, and that you have all the necessary equipment.

Upon arrival at the snow course, assemble the snow sampling tubes in the correct sequence. Always wear mittens or gloves while handling the sampling tubes. Heat from bare hands will leave a spot where snow can stick to the tube. Use sufficient sections to penetrate the entire snowpack. Be careful when threading the sections together as the threads will seize if they are cross-threaded. The actual weight of the sampling tube must be sufficient to give a scale tare weight above zero. This is usually a minimum of three sections. Do not attempt to measure snow with a zero tare weight. Add a driving wrench or another tube section, if necessary. Wear skis or snowshoes on the snow course even though the snow may be firm enough to support your weight. Holes left by footprints or snow machines will fill with drifting snow which can cause future readings to be inconsistent. Also avoid walking on or near the sample points as much as possible.

If sampling points are not marked on the snow course, use a detailed site map and tape measure to determine the correct sampling point number and distance between samples. Skis, snowshoes, or sampling tubes can be used to measure the distance between sample points in an emergency, but, if possible, use a tape measure. While at the snow course, record data on the field note SCS-ENG-708. Record the correct sampling number for each sample. If the first sample is taken at Station No. 10, be sure to record it on the notes as sampling point No. 10, not No. 1.

When sampling, drive the snow tube vertically between skis or snowshoes to prevent dislocation or back injury. A steady downthrust is the preferable method for obtaining samples. A slight twisting in a clockwise direction aids in driving the tube and also facilitates cutting thin ice crusts. Do not bounce the tube up and down, as excess snow might be introduced into the tube.

When the cutter reaches the ground surface, turn the tube three or four clockwise revolutions to shear the snow-soil bond and to pick up a soil plug. Read the snow depth on the outside of the tube to the nearest 1/2 inch. The notekeeper should record this value on the notes under "snow depth." Withdraw the tube slowly and steadily. Read the core length to the nearest 1/2 inch and report this value to the notekeeper. Ask the notekeeper to repeat each reading as he/she records it to make sure he/she enters the correct values. Depending on the type of snow, the core length should closely approximate the snow depth.

Clean any duff and soil from the cutter. Discard this debris away from the snow course. If it is dropped on the snow course, this material will absorb solar radiation and cause snow pits in the sample areas. If the plug is more than 1/2 inch, adjust snow depth and core lengths for the length of this plug.

Place the tube in the cradle attached to the scale and record the weight of the tube and core to the nearest 1/2 inch of water. Support the scales with a ski pole. If a ski pole is not available, use a firm means of support. Do not hold the scales by hand. Avoid binding the scales. Support the scale only from the ring on top of the scales. Tap the scales slightly when reading to assure that the barrel is free. A 20-foot capacity scale usually has gradations in increments of 2 inches; a 12.5-foot scale usually has 1-inch increments. Empty all snow from the tube and weigh the tube. The difference between the tube and core and the empty tube is the snow-water content. Tare weight should be taken after the first snow sample. Recheck the weight of the empty tube after the fifth and tenth samples are taken. Do this at each snow course even though you think you know what the tare weight should be.

The density of each sample is determined by dividing the snow-water content by the snow depth. The density determination chart, on the green instruction pages in the snow survey notebook, facilitates the computation of density in the field. Another convenient method of computing density is use of a small, inexpensive pocket calculator, but it must be kept warm to function. An inexpensive slide rule may be the best. Density is recorded on the field notes to the nearest percent. Determine the density for each sampling point before leaving the course. Density is calculated by dividing the water content by the snow depth. Normally snow depth and water content will vary between samples, but the densities should remain fairly stable. A good snow surveyor, on a good snow course, can keep the spread from the lowest density sample to the highest density sample within 3 to 5 percent.

Unless unusual conditions are experienced, such as drifting or blowing snow, a spread of 5 percent should be maximum. Any deviation outside this spread requires resampling. If the density remains outside the suggested spread, indicate under "Remarks" the number of samples taken and the possible reason for the samples not falling within the acceptable range.

To obtain the average snow depth and water content of a snow course, add each column and divide each total by the number of samples. Average snow depth is rounded to the nearest inch. The average water content is rounded to the nearest tenth of an inch.

Density for the snow course is determined by dividing the average water content by the average snow depth. **Do not add the individual sample densities and divide by the number of samples.** The density for the snow course should be about the middle of the densities obtained for each sample. If not, an error in addition or averaging of snow depth or water content or in computing density has been made. Recheck to find the error.

Explain under "remarks" any unusual conditions. Remarks are helpful to the snow survey supervisor for interpreting notes. Complete the back side of the snow survey notes. This information provides an evaluation of snowpack and soil conditions not otherwise reported.

Mail the original notes to the Data Collection Office as early as possible. Before transmitting snow survey data to the supervisor, the snow surveyor should recheck the notes for legibility, completeness, remarks, arithmetic, then initial the "computed by" space at the bottom of the form. A copy should be kept by the snow surveyor in case the original notes are lost or delayed in the mail.

Remember, accuracy is very important in all phases of snow surveying.

Shallow Bulk Snow Sampling

Shallow snowpacks require a little different sampling technique. This is explained in the Snow Survey Sampling Guide. When the snow course has less than 2 inches of snow-water equivalent, use bulk sampling procedures. Determine the tare weight by weighing the empty bag or other empty container and the snow tube. Record this tare weight on the snow notes under "weight of empty tube." Read the snow depth and core for each sample just like regular snow sampling and record these values on the snow notes. Place the core from each sample in the bag or container. Make sure you have a good sample and that any foreign material is removed from the cutters before placing the core in the container. Weigh the bag or container of snow cores plus the snow tube, and record the weight on the snow notes under "weight of tube and core." Compute the water content by subtracting the empty weight from the weight of the tube and cores. Divide the water content by the number of samples to determine the average water content. Write "bulk sample" across the snow notes. Figure 5.6 shows the proper technique to record the field notes. Compute the average depth of snow and density and complete the notes as you would for a regular snow survey.

Figure 5.6 Bulk Sampling

United States Department of Agriculture
Soil Conservation Service

SCS-EN-708
12-79

FEDERAL-STATE-PRIVATE
COOPERATIVE SNOW SURVEYS

Snow Course Suicide Park
Drainage Basin Gila State Arizona
Sampler G. Watt Note Taker D. Enz
Date Feb. 15, 1984 Began 11:00 a.m. Ended 11:30 a.m.

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube and Core	Weight of Empty Tube	Water Content Inches	Density Percent	Remarks (See Reverse)
1	2	2					Dry
2	2 1/2	2					
3	6	5					
4	3 1/2	3					G D F
5	2	2					
6	6	5 1/2					
7	8 1/2	7					G D F
8	2	2					
9	3 1/2	2 1/2					
10	5	4 1/2					
	//						
10	41		30.5	18	12.5	30	Total
10	4.1				1.3		Average

Bulk Sample

Deep Dense Snow Sampling

Snowpacks that exceed 100 inches may be difficult to sample if the snow is dense or has ice layers in the pack. The most common problems are snow packing in the cutter prohibiting all of the core from entering the tube and not being able to drive the sampler through the snowpack. Problems develop less frequently with a snow sampling tube that is well waxed or siliconed. Make sure your equipment is in good condition before going to the snow course. Also, if the combined weight of the tube and core exceeds 135 inches, you will need a 20-foot scale.

Many times, good samples can be obtained by keeping the tube moving through the snowpack. Once you start driving the tube down through the pack, don't stop until you get to the bottom. Two surveyors, facing each other, can work together driving the tube hand over hand when the snow sampling is difficult for one person. The addition of a driving wrench will help in some snow conditions. If it is still impossible to get to the ground, drive the tube until it stops, read the depth, and weight the sample like a regular snow sample. Empty the core and carefully insert the tube back into the hole and try to go the remaining distance to the ground. Record the depth and weigh the core. The water content is the sum of the two.

If it is absolutely impossible to obtain a core, continue as far as you can, dump out the core, reenter the hole and repeat until you get to the ground. As a minimum, record the snow depth on each sample so that the water content can be estimated by the snow survey supervisor. If you have trouble getting a good core at the first sample, don't assume all samples are impossible to obtain. Try sampling at each sample point since there may be variations in the snowpack that allow you to get one or more good sample. Also, try different sampling techniques to see if one method is better than another for getting through dense layers.

If you have frequent problems sampling very deep, dense snowpacks, even when you have well waxed or siliconed tubes, a McCall type sampler may help. The McCall is a much heavier sampler, has no external couplings, has a different cutter design, and requires a different scale. However, samples can be obtained with the McCall under some conditions when they cannot be obtained with a standard sampler.

Pounding the tube through dense layers is not recommended since compaction of snow in the cutter prevents the core from entering the tube and the snow sampling tube can be damaged.

If you have problems in the field, check the snow sampling guide. Don't give up until you have tried different methods of sampling. Additional effort at the snow course may save you a trip back up the mountain.

Special Conditions

- Hoar Layer Near Surface—A problem often encountered, particularly in shallow snowpacks, is a depth hoar layer near the ground surface. Depth hoar layers consist of large granular snow grains with little bonding and are formed when very cold snow surface temperatures combine with relatively warm soil temperatures. When taking snow samples, the depth hoar snow layer often collapses or falls out of the tube when lifted-resulting in incomplete or short cores. To obtain a good sample, it may be necessary to plunge the tube rapidly to the ground surface and apply pressure with a clockwise rotation of the tube to ensure a good earth plug is obtained. The rapid plunging of the tube will prevent snow from sluffing away from the tube end. This will result in a better tube core. The earth plug will prevent the depth hoar layer from falling out when the tube is lifted. Remember to remove the earth plug before weighing. The depth hoar layer may still collapse and cores may appear short using this technique, but resulting snow water contents and densities will be higher.

- Snow Freezing in Tube—Another common problem is snow freezing in the tube, preventing the entire core from entering. This most often occurs when air temperatures are above freezing; i.e., the snowpack has not warmed to isothermal conditions.

  — To help avoid this situation, you may wish to plan your-trip to the site in early morning when air temperatures are cooler. Once at the site, cool the tube by setting it in the shade or burying it in the snow before attempting to take snow samples. If the snow freezes in the tube, thoroughly clean the tube of all water droplets and/or snow crystals. Recool the tube and try rapidly pushing it through the snow without stopping until you reach the ground. If you are unable to penetrate the entire snowpack using this procedure, thrust the tube as deeply as possible without stopping. Remove the tube carefully with a minimum of disturbance to the hole. Record the core length and weight. Empty the tube and return it carefully to the bottom of the hole. Again thrust the tube deeper into the snow until it stops or reaches the ground. Repeat this process as many times as necessary to reach the ground.

  — Record the data as shown in figure 5.7 of the notekeeping section. The Snow Survey Sampling Guide also outlines this procedure.

- Snow Tube Too Short—Another less frequently encountered problem is snow tubes being too short for the depth of snow. This situation can be overcome by doing the following. Drive the tube into the snow to its full length. Place a handkerchief or similar object over the top of the tube and dig down around the tube to a depth of about 1 foot. Force the tube down further (see figure 5.8). Remove the wadding and observe the core. When the core reaches the top of the tube, you have reached the limit for this method. The snow depth is the tube length plus the distance from the top of the tube to the snow surface.

— If the snow is too deep to get the whole sample using this method, dig a hole in the snow at the sample point to a depth of 2 or 3 feet. Try sampling in bottom of hole to see if the ground surface can be reached. If not, dig deeper until ground surface is reached. Slide a metal plate or firm flat object into the pit side wall below the top of the grounded sampler. Remove sampler from bottom of pit and take snow sample from snow surface down to the metal plate. Record snow depth, core, and weight of first section of snowpack. Then carefully break off snow into pit down to the metal plate. Complete sample point measurement by taking another sample from the metal plate to the ground. Record the data as shown in figure 5.8. Fill in hole if the course is to be measured again at a later date. This procedure is also outlined in the Snow Survey Sampling Guide.

- Tube Weight Exceeds Scale Capacity—Another infrequently encountered problem is the weight of the tube and core exceeding the capacity of the scales. This problem can be overcome by carefully disassembling the tube into two parts with a minimum of two tubes per section and weighing each one separately. Care must be taken to hold the tube horizontally when disassembling the tubes to prevent losing any portion of the core from the end of the tube. Care must also be take to avoid losing a portion of core at the coupling where the tube is disassembled. Record the total and tare weights of each section. Sum the calculated water contents for each section to obtain the total water content for the sample.

Aerial Marker Observations

Aerial marker observations are made from aircraft and are substitutes for ground measurements. Their use provides accurate snowpack depth information from remote and wilderness sites where oversnow visits to the site are impossible. Pilots contracting this work must be familiar with the terrain and experienced in winter flying in the mountains.

The type or style of aerial marker varies. Some have only horizontal cross bars, alternately long and short, while others have a combination of horizontal and diagonal members. In all cases the center of the members are at one-foot intervals on the pole. Usually wide cross bars are placed horizontally at even foot points and narrow members either horizontally or diagonally at odd foot levels. The height of markers differs according to maximum snow depth (see figure 5.2).

The pilot should approach the site at a slow but safe speed allowing the observer at least two looks at the marker. On the first pass, the observer counts the number of wide cross members and visibility of narrow or diagonal members below lowest wide board and records these observations. The second look allows the observer to estimate and record the distance in inches between the surface of the snow and the bottom of the lowest visible wide cross member (see figure 5.9).

Additional detail is available in Section 22, National Engineering Handbook and on the back of note form SCS-166 rev. 10-64 (figure 5.9).

SNOTEL Theory and Operation

The NRCS has implemented an automated data collection, transmission, and processing system designated SNOTEL. The system transmits the data to a central computer where it is stored, validated, and provided (by computer access) to a variety of cooperating users.

The SNOTEL system now includes nearly 600 remote stations. Each one can be thought of as consisting of two main elements: (1) data collection equipment and (2) communication electronics.

The data collection equipment consists of the sensors and transducers which convert snowpack water content and related conditions into electrical values which eventually can be transmitted. At each of the remote stations, the collection equipment is similar, consisting of a snow pillow, a precipitation gage, a temperature sensor, and corresponding transducers. However, as the system matures and is used by other disciplines, the mix of sensing devices will vary from one installation to another. In response to needs for special hydrologic agricultural and range monitoring data, sensors have been added at some sites to monitor soil temperature, soil moisture, relative humidity, wind speed and direction, solar radiation, pan evaporation, and fuel moisture.

Figure 5.7 Notekeeping When Snow is Freezing in the Tube

United States Department of Agriculture SCS-EN-708
Soil Conservation Service 12-79

FEDERAL-STATE-PRIVATE
COOPERATIVE SNOW SURVEYS

Snow Course Dead Man Creek
Drainage Basin Columbia Willamette State Oregon
Sampler T. George Note Taker M. Vance
Date Apr. 1, 1984 Began 11:00 a.m. Ended a.m./p.m.

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube and Core	Weight of Empty Tube	Water Content Inches	Density Percent	Remarks (See Reverse)
1a	30	29	31 1/2	19	12 1/2	42	GNF
1b	88	88	58	19	39 1/2	45	Damp
1	118	117			52	44	←
2a	38	36	34	19	15	39	GNF
2b	86	85	55	19	36	42	Wet
2	124	121			51	41	←
3a	22	20	28	19	9	41	GNF
3b	89	88	57	19	38	43	Grass Damp
3	111	108			47	42	

Example of note keeping for samples taken in sections.

Totals are found by adding figures in rows 1, 2, 3, etc.

No. of tube sections used. 3
Was driving wrench used? Yes
No. 1 of 3 sheets. Comp. by M.V. Checked by T.G

Figure 5.8 Tubes Too Short For Depth of Snow

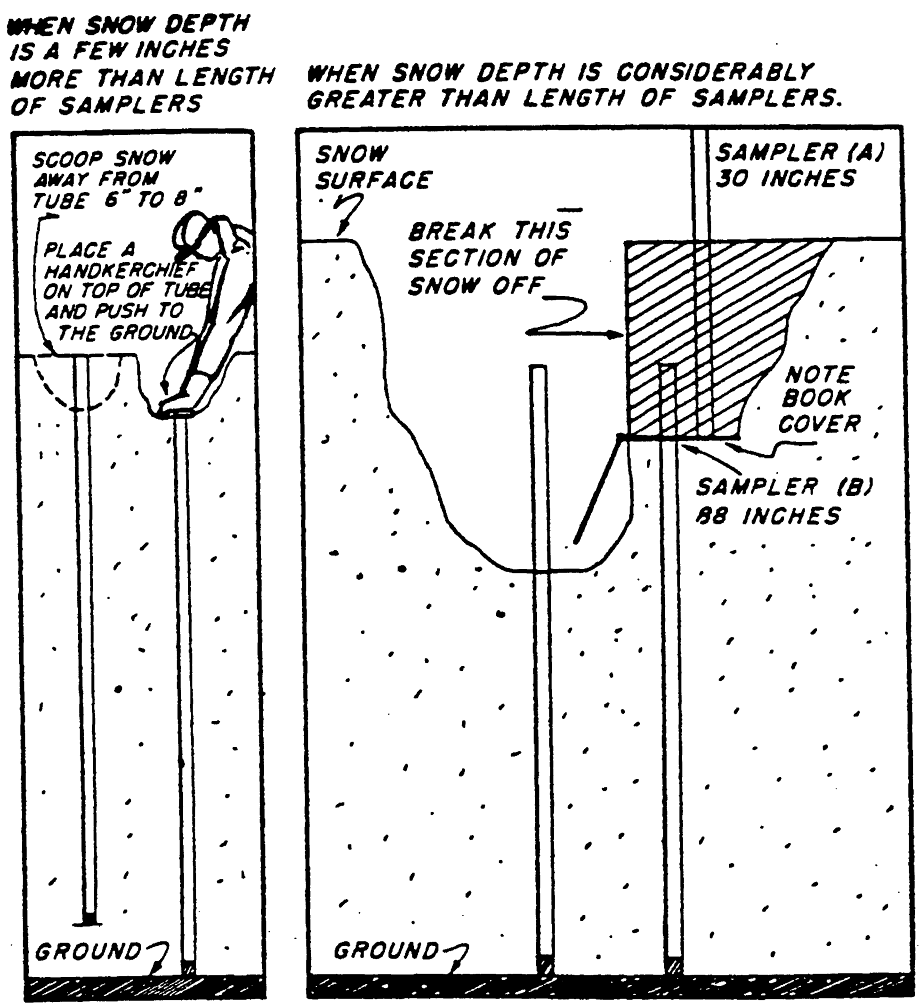


Figure 5.9 Aerial Marker

SCS-166 Rev.
10-64

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FEDERAL - STATE - PRIVATE
COOPERATIVE SNOW SURVEYS

FOR OBSERVERS USE

State: Idaho
Drainage Basin: Boise
Aerial Marker: Trinity Mt.
Observer(s): Jones
Wilson
Date: Feb. 27, 1966

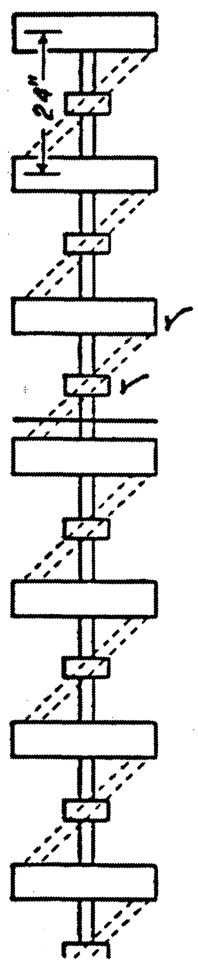
Place a check (✓) on Diagram beside lowest visible wide cross bar
Place a check (✓) beside the next lower narrow cross bar if visible above snow line
Draw line across marker diagram to show snow level
Estimated distance in inches between snow line and bottom of lowest visible cross bar: 3

Flying Conditions:
Smooth ✓ Fair ___ Rough ___

Visibility at Marker:
Good ___ Fair ✓ Poor ___

Weather: Cloudy ✓ Fair ___
Cold ___ Warm ✓ Windy ___
A.M.
Time: 11 ~~P.M.~~

Remarks: Light Fog in marker Area



FOR OFFICE USE

Aerial Marker: Trinity Mt.

Date: Feb. 27, 1966

Marker Height (Inches): 172	Obs. Snow Depth: 105
Conversion Formula:	Corr. Snow Depth:
Reference Snow Course: 97	Density: 103
Density Formula: TM = 98BB-2.0	Computed Density: 29.8

Water Content (Inches): 30.9

Remarks:

Computed by: JAW

Checked by: MWN

The communication electronics at each remote station are housed within the same shelter that contains the pressure transducers and associated plumbing. The electronics package (transceivers) consists of sensor interface electronics, a microprocessor, a VHF radio transmitter and receiver, and a power supply. All are contained in a separate enclosure within the shelter. In most cases, an antenna and one or more solar panels are mounted on a tower adjacent to the shelter (see figure 5.10).

The operation of the remote station is fairly straight forward. Every 15 minutes, or more frequent when necessary (i.e., wind speed), the sensor interface electronics are activated, sensors are sampled, and data are converted to digital format and stored for transmission. This process occurs regardless of when the remote site is polled, so that current data are always available. The microprocessor also prepares daily calculations of data such as averages and maximum and minimum values. The VHF receiver is constantly awake and awaiting the arrival of a polling signal addressed to that remote station. The receiver and control logic are designed to ignore unwanted noise. Even valid signals addressed to other remote stations may be ignored. However, when the receiver logic detects the proper addressing, the transmitter is activated, and the current data (up to 15 minutes old), are transmitted as well as daily calculated values.

The electrical power for the entire remote station is supplied by 12-volt batteries. Solar panels are used to recharge the batteries. The site opening to the sunlight dictates sizing of these components.

One master station in Anchorage controls the SNOTEL network in Alaska and is called Alaska Meteor Burst Communication System (AMBCS). The AMBCS is operated by several agencies. Two master polling stations are used in the lower portion of the western United States to send the required polling signals to the remote stations and to gather the data. The master stations, are located in Boise, Idaho, and Ogden, Utah. Both systems use forward scatter meteor bursts to communicate with the remotes. This technique relies on the fact that individual ionized trails in the upper atmosphere, resulting from the billions of tiny meteors entering the atmosphere daily, actually reflect VHF signals back to earth. Thus, when an ionized trail is present, a radio path may be established between a master station and a remote station more than 1,000 miles away (see figure 5.11). SNOTEL uses those reflective paths in lieu of repeater towers or satellite links to send and receive information.

When the master station is commanded to poll an individual station, for example, a polling signal is continuously transmitted with that station's address. For example, a mountain range may block a VHF signal, since VHF is normally restricted to line-of-sight operation. In such a case, the remote station will not "hear" the signal, and it will not transmit its data. However, when a meteor enters the atmosphere at the right place and at the right angle, the resulting ionized trail reflects the signal down to the remote station (figure 5.12 and 5.13). The remote station recognizes the signal and transmits the current data back to the master station using the same reflective path (figure 5.14). The same technique can be used to poll a group of stations simply by generalizing the address in the polling signal so that more remote stations will respond. When a master station needs to poll a large number of remotes, it may poll a hundred or more at one time; however, they will answer one-by-one because of the selective nature of the meteor trail paths. The master stations keep track as the remotes-respond until all have reported or the polling period runs out. The master station stores the incoming remote sites data and forwards it to the central computer at the National Water and Climate Center (NWCC) via dedicated telephone lines. AMBCS master station acts like the central computer and the various agencies call into the master station to obtain the remote's information.

The central computer for SNOTEL is located within the NWCC in Portland, Oregon. This computer issues commands to both master stations. This causes the master stations to poll individual remotes or groups of remotes. The central computer also commands the master stations to forward their data to the central computer for validation and dissemination to SNOTEL users. These commands are issued for two modes of operation. The first mode involves polling all remote stations in the system on a periodic basis, normally once or twice a day. The second mode involves special polling of selected remotes, as commanded by users themselves. An authorized individual SNOTEL user may request that a remote station be polled on a special one-time-only basis, or the user may request that a station or group of stations be polled on a special schedule, e.g., eight times per day. The central computer complies automatically to these requests, issues the proper commands (at the proper times) to the master stations, then collects the resulting data from them. The computer provides a variety of reports to users who request them, allowing individual users to define which data are to be included in a particular report. In all cases, the central computer validates the incoming data, verifying that certain minimum data criteria are met.

Figure 5.10 Typical SNOTEL Site Configuration

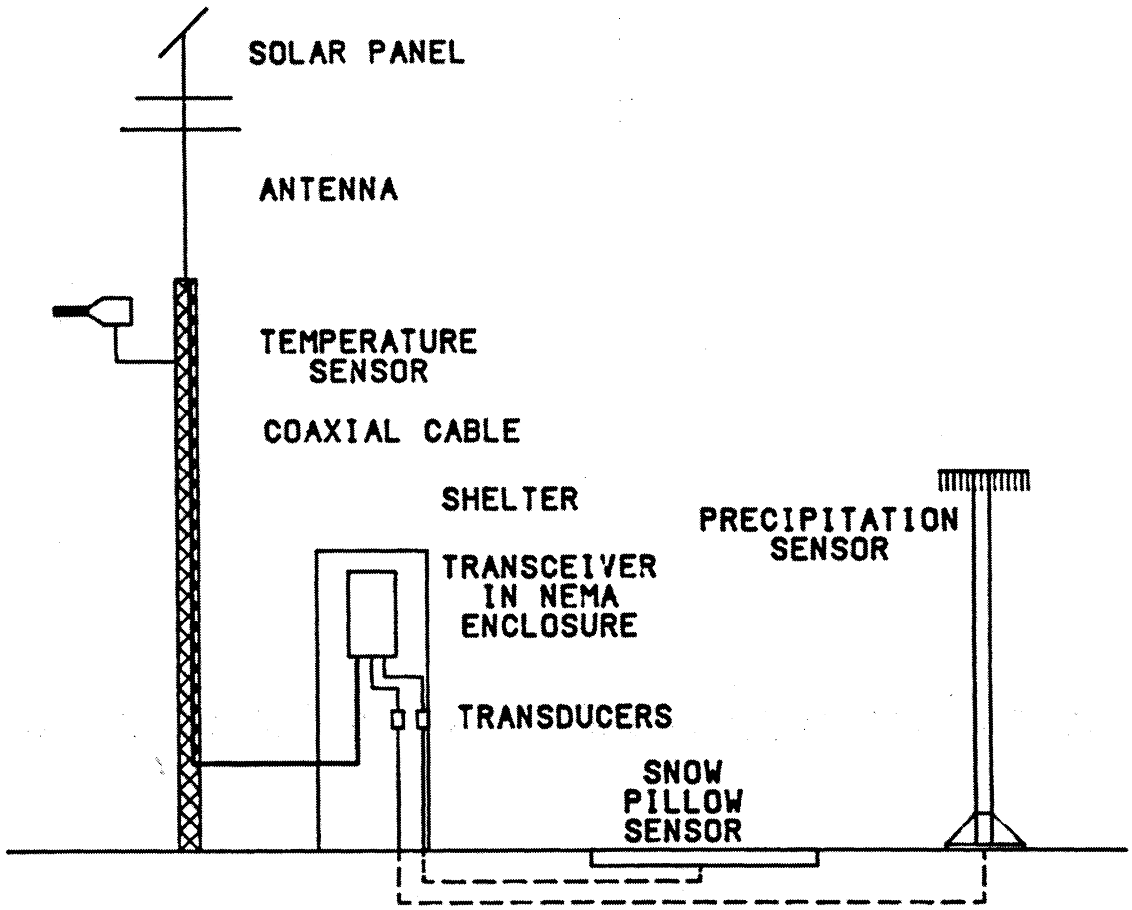


Figure 5.11 Geographical Extent of the SNOTEL System

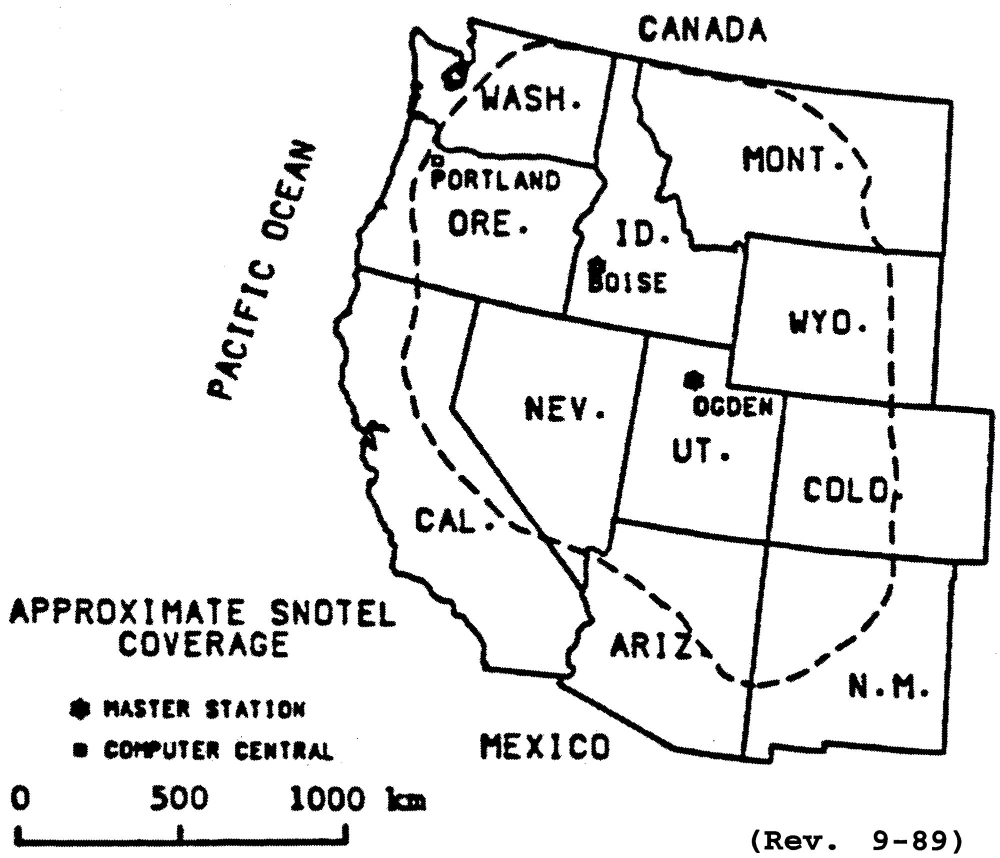


Figure 5.12 Master Station Probe is Usually Obstructed

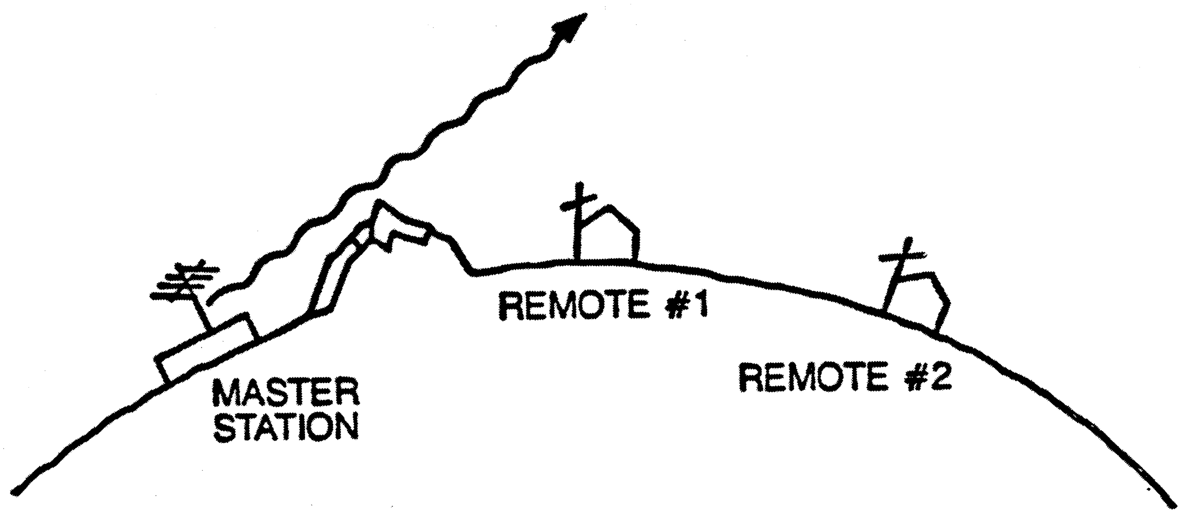


Figure 5.13 Reflection from Ionized Meteor Trail Allows Reception of Probe by a Single Remote

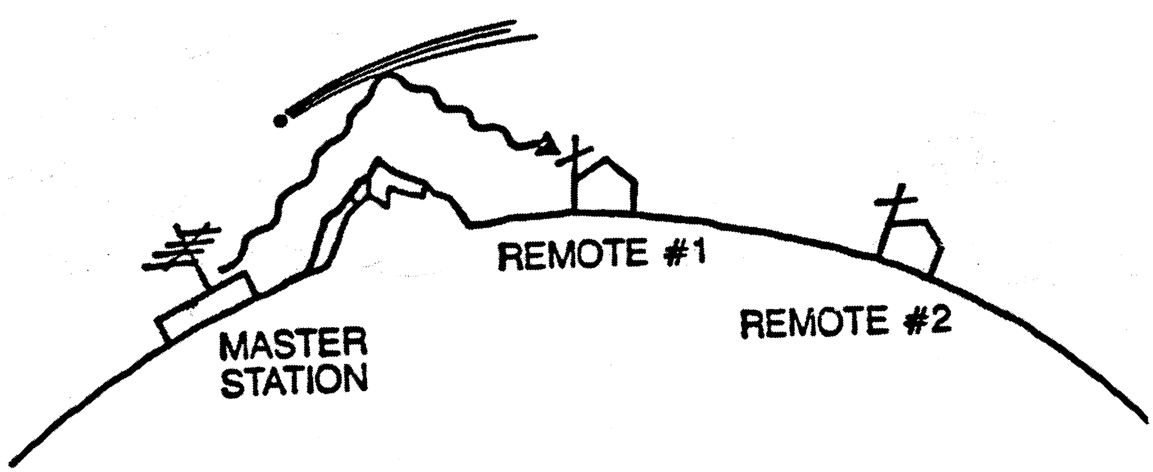
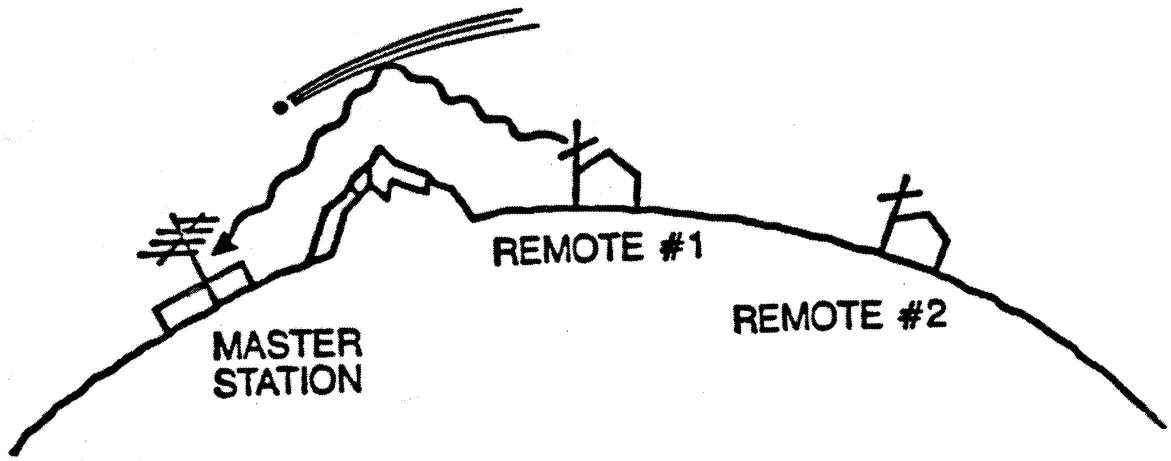


Figure 5.14 The Same Ionized Trail is Used for the Return of Data



The SNOTEL users themselves gain access to the system using remote computer terminals. These terminals connect directly with the central computer in Portland via dial-up telephone lines. Additional computer access is available through the Data General, MU8000 mini computer. This computer system is the main point of user access for all types of hydrometeorological information and analysis. This system is called the Centralized Forecast System (CFS) and is also located at the NWCC in Portland, Oregon. This means users may tie into the SNOTEL system from any location that has a telephone. Presently, remote terminals afford access to the system by all NRCS state offices and many field offices in the West. Other agencies and private cooperators also have access to a variety of information. The actual number of users is growing as the system grows, and as the community of data users increases.

Once a user has remote terminal access, the SNOTEL database may be interrogated and data reports and analyses may be received almost immediately. Furthermore, if a user has the authority to actually poll a given remote station, a command can be entered which will cause that station to be polled. Because of limited remote station power supplies, such polling must be controlled to some extent, and the authority to poll will be restricted to certain individuals.

The central computer automatically loads each days data into an accumulation database for further analysis, editing, and user requests.

SNOTEL Observations

Although SNOTEL sensors have proven to be reliable, there are many conditions which can affect the accuracy of readings. Snowpack bridging, downhill creep, precipitation gage plugging, electronic malfunction, vandalism, or air locks in the plumbing lines are just a few of the more common factors which can affect data accuracy. Onsite observations are made at the SNOTEL sites as often as practical to ensure that the Data Collection Office (DCO) can evaluate accuracy of telemetered sensor data. At a minimum, manual observations should be made each time a snow survey is conducted or a maintenance visit is made to the site.

- Groundtruth

  — Manometer: Check to see that manometer valves are opened and fluid levels are stabilized before taking readings. Valves that were closed must again be closed so that manometers do not overtop before the next recharging date.

  — Snow Pillow Groundtruth Observation: During maintenance or recharge activities on the snow pillow or precipitation gage, allow maximum time after disturbance to either of these sensor's fluid levels before final readings are taken.

  In general, four (4) manual snow tube samples are taken around the snow pillows (ground truths) on each visit, one near each corner of the pillow array. These samples should be taken on the pillow pad near the pillows. The exact location to take these samples are specified by marker poles at the site, detail site maps, or local policy of DCO/WSS. Surveyors should use caution and not sample directly over the pillow, as the cutter tip can easily puncture the pillow. If you are not sure of the exact pillow location and the sample points are not clearly marked, allow a margin of safety in selecting your sampling point and drive the sampling tube slowly into the snowpack using light pressure. Otherwise, the standard techniques, as explained for snow course sampling (Ag. Eng. Handbook No. 169) all apply to these ground truth samples.

  Reading the manometers is accomplished by noting the fluid level in the clear tubing inside the shelter house. Using a straight edge held horizontally across the lowest point of the curved top surface of the fluid (meniscus) and the tape measure, read the scale to smallest discernible unit, i.e., 1/16 or 1/10 of an inch. The observer must keep his/her line of sight at the manometer horizontal for the most accurate readings. A layer of oil may rest on the top of the fluid level in some manometers. If so, take your reading at the top of this uppermost layer (see figure 5.15).

Use a flashlight if extra light is required to discern actual fluid level in a dark shelter. Do not use a match for illumination as there is a remote possibility that flammable gases may be present. Report dirty or unreadable manometer tubes or tape scales to the DCO.

— Thermometer: when observing the data from a thermometer at the site, follow local policy as to where the data is taken, e.g., in shelter, out of shelter, etc. Reset the maximum/minimum pointers after reading. Take note of Centigrade or Fahrenheit scales.

Precipitation Gage

Precipitation storage gages of various types have been used to measure precipitation for many years. The amount of precipitation is determined by the volume or the weight of the catch. Determination of the weight is usually the preferred method.

Gages used in snow zone areas are placed in towers or have a tall enough body height to reach above the deepest expected snow depth. Precipitation gages can be categorized as nonrecording or recording.

Nonrecording gages are the storage type. The SNOTEL standard orifice is 12 inches in diameter, but gages of other diameters are used. The depth of the gage can vary depending on the amount of precipitation the gage is expected to hold. This, in turn, is related to the normal amount of precipitation a station receives and the frequency of manual observation. The storage gage must be emptied and recharged when it becomes full.

Precipitation in nonrecording gages can be measured using a calibrated dipstick to read the depth of the catch. Changes in the liquid depth relate to the amount of precipitation received. Precipitation in nonrecording gages also can be measured by weighing the gage on a calibrated scale that reads directly in inches of water weight. Precipitation catch can be read by the use of manometer tubes with associated scales.

Recording precipitation gages may be a storage-type gage, or a nonstorage-type gage, such as a tipping bucket. The precipitation catch is recorded as a pen trace on a strip or drum chart; as numbers on a paper tape; or on a punched paper tape. Modern technology allows recording of precipitation data on electronic data loggers.

Precipitation values can be transmitted by telemetry such as SNOTEL. The standard SNOTEL precipitation gage is a storage type missile gage 12 inches in diameter, 6 to 26 feet tall, and uses a pressure transducer to measure the weight of the accumulated catch.

All precipitation storage gages must be drained and recharged, periodically. The standard recharge fluid is glycometh, which is 40 percent ethylene glycol and 60 percent methyl alcohol. The amount of glycometh added depends on the amount of precipitation catch expected and the degree of freezing expected. An oil float, one-fourth to one-half inch deep, is added to the recharge mixture to control evaporation loss.

Notekeeping

The West-wide Snow Survey Training School was designed to teach you to travel into the mountains, take snow measurements, and return safely. If you don't keep accurate, legible notes of snow measurements, the trip will have been a total waste of time and money.

Manual Snow Course Notes: SCS-ENG-708

Data is entered on SCS-ENG-708 note pads. These forms have been designed specifically for snow surveys and, if used properly, make the notekeeping procedure much simpler. The front and back of this form contain simplified directions which explain how to record results and can be seen in figure 5.16. A chart is included for determining sample densities. Read this portion carefully. More detailed guidelines are available in the USDA Engineering Handbook No. 169, "Snow Survey Sampling Guide."

Before beginning the survey, fill in the heading on the notes. Use a soft lead pencil. Fill in all the blanks and use the full name of the snow course. Record both the snow depth, length of core, and weight of tube with core to the nearest 1/2 inch. Your DCO supervisor or WSS will advise you if you should use a different procedure.

When a sample is taken, the sample point number, snow depth, and length of core are recorded. Normally, the core length should be at least 90 percent of the snow depth. The weight of tube and core is recorded next. When the weight of the empty tube is subtracted from the tube and core, the remainder is the water content. By dividing this figure by the depth of the snow, the density for that sample can be determined. Figure the density at the time the notes are taken. Density should not vary more than 5 percent between samples. If it does, take another sample. It is too late to resample after returning to the office.

A sample that is determined to be questionable should be retaken. If sample number 3 is retaken, label it 3A. Draw a line through the erroneous data when a more accurate sample is recorded (see figure 5.17). If a sample point is bare, do not leave that line blank on the notes. Enter 'O" readings in the appropriate locations because they are valid readings and are used in the final computations. When a number needs to be changed, cross it out and start over. The front side of a completed 708 should look like figure 5.18.

When all the samples have been taken and you are satisfied that the notes are accurate, complete the back of the form. The remarks portion at the bottom is for your use. Explain any problems you encountered while measuring the snow course. If you need more note pads or have equipment failures, write it down. Don't wait until you are ready to begin the surveys next month.

In the spring, some snow courses will be entirely bare when you go out to read them. Fill out a set of notes and send them in. It is a legitimate measurement and may be used in forecasting.

Figure 5.15 Reading the Manometer Meniscus

Manometers

Read at bottom of miniscus

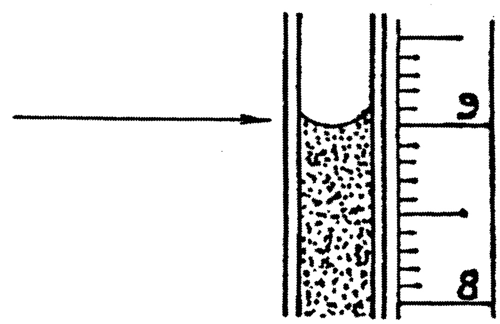


Figure 5.16 Page From SCS-ENG-708 Note Form

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-ENG-708
3-86

FEDERAL-STATE-PRIVATE COOPERATIVE SNOW SURVEYS

Snow Course ______________________________

Drainage Basin ______________ State ______________

Sampler ______________ Note Taker ______________

Date ______________ Began ____ a.m. p.m. Ended ____ a.m. p.m.

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube and Core	Weight of Empty Tube	Water Content Inches	Density Percent	Remarks (See reverse)

No. of tube sections used. ______________________

Was driving wrench used? ______________________

No. ____ of ____ sheets. Comp. by ______ Checked by ________

NOTE. - Please fill in while in the field.

SAMPLING CONDITIONS

(Please check items descriptive of present conditions)

Weather at Time of Sampling

___ Clear, ____ Partly cloudy, ______ Overcast, ____ Rainin

___ Snowing, ____ Blowing, ____ Freezing, ______ Thawing.

Snow Conditions at Snow Course

Snow samples obtained with ____ ease, ______ moderate difficulty.

Snow samples obtained with ______ extreme difficulty.*

Ground under snow: ______ frozen, ________ not frozen,

______ dry, ________ damp, ________ wet (saturated)

Ice layer on ground _____ How thick? ______ inches.

How many inches of new snow at snow course? ________ inches.

Depth to first snow crust ______ inches.

Are there ice layers in snow pack? Yes ____ No ______

If yes, show depth from surface ______________ inches

General Conditions

Snow on ground at Hdqtrs. office ________ inches. ________

Name of Hdqtrs. office ______________

____

Air temperature (if known) ______________________

If at aerial marker, record snow depth ____________ inches

*Explain fully under remarks

PRECIPITATION DATA

Month	Day	Year	Precipitation	Readings	Reading Made by (check)	Dipstick	Weight
			Current				
			Previous				
Station name			Catch, inches		Scale adjusted to zero		
			After recharge		___ Yes ___ No		

Remarks: ______________________________

____

____

____

____

____

____

____

____

____

____

____

Figure 5.17 Resampling

SCS-ENG-708
Rev. 12-74
File Code ENG-21

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FEDERAL-STATE-PRIVATE
COOPERATIVE SNOW SURVEYS

Snow Course SHOWER FALLS

Drainage Basin MISSOURI State MONTANA

Sampler HUFFMAN Note Taker HERRING

Date 3-28-79 Began 1:15 P.M. Ended 1:30 P.M.

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube and Core	Weight of Empty Tube	Water Content Inches	Density Percent	Remarks (See reverse)
1	60	58	32	10	22	37	
2	56	55	30	10	20	36	
~~3~~	~~57~~	~~45~~	~~24~~	~~10~~	~~14~~	~~25~~	
3A	57	55	30½	10	20½	36	

No. of tube sections used.

Was driving wrench used?

No. of sheets. Comp. by Checked by

(Rev. 9-89)

Figure 5.18 Completed Snow Course Note

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-EN-706
12-79

FEDERAL-STATE-PRIVATE
COOPERATIVE SNOW SURVEYS

Snow Course *Blizzard Ridge*

Drainage Basin *Missouri-Gallatin* State *Montana*

Sampler *G. Clagett* Note Taker *P.E. Farnes*

Date *Feb. 28, 1984* Began *1:00* p.m. Ended *2:35* p.m.

Sample Number	Depth of Snow Inches	Length of Core Inches	Weight of Tube and Core	Weight of Empty Tube	Water Content Inches	Density Percent	Remarks (See reverse)
1	94	92	62½	35	27½	29	GNF Damp
2	91	89	62		27	30	
3	92	86	62		27	29	
4	85½	79	60½		25½	30	
5	87	82½	60½	35	25½	29	Dry Soil
6	87	82	61½		26½	30	
7	83½	79	59		24	29	
8	84½	81½	60		25	30	Needles
9	85	76	80½	56	24½	29	
10	79½	71½	78½	56	22½	28	2 samples
(10)	869				255	29	Total
(10)	86.9				25.5		Average

No. of tube sections used. *4*

Was driving wrench used? *Yes, on samples 9 and 10.*

No. *1* of *1* sheets. Comp. by *P.E.F.* Checked by *G.C.*

(Rev. 9-89)

It is important that the snow note information reach the DCO supervisor as soon as possible after the readings are taken. When you get back to the office, make a copy for your files and mail the original to the Snow Survey Unit. Sometimes you may be required to enter the data results directly into the database in Portland, via composer and modem. If conditions are such that you cannot finish the entries and still get the notes to the DCO by mail before the first of the month; telephone the information to the DCO as soon as you get back. Then mail the notes.

The accuracy with which the data was recorded is as important as the care taken to obtain and weigh the samples. The data is used by many federal, state, and private concerns. The more reliable the data, the more confidence others will have in our work. Taking time to do the job right in the field makes it easier for those using your data to turn out quality work.

Aerial Marker Notekeeping

Enter all information requested at the top of the form. Mark the diagram of the marker to indicate the lowest wide cross-arm and the small cross-arm position visible above the snow pack. Enter an estimate, in inches, of the vertical distance from snow surface to the bottom of the lowest bar. Draw a line or place a check mark across the diagram to indicate the observed snow line.

Enter information as to flying conditions, visibility, weather, and time in appropriate spaces. Unusual conditions should be noted under remarks (refer to figure 5.19). Snow depth, water content, etc., for which space is provided, will be computed and entered in the Snow Survey Supervisor's (SSS) office. For more detailed information refer to Section 22, NEH, Form SCS-166-Rev.

SNOTEL Notekeeping

The SNOTEL Data form is used for recording all pertinent information while visiting a SNOTEL site. In some cases, the pad of SNOTEL Data Site forms remains at the site for storage and maintains a copy of the previous data recordings using carbonless paper. This operation varies by DCO.

Begin by filling out the heading information (see figure 5.19) completely. Fluid level in the manometer tube labeled "precipitation" is the next entry and should be recorded in the "current" block. Remember to specify inches (in) or centimeters (cm). Write firmly to produce legible NCR copy on the second page of the form. The new manometer level following a recharge of the gage should be recorded in the "recharge" block and the number of gallons used in the "gallons" block. All readings should be recorded to the smallest discernible unit of the scale beside the manometer tubing. Be certain to identify readings as labeled when more than one manometer tube reading is taken. In some cases two snow pillow sensors are present, as well as two precipitation gages.

The snow pillow manometer fluid level is recorded in the first empty block under "inches/cm". This value should be accurate to the smallest discernible unit of the manometer scale. Complete this portion of the form at each visit even in periods of no snow. The other calculations which could apply at the current readings in the precipitation and snow pillow data section of the SNOTEL forms will be done at the DCO/WSS offices, unless specified.

Snow samples near the pillow are obtained and recorded in this section providing another form of snow sensor performance verification. Recording of the manually sampled snow pack at the designated points around the pillow is done exactly as if it were another snow course with four samples. Enter the data on the line that you number or identify according to the location of the sample point. Determine the snow water equivalent and density of each sample. Record and calculate this information for additional samples, if needed, to bring the samples within 5 percent density of each other. Calculate and record the average depth, water content, and density values on the bottommost lines of this section. For comparison purposes, data from a nearby snow course may be entered in the next three blocks. Air temperature readings are to be entered in degrees F or C (see figure 5.19).

It is important to enter any information about WEATHER/ SNOWPACK conditions or other REMARKS/SITE CONDITION information that will be helpful to the DCO/WSS in evaluation of the sampling report and in diagnosing site maintenance needs. If the site has nonstandard sensors, ask your DCO what information is needed to ensure that performance data accuracy can be evaluated, since much of this form needs to be completed at each visit. Forward the original data sheets to your DCO immediately after the site visit, if possible. Retain a copy of the data in your office in case the originals are lost in the mail.

Storage Precipitation Gage Notekeeping

Storage precipitation gages should have the field observations recorded on the form SCS-ENG-2 (see figure 5.20), with the exception of SNOTEL manometers. This applies to nonrecording and recording storage gages. SCS-ENG-2 should be completed filling in all header information, station name, state, drainage basin, and observer.

The precipitation gage reading and date are entered next to "current." The "previous" reading from the last observation should be filled in before leaving the office so the "catch" can be calculated in the field. If a scale is used to measure the precipitation, no additional comments are needed. If a dipstick is used, the word "dipstick" should be written on the notes. The "catch" value should seem reasonable.

If the precipitation gage needs to be recharged, the new weight or dipstick depth should be written next to "after recharge."

For very tall precipitation gages that may only be measured and recharged once a year, the catch may have to be weighed a little at a time. This series of weights should be entered in the table found in the middle of SCS-ENG-2 under "current weigh-out readings." Recharge of these gages should be recorded at the bottom of SCS-ENG-2 under "recharge readings."

The data on the back of SCS-ENG-2 should be filled in as completely as possible (see figure 5.21).

Figure 5.19 SNOTEL Data Form

SNOTEL DATA

Site Name Wolf Creek Summit State Colorado
Date 4/27/89 Time 10:40 A.M.
Observer Schaefer/Helseth

Precipitation Gage

DATA	Shelter Manometer (Inches/Cm)				
Current	52.3 in				
Previous Reading	50.3 in	Date	4/3/89		
Catch	2.0				
Recharge	10.8 in	S.G.	0.765	Gallons	5

Snow Pillow

Manometer Readings Inches/Cm	Zero Level	Net	Specific Gravity of Pillow Fluid	Snow Water Content (in)	Pillow Type
40.5	5.5	34.0	.975	33.2	Metal

Snow Samples Near Pillow

Sample Number	Snow Depth (in)	Length of Core (in)	Weight of Tube & Core (in)	Wt. of Empty Tube (in)	Water Content (in)	Density Percent	Remarks
1	92	89	70	35	35	38	GNF
2	90	87	69	35	34	38	
3	90	87	69	35	34	38	
4	91	87	69	35	34	37	
Total	363				137		
Average	91				34.2	38	
Snow Course	89				34	38	

Air Temperature (°F/ °C)
Current 28 Maximum 38 Minimum 10

Weather/Snowpack Conditions ______________________

Remarks/Site Conditions ______________________

(Rev. 9-89)

Figure 5.20 Precipitation Data

[illegible]
3-71
File Code [illegible]G-21

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Federal and State Cooperative Snow Surveys

PRECIPITATION DATA

Precipitation Station ______________________________

State ____________ Drainage Basin ____________

Observer

Month	Day	Year	Precipitation	Readings
			Current	
			Previous	
Please check-			Catch, inches	
Readings include:			After recharge	

Gage plus solution weight ________ Scale adjusted to zero___ Yes ___ No

Solution weight only ________ If no, scale reading was ________

CURRENT WEIGH-OUT READINGS

Auxiliary Bucket No.	Solution plus Aux. Bucket (1)	Empty Auxiliary Bucket (2)	Net Solution Weight (1)-(2)	Remarks
				on weigh out, read bucket weight before filling with solution.
1				
2				
3				
4				
5				
6				
7				
8				
Total solution weight				
Weight, removable gage				
Total weight				

RECHARGE READINGS

1				on recharge, read bucket
2				weight after emptying
3				into gage.
4				
Total solution weight				

No. ______ of ______ Sheets Compiled by: ________ Checked by: ________

(Rev. 9-89)

Figure 5.21

Note.-Please fill in while in the field. Check items as appropriate.

Time ________ am / pm

Weather and Snow Conditions

________ Clear, ________ Partly cloudy, ________ Overcast, ________ Raining,

________ Snowing, ________ Blowing, ________ Freezing, ________ Thawing,

Snow line elevation ________ ft. Inches of new snow ________ in.

Snow depth on ground ________ in. Water content ________ in.

Type anti-freeze used		Recommended initial charge ratio:
Glycometh	________	40% glycol, 60% methanol
Ethylene glycol-- (Prestone)	________	1 gallon glycol to 1 pt. or 1 qt. water
Calcium chloride	________	3.75" salt + 6.25" water-weight on precip scales.
Other	________	

Antifreeze charging quantities

Gages with 8" orifices:

Glycol-

Final freeze temp. approx. 5°F.-1 gallon glycol (plus 1 qt. water) per ea. 10" precip.

Final freeze temp. approx. 23°F.- 1 gallon glycol (plus 1 qt. water) per ea. 30" precip.

Glycometh-

Final freeze temp. approx. -4°F.- 1 gallon solution for ea. 10" precip.

Final freeze temp. approx. 24°F.- 1 gallon solution for ea. 30" precip.

Gages with 12" orifices - 2.25 gallons of glycol or glycometh for each condition.

Oil Film - Amount of oil to produce film approx. 0.15 to 0.20 inches thick to prevent evaporation in precipitation gages having storage section diameters as shown: With Glycometh add one-third to quantities shown.

Diameter, Inches	8	12	16	20	24	30
Oil in liquid ounces	6	12	24	36	54	84

Type Oil

Oils having SUC ratings near 70-100, pour point of -40°F or lower.
Examples-Refrigerant oils such as Texaco's Capella AA; Standard's Rycon #11.

Check Measurement - Tape or stick distance from gage orifice to liquid surface

Before weigh-out ________ inches; After Recharge ________ inches.

Test Load - Current Weight ________ inches: Base Weight ________ inches.

Remarks: ________

____

____

____

____

(Rev. 9-89)

Importance of Accuracy

It is vitally important that the most accurate data possible be obtained from your data collection efforts. The data collected will be used by many different agencies and groups for a multitude of applications. Probably the single, most important, use of snow survey data is water supply forecasting and, while accurate forecasts depend on many factors, they begin with accurate data. To illustrate the importance of data accuracy for forecast purposes, lets assume the seasonal volume forecast equation for a hypothetical forecast point is as follows:

$$Y = 8.65 + 1251X_1 + 26.30X_2 + 40.45X_3$$

Where,

Y seasonal volume runoff in 1000's acre-feet

X_1 basin soil moisture index

X_2 spring precipitation index

X_3 winter snow water index

Let's also assume that X_3, the winter snow index, is simply the water content (in inches) measured at one or more snow courses in the basin. In this example, it is easy to see that a one-inch error in a snow course reading would result in a forecast error of over 40,000 acre-feet. Based on the erroneous forecast, water managers would make improper management decisions, releasing too much water from reservoir systems, and that volume of water could be lost to irrigators.

Economic Effects of Data Collection Error

For simplicity, lets further assume the economic value of this water is $50 per acre-foot, which is conservative in today's economy. Using these figures, this translates into over $2 million (40,000 acre-feet x $50 per acre-foot) in economic loss to the agricultural sector alone and does not account for other major losses such as hydro power.

There are approximately 20 million acres of irrigated land in the West, of which about 12 million benefit directly from streamflow forecasts. The economic benefits to irrigated agriculture alone amounts to tens of millions, annually.

In the above example, the snow course error resulted in a substantial forecast error and economic loss for that single forecast year or period. Such errors can also effect future forecasts, as well. If left undetected, the erroneous snow course reading would be archived in the historical database. This data could then be incorporated in the development of future forecast equations, resulting in less accurate and reliable forecast procedures.

Summary

The key to data collection is, and always will be, accuracy. This is true whether the data is manually collected or collected by SNOTEL.

In order to collect accurate data, surveyors must be thoroughly trained in their jobs. They need to know their sites, samplers, and sampling techniques, precipitation gages and, above all, notekeeping procedures.

Chapter 6—Preparedness

Objectives

Upon completion of this lesson, participants will be able to:

- Explain the importance of being in good physical condition.
- Dress to meet specific conditions and assemble needed equipment and survival gear.
- Effectively use maps and compass.
- Prepare a trip plan and arrange for emergency rescue.
- Identify your special training needs.

References

General Manual 360-PER, Amendment 46 (Part 420), Clothing, Health, and Safety

National Engineering Handbook (NEH) Section 22

State Supplements to General Manual.

Time

2 hours 15 minutes

Outline

I. Introduction

II. Explanation

- A. Physical Condition
  1. NRCS Policy
  2. Endurance and Strength
  3. Stress encountered at high elevations, cold temperatures, and emergency circumstances.
  4. Limitations
  5. Physical examinations.
- B. Outfitting for the Field
  1. Regulation of body temperature—methods of heat loss.
     - a. Condition
     - b. Convection
     - c. Evaporation
     - d. Radiation
     - e. Respiration
  2. Characteristics of insulating garments
     - a. Woven fabrics
     - b. Nonwoven fibers
  3. Use of clothing to control body heat
  4. Selection of clothing
     - a. Cold weather
       1. innerlayer
       2. intermediate layer
       3. outer layer
     - b. Hot weather
  5. Protective clothing/equipment for special applications
     - a. NRCS Policy
     - b. Aircraft
     - c. Oversnow vehicles
     - d. All-terrain vehicles (ATV's)

6. Survival Pack
7. Equipment and supplies
    a. Snow sampling equipment
    b. Snowshoes, skis, and poles
    c. Radio
    d. Maps and compass
    e. Avalanche beacon
    f. Electronic maintenance equipment
    g. Extra fuel and traveling equipment

C. Map and Compass Use
1. Map orientation
2. Determining your location
3. Setting and following a compass course

D. Trip Plans
1. NRCS policy
2. Contents of trip plans
3. Effective implementation

E. Emergency Operations
1 NRCS policy
2. Action criteria
3. Search and rescue

F. Special Training Needs
1. Hazardous materials
    a. Handling
    b. Storing
    c. Disposal
2. Vehicle operations
    a. Truck/Trailer
    b. All terrain
    c. Oversnow
3. Aircraft operation

4. Non-motorized
    a. Skiing
    b. Snowshoes
    c. Hiking
    d. Horse/mule
5. Medical emergencies
    a. First aid
    b. CPR
6. Avalanche rescue
    a. Beacons
    b. Probing

Introduction

Advance preparation is absolutely essential to the successful completion of field trips. Your careful upfront assessment of the trip will help you make sound critical decisions about the preparations needed.

This chapter is designed to address the importance of physical conditioning, the principles of proper selection of clothing, developing trip plans, assembling a survival pack, and assessing your special training needs. All of this information is designed to build your confidence so that you can successfully manage possible emergencies.

Explanation

Physical Conditioning

NRCS policy

The NRCS policy concerning adult care is in General Manual, Section 420.102(F), Safety and Health Management. Further information about this policy is in appendix A (chapter 12).

Endurance and Strength

If a human body is kept in good physical condition, it functions more efficiently. Lung capacity is increased, thus increasing the available supply of oxygen. The production of red blood cells is increased, which improves the blood's ability to transport oxygen to the muscles. This results in muscles that are better able to cope with extended periods of exertion.

The body has a relatively narrow temperature comfort range. When air temperatures fall below this range, the body begins to feel discomfort. If this condition persists, mental anxiety follows.

The body's first defense against cold is to increase the circulation of blood needed to provide heat to the colder areas. Keeping in good physical condition helps assure that the circulatory system works at maximum efficiency, thus insuring the circulation of heat. This helps to maintain near normal body temperature, reduces discomfort, and controls mental anxiety or stress.

Travel, especially in winter, is physically demanding. Exercise and proper diet are important. The NRCS strongly encourages each employee to actively participate in regular mild physical exercise. Personnel in poor physical condition jeopardize not only their lives, but the well-being of the other members of the party.

Stress

Excessive weight on the body causes a great deal of stress, not only on the heart and lungs, but on muscles and joints. To more fully understand the necessity to be physically fit and in good health, we need to examine the stresses encountered by the body.

Immediately upon arrival at a high elevation, only moderate physical work can be performed because of extreme breathlessness. Even after several weeks of living at 8,000 feet, the maximum rate a person can work will only be 70 percent of his/her normal rate at sea level. Performance approaches sea level values only after many months or years of continuous stay. The deficit is even greater at higher elevations. If the change in elevation is large and abrupt, most individuals suffer the symptoms of acute mountain sickness. Disappearance of the symptoms (after 4 to 7 days) does not indicate complete acclimatization.

Listed below are some of the behavioral effects that can occur if an individual is not acclimatized:

- Increased errors in performing simple mental arithmetic.

- Decreased ability for sustained concentration.
- Deterioration of memory.
- Decreased vigilance.
- Increased irritability in some individuals.
- Impairment of night vision and some constriction in peripheral vision.

Self evaluation is impaired in the same manner as if that person were intoxicated. More information concerning mountain sickness and High Altitude Pulmonary Edema (HAPE) is located in Section 4 under "Altitude Illnesses."

Traveling over steep, uneven terrain or in deep, soft, powdered snow requires you to expend a great deal of physical energy, which may lead to exhaustion and fatigue. Good physical conditioning increases your endurance and ability to fight off exhaustion by providing improved lung capacity, circulation, and muscle conditioning.

Your personal mental attitude is the most important asset you bring with you. Your state of mind has a tremendous impact on the stress that can be produced within you. Being mentally prepared helps to overcome the stress encountered when dealing with insufficient training or experience, being psychologically unprepared for a trip, not having the proper equipment, recognizing and overcoming phobias, dealing with deteriorating weather conditions, and handling mechanical failures.

Approach each trip with an open mind. Realize that each one of these situations could happen to you or other members of the party. Attempt to visualize yourself in each situation and develop a strategy for coping with it. Having mentally dealt with these challenges minimizes your potential stress and gives you a greater ability to maintain a positive attitude. Emergency situations create both physical and mental demands. Being prepared for these eventualities will lessen the impact.

If an overnight bivouac becomes necessary, you will experience immediate psychological stress as well as actual physical stress. Preparation in the form of training and having the proper equipment with you will instill a greater degree of confidence and ensure survival.

Physical injuries are a real possibility. A person should be trained in first aid and have the basic supplies to cope with the injuries most likely to occur. This type of situation may necessitate a bivouac.

Personnel who travel on oversnow vehicles should be trained in correct operating procedures and basic field maintenance. A supply of spare parts and tools should be carried. In the event of a serious breakdown, a bivouac may be necessary.

The use of skis and snowshoes requires training and practice to become proficient and confident in their use. Spare parts and repair supplies should be carried. Repair procedures should have been taught and practiced.

Personnel traveling in aircraft may encounter an extreme emergency, a crash, or other disabling condition. Advanced survival and first aid training is highly recommended. The possibility of having to ski or snowshoe out from any emergency should also be considered. Proper equipment should be carried, and personnel should be proficient in its use.

In areas where there is danger of avalanche, personnel should be trained in avalanche terrain recognition, avalanche path avoidance, and search and rescue procedures. Avalanche beacons, shovels, and probes should always be carried. First aid and survival training should be given, and the proper medical and other supplies carried.

Limitations

Physical conditioning and abilities differ from one person to another. You must know your limitations so that you can better assess situations and not attempt to do more than you are capable of accomplishing safely. Knowing your ability to carry heavy loads or walk long distances can be important. Your ability to ski or snowshoe helps to determine the type of equipment you should take. In addition to knowing your own limitations, it is also important to know those of your team members. The group's ability to perform its duties depends upon the performance of the weakest member. Field trip activities should take these restrictions into account and be planned accordingly.

Physical Examination

All employees assigned to perform snow survey activities are required to be examined annually to assure that no physical problems could threaten their health and safety. Physical examinations are paid for by the government and are more intensive, depending on the individual's age and general health. If an examination reveals that the NRCS employee would be a hazard to himself/herself, to others, or to government property, that employee is not assigned to such duty.

Fellow snow surveyors, not employees of NRCS, are also encouraged to have annual physical examinations. Refer to appendix A (chapter 12) for more detailed information on NRCS policy.

Outfitting for the Field

Regulation of body temperature

Humans are called *homoiotherms* because, as warm-blooded creatures, they maintain a body temperature that is relatively constant despite changes in environmental temperature.

Homoiothermy is required for optimum function of the body enzyme systems, which work best at 98.6 to 100 degrees F (37.0 to 37.5 degrees C). The human body can be thought of as a *heat generating machine* in which the internal body temperature is the net result of opposing mechanisms that tend to increase or decrease body heat *production*, body heat loss, and the addition of heat available from the outside. Basal heat production is the result of internal metabolic processes, and averages 50 kilocalories per square meter of body surface per hour. This can be increased by muscular activity, such as shivering and exercise; by eating, by fever, and by exposure to cold which increases hunger and the release of hormones that stimulate heat production. Shivering can increase heat production 4 to 5 times, and hard exercise can increase it up to 10 times the basal level. Heat can also be added to the body from external sources, such as the sun, fire, hot food, and drink.

Heat is lost from the body through conduction, convection, evaporation, radiation, and respiration. To illustrate the relative importance of these:

- A resting body at a still air temperature of 70 degrees F (21 degrees C) loses 70 percent of its heat by radiation, conduction, and convection; 27 percent by evaporation; and only 3 percent through urine, feces, and the lungs.
- With hard exercise, evaporation can account for up to 85 percent of heat loss, while conduction, convection, radiation, and respiration account for only 15 percent.
  - **Conduction** refers to the direct transfer of heat by contact from a warm body to a cooler object. The amount of heat transferred depends on the difference between each body's temperature and the rapidity with which the heat is conducted. Contact with metal or other materials that conduct heat rapidly can cause considerable heat loss or even frostbite at low temperatures and burns at high temperatures.

— **Convection** refers to the transfer of heat from the body when air of a lower temperature than the body moves across its surface. The amount of heat transferred depends on the speed and temperature of the air. At low temperature, in the absence of shelter, high winds are a major source of dangerous heat loss.

— **Evaporation** refers to the loss of heat from the body when water or another volatile liquid on its surface is transformed into vapor. Because water has a very high *heat of vaporization* (540 calories of heat are consumed during the evaporation of one gram of water), considerable heat can be lost in this way. Evaporation is increased in the presence of wind and low humidity, and decreased in the presence of high humidity. It is a major source of beneficial heat loss in hot, dry climates. Gasoline and other volatile organic liquids that have a freezing point lower than that of water can, when spilled on the skin, cause frostbite because of conduction and evaporation.

— **Radiation** refers to the loss of heat in infrared waves from the body to a cooler object not in contact with it. The amount of heat loss depends on the difference between the body and the cooler object's temperature. Heat loss by radiation from uncovered skin is also a major source of heat loss in hot climates and can be significant in cold climates if the skin, particularly the head, is uncovered. Heat loss by radiation from objects on the ground to the sky can be considerable on clear, cold nights.

— **Respiration** refers to the loss of heat from the body due to the raising of inhaled air to body temperature before it is exhaled. The amount of heat loss depends on the outside temperature and the rate and depth of breathing.

Personal equipment must be appropriate to the trip being made. This applies to clothing as well as basic survival equipment. Individual judgment must be used because there is a practical limit to what is necessary or can be carried.

Characteristics of insulating garments

Insulating garments can prevent heat loss caused by conduction, convection, and radiation. Because air has extremely low thermal conductivity, the best garments for cold climates are made of materials that trap a layer of still, warm air around the body and maintain this microclimate despite extremes of wind and cold. Some insulating ability is lost when garments are wet or when air spaces are reduced because the garment has become compressed or matted.

Suitable materials fall into two general groups:

- woven fabrics
- nonwoven fabrics

Some nonwoven fibers, such as polyester pile, are incorporated into a fabric; others, such as down, are used in garments as a filler to provide loft. In some cases, a fiber, such as polyester, can be made into fabric as well as filler.

Traditionally, the best and most practical insulating fabrics for cold weather clothing have been wool, polyester, and acrylic; and the best fibers have been down, Dacron, and foam. Wool has a special property; it remains warm even when wet because of its low wicking action and ability to suspend water droplets between its fibers without seriously affecting insulating ability. Cotton garments, particularly denim and corduroy, should not be worn in cold weather because of cotton's poor insulating value, which is reduced even further when wet.

Down is unsurpassed for dry, very cold climates, but is inferior to Dacron in damp, moderately cold climates because wet down balls up and is less warm and harder to dry than wet Dacron. Orion and related acrylic fabrics were developed to mimic the properties of wool at a lower cost. These fibers are almost as warm as wool and are lighter, easier to dry, and less itchy. Foam, a lightweight plastic material containing multiple small air bubbles, is used to insulate boots, mittens, and gloves.

Newer insulating materials include:

- Hollofil II and Quallofil—hollow, synthetic fibers designed on the principle of reindeer hair;
- Thermolactyl—a fabric containing acrylic and polyester;
- Thermoloft—a combination of solid core polyester, Quallofil fibers, and polyester pile. Polyester pile jackets are superior to wool sweaters because they are lighter, dry more easily, and stay warm when wet.
- Thinsulate and Thermolite fibers have increased insulating value because they are small, more finely divided, and trap more air than other materials when made into garments of similar thickness.
- Olefin and polypropylene are two popular new fabrics that have low thermal conductance, high insulating ability, and the ability to wick moisture quickly away from the skin.
- Capilene is a type of polyester treated to increase wicking ability.

These new fabrics are popular selections for thermal underwear and may be the best choice for persons who perspire heavily during cold-weather activities. See figure 6.1, Characteristics of Insulating Garments.

Use of clothing to control body heat

Use of the layer principle of clothing is effective in preventing chilling and overheating because one or more layers may be added or subtracted as necessary to control body heat and perspiration.

Overheating is undesirable because it leads to excessive perspiring and saturation of clothing with moisture, causing loss of heat from conduction and evaporation. Because water conducts heat away from the body 32 times faster than air of the same temperature, wet clothing can cause rapid heat loss in cold weather. An alpine skier, for example, who spends considerable time riding the chair lift and whose downhill speed generates significant windchill, needs more layers of clothing than a nordic skier who generates much more heat from muscular activity. Clothing should be easily adjustable. A sweater, shell, or jacket should have a full-length zipper and shell ventilation zippers in the armpits. Outer layers should be sized generously to allow expansion of inner layers to their full thickness.

Heat loss from convection, conduction, and evaporation should be prevented by wearing windproof and water resistant outer garments of nylon, 60/40 cloth, or Gore-tex. These should include a ski or mountain parka and wind or warm-up pants. The parka should be fingertip length unless bibs are worn.

As the wind velocity rises, the "effective" temperature drops (windchill effect). Charts illustrate the relationship between actual temperature, wind velocity, and effective temperature at the skin surface, and underscore the necessity for windproof outer clothing and for seeking shelter during periods of cold and high wind. See 6-2, Wind Chill Chart. It should be remembered, however, that the windchill concept refers to the rate of heat loss rather than the actual temperature reached, as long as evaporation is not a factor. Many cases of frostbite have occurred among improperly protected skiers sitting on chair lifts during times of high exposure.

Figure 6.1 Characteristics of Insulating Garments

Clothing Materials Chart

Materials	Insulator	Moist. Barrier	Wind Barrier	Breath Ability	Fire Resist	Comfort	Drying Speed	Wear Resist.	R.I.W.W.[2]	Uses[3]
Natural										
felt	G[1]	F[1]	F[1]	G[1]	G[1]	P[1]	F[1]	F[1]	G[1]	F,HT
wool	G	F	F	G	G	P	F	G	G	ALL
cotton	P	P	P	G	F	G	F	G	P	ALL
silk	P	P	P	G	F	G	F	P	P	I,A
leather	F	G	G	P	F	F	P	G	P	O,F,HT,A,H
fur	G	G	G	P	F	F	P	G	F	O,F,HT,H,A
rubber	P	G	G	P	P	P	—	G	G	O,F,H,A,HT
down	G	P	P	G	P	G	P	P	P	O,F,H,A,HT
Synthetic										
pile	G	P	F	F	P	F	G	F	F	O,M
nylor	P	F	G	P	P	F	G	G	P	P,HT
gortex	P	G	G	G	P	F	G	F	—	O,F,H,A,HT
polypro	P	P	P	G	P	F	G	F	—	I
capalene	P	P	F	G	P	F	G	F	—	I
thinsulate	G	P	P	G	P	F	G	F	G	O,M,F,H,A
thermax	G	P	P	G	P	F	G	F	G	O,M,F
hollifil	G	P	P	G	P	G	G	F	G	O
polargard	G	P	P	G	P	G	G	F	—	O
plastic	P	G	G	P	P	P	—	F	—	O,F,HT
vinyl	P	F	F	P	P	P	—	G	—	O,HT
nomax	P	P	F	F	G	F	F	F	P	O,H,A

1 PROPERTIES: Good, Fair, Poor

2 R.I.W.W.: Retains Insulating Qualities When Wet

3 Uses: I = Inner, M = Intermediate, O = Outer, F = Feet, H = Hands, A = Aircraft, HT = Hat

Figure 6.2 Wind Chill Chart

U. S. CUSTOMARY WIND CHILL CHART

Combined Speed Of Wind and Snowmobile In MPH	Actual Thermometer Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Temperature (°F)											
0	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-21	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-36	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-124
25	30	16	0	-15	-29	-44	-59	-74	-86	-104	-118	-133
30	28	13	-2	-18	-33	-46	-63	-79	-94	-108	-125	-140
35	27	11	-4	-20	-35	-49	-67	-82	-96	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(wind speeds greater than 40 mph have little additional effect)	LITTLE DANGER* *(FOR PROPERLY CLOTHED PERSON)				INCREASING DANGER*			GREAT DANGER*				
	*DANGER FROM FREEZING OF EXPOSED FLESH											

Moreover, a body in motion tends to create its own wind; other things being equal, a skier or snowmobiler is more susceptible to frostbite in motion than when stationary. Experience has shown there is a marked danger of frostbite when the "windchill factor" is -25 degrees F or below, a range easily attained by a moving skier or snowmobiler when the temperature is -10 degrees F (-23 degrees C) with a wind speed of 20 mph.

A dangerous combination is cold and wind combined with water, for example, in a blizzard around 32 degrees F (O degrees C) or after falling into a mountain stream. In these cases evaporation, convection, radiation, and conduction combine to produce rapid heat loss. Frostbite and hypothermia are real threats.

Loss of heat from infrared radiation is prevented by wearing a hat. At 5 degrees F (-16 degrees C), up to 70 percent of total body heat production can be lost from an uncovered head, partly because the cold body does not reduce the blood supply to the head as it does that of the extremities. **The old adage "if your feet are cold, put on your hat" is true!**

In cold weather, loss of heat from respiration is prevented by avoiding overexertion and overheating, which may cause excessively heavy breathing. When it is extremely cold, the inhaled air should be warmed by a hood, which can be pulled out in front of the face to form a "frost tunnel."

Heat loss from conduction is avoided by such strategies as sitting down on a toboggan, pack, or log, rather than in the snow or on a cold rock or metal object. Because the high conductivity of ski bindings, crampons, and other metal objects can cause bare fingers to freeze to metal at low temperatures, especially if they are damp, thin gloves (liners) should be worn. Spilling gasoline, or other liquid that has a freezing point lower than water, on the skin should be avoided. This causes instant frostbite at low temperatures because of conduction and evaporation.

In cold weather, heat loss from conduction and evaporation is lessened if you stay dry or dry yourself quickly when wet. Ideally, outer clothing should be windproof and should not collect snow. It should shed water but not be waterproof; otherwise, inner garments will become wet with sweat. Designers of the ideal outer garment are thus faced with the difficult task of creating a fabric that allows water to pass from the inside out, but not from the outside in. At this time, the fabric that appears to do this best is Gore-Tex, although other good fabrics are becoming available. Gore-Tex is highly windproof and a good choice for outer garments.

Adequate coverings should be available for the body parts that have a large surface-area-to-volume ration—such as the head, ears, hands, and feet—to counteract their tendency to lose heat more rapidly than other body parts by conduction, convection, and radiation. However, these coverings should not be tight enough to restrict blood circulation. If socks and mittens get wet, they should be dried or replaced with dry spares.

Selection of clothing

Cold weather

The selection of cold weather clothing depends on the type of activity, the expected temperature ranges, predicted amounts and types of precipitation, and the altitude to which the individual will be subjected.

For example, in the Coastal Alpine Zone (Cascades, Sierras, Appalachians) where temperatures are moderate and precipitation is heavy and apt to consist of rain even in the winter, a person should choose clothing made of fabrics that function well when wet, are easy to dry, and repel water (wool, polyester pile, polypropylene, Gore-Tex). In the High Alpine zone (Rocky Mountains and other inland ranges) where temperatures are lower and a person is less apt to get wet, insulating value and wind-proofing is more of a concern. Down may be selected over Dacron; nylon or 60/40 cloth over Gore-Tex. See table 6.1, Clothing Selection Guide.

Table 6.1 Clothing Selection Guide

Clothing Selection Guide

Layers	Choice	< 40°F CD-dry	< 40°F CD-wet	> 40°F WRM-wet
Inner layer	best	wool	wools	polypro
	good	poly, silk	poly, silk	wool/cotton
	poor	cotton	cotton	—
Intermediate layers (multi-yes)	best	wools/down	wools/ thinsulate hollofill	wools/ thinsulate hollofill
	good	hollofill/pile thinsulate	pile	pile
	poor	cotton	cotton/down	cotton/down
Outer layer (shell)	best	nylons/Gore-tex	Gore-tex	Gore-tex/nylon
	good	leather/wools pile	nylon/wool pile	pile/wools
	poor	cotton	cotton/ leather	cotton/ leather

Innerlayer

- *Underwear*—100 percent wool or 85 percent wool/15 percent nylon is good, but polypropylene and Capilene are probably the new standard. Net is satisfactory, but it should be of wool. Alpine skiers can get away with Duofold and other synthetic combinations. Waffle-weave “thermal” and other types of cotton underwear should be avoided.

- *Socks*—Wool and polypropylene socks are best. They are preferably worn in layers with a pair of thin, polypropylene socks next to the skin and one or two pairs of heavy, wool socks over them.

- *Vapor Barrier Garments*—The “vapor barrier” system consists of a waterproof garment worn either next to the skin or over a thin garment of polypropylene or similar material. This results in a warm film of moisture next to the skin, which decreases water requirements by reducing sweating and increases the insulating properties of the outer garments by keeping them dry. This system seems to work better in very cold weather than at moderate temperatures and some dislike the clammy feeling that results. Additional spare underclothing must be carried to ensure that a dry set will be available each day.

Intermediate layer

- *Shirt*—Wool and polypropylene shirts are best. They should open completely in front or at least have a half-zipper. A turtleneck design protects the neck, or a special “neck-warmer” which can be pulled up to protect the face, can be used. Orlon, nylon, or polyester blends are suitable for alpine skiers.

- *Pants*—Wool pants or knickers are preferable. The hard-finish wool pants in “army surplus” stores are durable and reasonable in price. Downhill skiers should select wool or part wool “stretch” or quilted pants or bibs. Cotton, particularly denim and corduroy, should be avoided.

- *Sweater*: Wool is good, but is being replaced by polyester pile vests and jackets. The front should have a full zipper, buttons, or snaps.

Outer layer

- *Parka/Jacket/Coat*—This can be a standard ski or mountain parka filled with down or Dacron. The combination of a jacket or vest and a windproof and water-resistant shell is more versatile. The parka or shell should have a hood with a drawstring closure, and unless bibs are worn, should be fingertip length. This helps to keep the hips and waist warm and avoids exposing bare skin when bending over.

- *Wind or Warm-up Pants*—These are a must for cold, windy weather, for digging a snow cave, or when working in wet or deep snow. They can be of nylon or Gore-Tex.

- *Hat*—Some variety of a wool or Orlon "stocking" type cap seems to be best. It should cover the ears. Unless a neck warmer is worn, a face mask or balaclava feature is desirable to protect the face from cold wind. A light eyeshade of the Headgasket or tennis visor type is useful when excessive glare is anticipated. Caps that have visors and ear protectors that can be pulled down as needed are also popular.

- *Mittens or Gloves*—Mittens tend to be warmer than gloves, but are less useful when delicate finger movements are required. A good combination is a pair of thin, polypropylene liners worn inside heavy wool mittens of Dachstein or wool/polypropylene plus an outer windproof shell of nylon or Gore-Tex. Depending on temperature and type of activity, any combination of these three layers can be worn at a time. The light liners are used to protect the hands when adjusting ski bindings or splinting. Alpine skiers may prefer leather mittens or gloves lined with foam, down, or thinsulate shells. If this type is worn, they should be long enough to cover the wrists.

- *Boots*—The type chosen depends upon the form of activity and the expected environmental temperature. For moderate temperatures, sturdy leather climbing boots can be used. The boots should be made of full-thickness leather, be 6 to 8 inches high, have rubber lug soles, and be roomy enough to accommodate a pair of polypropylene socks plus one or two pairs of heavy wool socks. They must be long enough so that the toes are neither cramped nor likely to strike the end of the boot during downhill travel. To avoid both cold feet and blisters, boots should be laced firmly enough so that the heel doesn't move, but not so tight that the toes cannot be wiggled easily. Gaiters should be added in snow country to keep snow out of the tops of the boots.

  For colder temperatures, double mountaineering boots work well for winter mountaineering. They can be of leather or have outer shells of plastic or nylon with inner boots of felt or foam. They also should be roomy enough to accommodate at least a pair of polypropylene and one or two pairs of heavy wool socks. For ice climbing, boots need to be quite stiff. For snowshoeing and other types of nontechnical activities, the Canadian Sorel type of shoe-pack, with a removable inner felt liner, works well. Special single and double ski boots are available for ski touring and ski mountaineering to fit either three-pin or mountaineering ski bindings. For high altitude mountaineering in cold weather, special overboots or felt-lined gaiters are desirable. Gaiters should be used to keep snow out of the tops of boots.

- *Rain Gear*—In moderate climates or very wet conditions when rain or wet snow may be encountered, outer garments of Gore-Tex may not be adequate and waterproof outer garments may be preferable.

Hot weather

Conditions conducive to serious heat stress exist in most parts of the temperate zone during the summer. The amount of heat stress depends on temperature and humidity. Death can occur if internal heat production plus heat gained from the outside raises the body's core temperature above 104 to 105 degrees F (40 to 40.6 degrees C) despite the body's cooling mechanisms. In North America, serious heat stress can occur during long climbs in sun exposed areas. Vehicle breakdowns in isolated locations can be very hazardous to unprepared passengers. Problems from excessive heat can be prevented in the following ways:

Heat loss by conduction, convection, and radiation can be increased by exposing the maximum amount of bare skin to the outside air. This technique will be limited by the danger of sunburn to the unprotected skin. This means a long-sleeved shirt and long pants of thin, loose-fitting, light-colored (preferably white) cotton. When in the shade, as much clothing as possible should be removed. A hat that has a wide brim or a cap that has a neck protector (the "foreign legion" type, with ventilation holes in the crown) should be worn, and the hands should be protected by gloves. Sturdy hiking or climbing boots are necessary to protect the feet from the hot ground and sharp rocks. High quality dark glasses with ultraviolet radiation protection are needed to protect the eyes from the glare.

The sweating mechanism can be maintained by drinking an adequate amount of fluid, some of which can contain electrolyte supplements. Enough water must be carried or be readily available in the field. Water bottles wrapped in clothing or otherwise insulated should be buried in the pack to keep the water cool.

Mountains cool rapidly at night. Use of the layer principle of clothing is advisable, so that layers can be taken off during the heat of the day and added at night.

Because of its high thermal conductivity, poor insulating ability, and good wicking ability, cotton is the fabric of choice for hot weather clothing. To improve air circulation, clothing should be loose.

As mentioned before, coverings for the head and body should be used to protect the body from the direct rays of the sun.

Shade should be sought during the hottest part of the day. A sun shelter can be made out of a tarp.

Muscular exertion during periods of high heat should be avoided, especially when humidity is high.

The skin should be protected from hot objects and metal at high temperatures and the feet should be protected by wearing shoes.

The body's mechanisms of adaptation to heat and altitude are better than those for cold. Acclimatization to heat is a process that takes 7 to 10 days to complete. It includes an increase in the volume of blood and the efficiency of the heart, so more blood is available to carry heat from the hot body core to the shell. The rate of sweating increases, and the sweat contains less salt. By the end of this time, exposure to heat is noticeably better tolerated and less debilitating.

On return to a cooler climate, these processes reverse. The most obvious change being a temporary increase in urine volume as the blood volume contracts and the excess liquid is excreted by the kidneys.

Protective clothing equipment for special applications

NRCS policy

NRCS policy requires special clothing and equipment when using aircraft, oversnow vehicles, or all terrain vehicles (ATVs). Refer to GM 360-PER, part 420, and Temporary Regulation E-5 in appendix A.

Aircraft

Helmets and NOMEX fire retardant clothing are required when traveling in any aircraft. The helmets must meet approved specifications. Special requirements for aircraft travel are covered in section 9 of your West-Wide Snow Survey School Workbook.

Oversnow vehicles

When operating or riding on oversnow vehicles without an enclosed cab, operators and passengers must wear an approved properly fitted helmet. Eye and car protection is recommended. For enclosed cab operation, helmets are not required, but hearing protection must be used.

All-terrain vehicle (ATV)

When using ATV's, operators must wear an approved helmet, goggles or a full-face shield for eye protection, substantial shoes, such as leather boots that come above the ankle, and long pants. In addition, it is recommended that the operator wear gloves and a long-sleeved shirt or jacket.

Survival pack

The survival pack you prepare is intended to make life threatening emergencies survivable and provide relative comfort. One survival pack for all types of trips and conditions is impractical. The nature of the trip you are taking will dictate the items to be included in the pack. The items selected will be influenced by the mode of travel, remoteness of the trip area, distance and anticipated time of trip, climatic conditions, personal comfort and medical needs, and local peculiarities.

Table 6.2 is a list of suggested items to include for various modes of travel. The first list is based on the premise of foot travel. The following lists show items to be added if travel is by snowmobile, cabbed-over oversnow vehicle, or aircraft. Highway vehicles should contain a similar survival pack. The basic survival pack is recommended for winter trips.

Remember to adjust your survival pack for the conditions you could expect to encounter. For example, in cold weather you might add the following items:

- heavy insulating clothing.
- a cold-rated sleeping bag.
- down and wool products.

For wet, warmer weather the emphasis should be on:

- water resistant and waterproofed items.
- a medium weight sleeping bag.
- wool or synthetic fabrics.

It is critical that the survival pack contents be replenished and fully useful. The items that are most often used and need to be checked or replaced are batteries, survival foods (which must be within shelf life limits), and candles (which melt easily if the pack is stored where it is too hot). Water bottles need to be clean and ready to use. First aid supplies need to be checked for shelf life and replaced if out of date or used. Stoves or lighters need to have fuel. Be familiar with your pack and keep your pack private and protected from others using or borrowing from it. Know its contents—keep a checklist in a pocket of the pack for quick reference. Know how to use the items on a moments notice.

Your survival pack is personal. You may require special skin care items, medicine, or special equipment. Comfort items, such as your favorite Teddy or E.T. bear, or simply a good book might make the night much easier to cope with.

Choices of sleeping bags follow the same general principles as clothing. Sleeping bags should be tailored to the climatic conditions to be encountered. Special emphasis should be paid to the choice of insulating materials, and clothing should retain its thermal qualities when wet.

Survival packs should be inspected on a regular basis to ensure that all items are in good condition and fully serviceable. Special attention should be given to such items as batteries and lantern bulbs, survival food items, candles, water bottles, medical and first aid supplies, and camp stoves or lighters and their fuel.

Table 6.2 Suggested Survival Pack Items

Suggested Survival Pack Items

ALL WINTER FIELD TRIPS (your pack should include the following basic items)

Recommended for foot travel:

Sunglasses
Knife (Swiss Army knife)
Maps
Compass
Snow Survey Safety Guide and/or
  Survival Manual
Fire starters (at least 5 types)
  Waxed matches
  Metal match
  Small ball of raw cotton
  Dry tinder (12" hemp rope)
  Small vial of kerosene or like
Emergency rations (min. 1 day)
Emergency space blanket or small
  nylon tarp
Candle
Metal cup
Plastic spoon
Light rope or nylon line
Safety pins
Toilet paper
Signal mirror
Whistle
Extra sweater, mittens, socks, cap
Spare blankets (2)
Water bottle
Toothbrush
Durable snow shovel

First aid packet
  Aspirin tablets
  Burn ointment
  Cut antiseptic
  Bandages
  Butterfly closure
  Adhesive tape
  Compresses
  Roller bandage
  Triangular bandage
Ski repair kit
  Screwdriver set & extra screws
  Pliers
  Spare cable or toe piece
  Plastic or aluminum ski tip or
  Snowshoe repair kit
  4 hardwood strip (1/8"x5/8"x6")
  Length of wire
  Several heavy leather thongs
  Pliers
  Spare bindings
Plastic sheet (8' X 8')
Brass or copper wire 30' x .025
  minimum size for snares
Flashlight w/batteries (Optional)

Although this list seems lengthy, it can be packaged into a small rucksack, which should be an inseparable part of your field gear. This pack should be adjustable depending on your mode of travel.

Snowmobile Travel (additional items to include):

Shovel
Hatchet or folding saw
Snowshoes or X-C skis
Machine maintenance kit
Small rucksack with extra clothes, mittens, socks, cap, etc.
Signal flares
Larger lightweight nylon tarp
Sleeping bag
Ensolite pad
Flashlight w/batteries separate
Heavy nylon tow rope
Small cook stove (backpacker style)
Small cook kit
More emergency rations
Small vial of soap

Snowcat Travel (additional items to include):

Large shovel
Axe or bow saw
Sleeping bags
Handyman winch
Propane torch
Larger cook kit
More emergency rations
Down booties (optional)

Aircraft Travel (additional items you may need):

More signal equipment (colored smoke, flare pistol, railroad flares)
Larger first aid kit
More emergency rations
Fish line & assortment of hooks and lures

Equipment and supplies

Before embarking on a field trip, evaluate your objectives and assemble the equipment and supplies needed for the trip. Tools and supplies should be inspected before leaving. Any repairs, replacements, or supplements should be completed before the trip begins.

Snow sampling equipment

Snow sampling sets will be inspected before each trip for completeness and condition. Make sure site maps and note forms are in the set. Assemble and disassemble the tube sections to check thread condition. Make sure the tube sections will produce a correct depth scale. Chapter 5 describes, in detail, the maintenance of snow samplers.

Snow shoes, skis, poles, and boots

Snowshoes, skis, poles, and boots must be inspected before every trip to ensure that all items are in good repair. If any changes in personnel are expected from trip to trip, be sure the proper sizes of equipment are available. Maintenance of this equipment is described in chapter 8.

Radio

Radios should be checked out for transmitting and receiving before each trip. Batteries should be fully charged.

Maps and compass

Route finding supplies, such as topographic maps and compasses, must be assembled before each trip, and all trip members will be shown the location of the final destination and the route to be followed.

Avalanche beacon

If avalanche beacons are to be used, they will be tested before each trip. Each member of the party will be fully familiar with the operation of the beacons and the procedure to follow in case of emergency.

Electronic maintenance equipment

Tool kits, electronic repair parts, electronic testing equipment, and any other tools or components will be assembled, checked, and tested before each trip. An inventory will be made to ensure that nothing is, or will be, missing, when the field site is reached.

Extra fuel and traveling equipment

Extra fuel, spare parts, tools, and operators manuals will be assembled before all trips and will be checked as oversnow machines are loaded.

Map and compass use

Using your map and compass requires practice and an understanding of the principles involved. Losing your direction while in an unfamiliar area may not seem too serious if it only means getting home late, but if you become lost to the point where you are stranded and cold or if you are injured and need attention, getting lost can be a tragedy. Peaks, lakes, rivers, cabins, and blaze marks can help in finding your way; however, when darkness, fog, or storms obscure your vision, it may be impossible to continue without a compass and map.

U.S. Geological Survey (USGS) topographic maps are the best maps available for your use. They provide a three-dimensional view of an area. These maps identify steep areas, valleys, ridges, streams, and other pertinent landmarks.

All quality compasses have similar basic features and may be used for cross-country travel. Practice using your compass and map until you become confident that you know how to use the procedure. Then, continue to practice until it becomes routine.

You can also determine direction by using your watch. On a day that you can see the sun, point the hour hand (corrected to standard time) toward the sun. Approximately, halfway between the hour hand and 12 will be due south. When facing due south, east is to your left, west is right, and north is in back of you. This method can be used regardless of whether your watch has hands or not. If it is a digital watch, simply estimate the position of the hour hand.

Map orientation

USGS topographic maps are always oriented to true north. They generally indicate the departure (declination) from true north towards which your magnetic compass will point. It is helpful to know what the magnetic declination is in your area because some maps will not show this information.

The departure is called the angle of magnetic declination and varies throughout the world. A compass pointer always orients with the magnetic north pole. Magnetic north varies from true north by 10 to 15 degrees in the Western United States.

Determining your location

You may determine the magnetic bearing of your direction of travel at any time by using the following steps:

- Orient your compass pointer to read 0 degrees azimuth (adjusted for the magnetic declination to achieve true north).
- Holding this compass position, sight along your direction of travel. Read the compass dial in degrees of azimuth (always

read clockwise, beginning at true north). This is your bearing.

Being able to judge or pace distances is helpful as you travel from point to point. Remember to keep your compass away from metal objects or known iron, nickel, or cobalt ore deposits.

The use of a map and compass are required when:

- You can locate your location and destination on the USGS map.
- You know your general location, but not your exact position.
- You are totally lost.

Setting and following a compass course

- Location and destination known
  - — Mark your location on the topographic map.
  - — Using a Silva-type compass, point the base plate towards your destination by laying its edge on the map along the desired direction of travel.
  - — Set the compass heading by turning the compass dial until "N" points to true north on your map (always at the top of the map). The direction in which to proceed is read at the index line on the dial.
  - — Hold the compass in your hand to proceed. The compass should be held level so that the magnetic needle swings freely.
  - — Turn your body until the read end of the needle aligns with both the orienting arrow and "N" on the dial.

— Sight to a distant landmark that lines up with your direction of travel and begin moving toward it. Select an easily recognized landmark that you will not lose sight of.

This procedure may need to be repeated several times because topographic features often prevent a straight line of travel.

- General location known but not exact position

In this case, you know your general location along a certain line, such as a ridge, river, or trail. It is possible to locate yourself in the following way:

— Orient your map to north as shown previously.

— Identify a prominent landmark that can be located on the map and physically. Mark it on the map.

— Take a bearing with the compass and draw a line from the prominent landmark toward your general location.

— The point of intersection with your known line is your location on the map.

As you continue to move toward your destination, you must recheck your position.

- You are totally lost

Even if you are totally lost, it is possible to locate your position on the map. The process is similar to the previous method:

— Orient your map to north as shown previously.

— Positively identify two (or more) landmarks on the map and physically, mark these landmarks on your map.

— For each landmark, take a bearing with the compass and draw a line from that landmark.

— The location where the lines intersect (or nearly intersect if three or more lines are drawn) should be where you are.

— Carefully, look at this intersection to ascertain if this point makes sense. If it does, then you have located yourself. If it does not make sense, start over because you have made a mistake in either identifying a landmark or in taking a bearing.

When you are satisfied that you know where you are, mark your location on the map and continue your travel as described above. Continue to recheck your position as you move along your route.

Trip plans

NRCS policy

While no specific national NRCS policy exists for using trip plans, individual state policies may exist. You should know if your particular state has existing policy. If it does, you must follow it. Non-NRCS personnel should check with their supervisors and become familiar with the policies and procedures used by their agency or organization.

Contents of trip plans

The contents of a trip plan can vary, but some basic information is a must. Include all pertinent information necessary to facilitate search and rescue operations. Figure 6.3 is an example of a trip plan form. It can be copied and used if one does not exist.

Effective implementation

The trip plan is only effective if two things occur. First, the trip plan must be given to a responsible individual. The individual chosen as the Home Base Coordinator (HBC) has the responsibility to initiate a search and rescue and carry out predetermined emergency actions if the field party is overdue. The coordinator's responsibility does not stop at the close of the business day.

When selecting a responsible person for check-in, pick someone who is easily located, responsible, and with more than a casual interest in the field party. This person must be in good communication with you or convenient to your point of return.

Second, the field party has the obligation, after they prepare the trip plan, to follow it and contact the HBC immediately upon returning home. The chances of a successful rescue are directly related to how accurately the trip plan is followed.

Emergency Operations

NRCS policy

Emergency operations for conducting search and rescue vary from state to state. Therefore, it is important to know and understand the proper procedures to follow for your specific location.

Within the NRCS, each state conducting snow survey operations should develop a supplement to the General Manual which establishes state policy for monitoring activities in remote areas. This supplement should address:

- Initiating a search.
- Using NRCS personnel in a search and rescue operation.

Become familiar with your state's General Manual supplement and know what to do in an emergency.

Appendix A (chapter 12) gives more specific information about emergency preparedness procedures. The General Manual, section 420.103(K) deals with NRCS personnel when called upon to assist in search and rescue operations.

The NRCS national policy says, "When snow surveyors are called upon by responsible local officials for emergency rescue assistance in saving a life, they should respond and notify the appropriate NRCS line officer as soon as practical. Such activity should be considered part of their assigned duty. It is suggested that an advisory meeting be held with local responsible officials, emphasizing that the NRCS will only become involved in life-threatening situations and where snow survey expertise and equipment are specifically required to augment normal rescue arrangements. NRCS equipment will be operated only by NRCS employees."

Action criteria

Successful emergency operations require clearly defined and understood action criteria for the HBC. As a minimum, each trip plan should define these action criteria:

A reasonable unit of time should elapse after the expected return/ check-in time that was established in the trip plan. When this unit of time has passed, the HBC is to take action.

The first action to be taken by the HBC is to determine if indeed the field party has not returned or reported.

If the field party has not returned and is overdue, the HBC is required to notify emergency rescue and administrative authorities. Local policy and the HBC's own judgment will determine which to notify first.

Figure 6.3 Trip Plan

Trip Plan

Departure Date: ______________________

Phone No.

Home base coordinator: ______________________ Office: ______________________
Home: ______________________

Home base location: ______________________

Alt. home base coord.: ______________________ Office: ______________________
Home: ______________________

Alt. home base location: ______________________

Work party members: ______________________ Office: ______________________
Home: ______________________

______________________ Office: ______________________
Home: ______________________

______________________ Office: ______________________
Home: ______________________

______________________ Office: ______________________
Home: ______________________

Motor Vehicle Used: Make: __________ Type: __________ Lic#: __________
Model: __________ Year: __________ Color: __________

Departure Point: ______________________

Ground Survey

Departure time: __________ Radio Contact with: ______________________
Phone: ______________________

Estimated return time: ______________________

Estimated enroute check-in times: ______ ______ ______ ______

Location: ______ ______ ______ ______

Planned route of travel: ______________________

____

____

____

Figure 6.4 Aerial Trip Plan

Aerial Survey

Phone No.

Aircraft contract: ______________________ Office: ____________

Location: ______________________ Home: ____________

Type: ______________________ Make: ____________

"N" Number: ______________________ Color: ____________

Flight following with: ______________________ Office: ____________

______________________ Home: ____________

Departure Point: ______________________ Time: ____________

Estimated return time: ______________________

Planned itinerary:

	Planned Stops	Stops Reported	Time	Arrival Time	Departure	Remarks
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Use additional sheets if needed.

These action criteria are displayed in the flow chart on the example trip plan (figure 6.5).

Matters of liability for the HBC's actions may arise in situations of injury or loss of life. The HBC bears considerable responsibility and must have correct, clear instructions.

Search and rescue

NRCS and other snow surveyors must realize that, although they may be very well qualified to conduct rescue operations, in nearly all cases they would violate local, state, and Federal regulations (including NRCS policy) by doing so. Follow the flow chart outlined in figure 6.5 as an example of a decision tree for search and rescue.

State and county law enforcement officials typically are authorized to organize and conduct rescue operations. Indian reservations, national parks, and military reservation officials usually are responsible in their areas of domain. Your responsibility as an NRCS employee is to know who the search and rescue authority is. As a matter of routine business, you should inform these officials of your winter travel activities, emergency preparations (training, survival gear, trip plans, and HBC), transportation capabilities, and status as a resource to their search and rescue efforts.

Your ability to respond on a moments notice is directly related to maintaining yourself in good physical condition. The importance of good conditioning has been discussed at the start of this chapter. The other consideration is that all equipment must be maintained in top working condition. If something needs to be fixed on the snow machine, don't put it off until you need to use the machine again. Repair it upon your return so that it is ready to go.

Special Training Needs

Depending on what your particular assignments are, you may require additional or special training. Appendix A (chapter 12) has the General Manual policy covering NRCS training requirements.

Some of the basic training area needs are listed below. The list is not complete and should be treated as only a guide. Your supervisor will be better able to help you pinpoint your training needs and either provide the necessary training or help you get it.

Hazardous materials

These materials include snowmobile fuel, glycometh (used for recharging precipitation gages), herbicides, and numerous other materials. Ask your supervisor to either provide training or help you get training on these materials. Your supervisor should also give you a copy of the Materials Safety Data Sheet. If one is not available, it can be obtained from the manufacturer. Items covered under hazardous materials training should be:

- handling
- storing
- disposing

Vehicle operations

You must be able to skillfully operate all of the vehicles available to your group, including:

- *Truck/trailer*—You must demonstrate to your supervisor your ability to drive under conditions you may be expected to encounter and be within compliance of all state laws. In other words, if a commercial or chauffeurs license is required by state law to operate a truck/trailer, then you must have one.

- *All-terrain vehicles*—SCS requires all personnel to complete an approved training course before operating an ATV. See Appendix A for policy.
- *Oversnow vehicles*—These vehicles include snow mobiles and snow cats.

Aircraft operations

You need "hands-on" experience in working in and around aircraft. For example, if you will use a helicopter, you must know how to approach and leave when the rotors are operating. Your supervisor should be able to show you the "ropes" for activities you will not learn during the West-Wide Snow Survey School.

Non-motorized vehicles

These vehicles include skiing, snowshoes, hiking, and horse/mule. For the first three, practice makes perfect. The better you become, the easier you job becomes. You must learn sound procedures. Continue to practice whenever you get a chance.

Horse/mule training requires some "hands-on" training from your supervisor or coworkers. Riding and pulling a pack-carrying mule requires that you develop considerable skill. Hopefully, you can gain this experience early while traveling with a seasoned surveyor. If not, you may need to ask your supervisor for training.

Medical emergencies

First aid and CPR training are necessary. You should have completed a basic (Red Cross or equivalent) first aid course and a CPR course before coming to the West-Wide Snow Survey School. If not, you must complete these courses as soon as you get back to your office. Additional training in first aid is advisable because you can never learn too much about this field.

Avalanche rescue

The West-Wide Snow Survey School covers avalanche rescue in some depth. However, if your supervisor feels you need additional training, this can be provided by the National Avalanche School. Your supervisor will need to find out the time and location for their next school.

Figure 6.5 Flow Chart

The home base coordinator or alternate will wait a predetermined amount of time after the expected return time/check-in time before initiating action. At that time, the following action *flow chart* should be followed.

Pertinent Phone Numbers:

Search and Rescue Authority: ______________________________ Office

Designated Administrative Authority: ______________________________ Office

Alternate Administrative Authority: ______________________________ Office

Chapter 7—Winter Survival

Chapter Objectives

Upon completion of this lesson, participants will be able to:

- Explain how to prepare, both physically and mentally, for a snow survey trip.
- Describe emergency procedures to initiate following an aircraft crash-landing, mechanical transportation failure, or similar emergency.
- Explain how to recognize and overcome the trauma and panic associated with winter emergency situations.
- Construct, or explain how to construct, at least four emergency shelters (snow trench, snow cave, lean-to, and ready-made shelters).
- Describe how to prepare signals for rescuers, best utilize the survey party's available food and water supply, start and maintain a campfire, stay warm in a sleeping bag, and ask the right questions when considering whether to leave the crash or equipment failure site.

References

West-Wide Snow Survey Training School Workbook

Time

Classroom: 1 hour, 45 minutes

Introduction

Mountainous regions and the bulk of Alaska are considered to be a hostile and unforgiving environment in the wintertime. Snow surveyors must travel into the mountains, and often far back into remote locations, in order to do their jobs. They usually expect to return to their headquarters or at least arrive at a well stocked cabin before nightfall. Many situations can suddenly occur, however, to prevent this from happening. The snow machine can break down or get stuck; the helicopter may have to make a forced landing; a storm may come up; or a whiteout may make travel too hazardous. Any of these can force the survey party to spend the night, or a longer period, in the snow.

Whatever the case, snow surveyors must be prepared and capable of taking care of themselves and those in their party. Emergency survival situations have occurred many times over the years and, each time, a properly trained snow surveyor was able to handle the difficulty without serious consequences.

Preparation

Before embarking on a snow survey trip, the surveyor must:

- Have collected the proper clothing.
- Assembled and checked a required basic survival pack.

This act should be an exercise that mentally prepares the surveyor for possible emergencies. It is not enough just to have a pack full of equipment, the surveyor must know how to use each item. *You should try to imagine every possible problem that can befall any trip and mentally resolve the situation using the equipment available.* This kind of mental exercise reduces, to a minimum, the likelihood of surprises and gives you a feeling of confidence.

A training session may not cover every item to the satisfaction of each individual. Also, some prior knowledge of a few subjects is taken for granted. The snow surveyor is expected to know, as a minimum:

- Basic first aid.
- How to use a compass.
- How to operate a camp stove.

If the snow surveyor, in preparing for a trip, feels deficient in some areas of safety and survival, it is essential to ask questions and/or seek further help. The surveyor must know how to use the equipment. Snow surveyors must also pass an annual physical examination. A *person in poor health or physical condition should never be allowed on a snow survey because he/she jeopardizes not only his/her life, but the others in the party as well*

Before leaving on any trip into back country, give your schedule to a responsible person remaining behind. This person must know:

- The route you will travel,
- Who is in the party, and
- When you expect to return.

If you are flying, always file a fight plan. If you do not return within a reasonable time, a search can be organized with little wasted time if these few facts are known.

Emergency

If you have crash-landed:

- Stay away from the aircraft until the engines have cooled and any spilled gas has evaporated.
- Check for injuries.
- Give first aid.
- Treat for shock.
- Make the injured comfortable.
- Be careful moving people with injured backs and fractures.
- Get the injured into a sleeping bag up off the snow.
- Get out of the wind or storm.
- Erect a temporary shelter.
- If the radio is operational, give periodic distress signals (keep batteries warm.)
- Be ready to signal or transmit on a moment's notice.
- Build a fire and make hot drinks.
- Build a permanent shelter.
- Keep a sharp eye on the injured. Remember, the injured may be you and you may have to direct the uninjured.

Recognition

Trauma associated with decision making

Many survival situations are straight forward. For instance, a helicopter may be stuck too far away in the mountains to even consider walking out. Consequently, the party is spared some of the psychological trauma of decision making. There is no question but that the night will be spent out of doors. The party is left with easier decisions, such as where to prepare the bivouac site.

Recognition of danger

The overland traveler, on the other hand, is much more apt to get into trouble. This person must be able to recognize a survival situation. This is the first step of winter survival. There are countless stories of people who froze to death because they did not recognize their life was in danger. *Therefore, you must recognize the danger and take action to stay alive.*

Panic

Sometimes panic follows recognition. Panic is caused by a lack of confidence and is the greatest contributor to death in a winter emergency situation. ***Preparation is the best control against panic.*** The more you know, the more control you have and the less tendency to panic.

Experience instills self-confidence

The experience each of you will receive in preparing a camp and sleeping a night in the snow is meant to instill some of the self-confidence and the psychological outlook which is so necessary if you are ever caught in a real survival situation.

Fear of snow

Man seems to have a subconscious fear of snow, and cold is generally associated with it. Many men have walked all night and completely exhausted themselves in an attempt to avoid camping out. They are afraid they will freeze to death if they go to sleep in the snow. Unfortunately, this is often true when the traveler is exhausted and wet with perspiration. A *traveler with confidence and some knowledge, however, will build a shelter and use the snow to stay warm.*

Overcoming the fear of snow

Fear of snow must be changed to respect. Snow provides the best protection when we are caught out in extreme cold:

- Snow has an insulation value similar to fiberglass and a foot of snow around a man in a sleeping bag will protect him.
- In the arctic, ptarmigan and foxes burrow into the snow and stay warm, no matter how low the temperature.
- An Eskimo's dog will curl into a ball, let drifting snow cover it completely, and survive the most severe storm.

Shelters

Following recognition of a survival situation (and having dealt with any serious injuries), the snow surveyor must next take stock of the situation. Shelter from wind, wetness, and cold must be obtained. The kind of shelter, its location, and materials may be important decisions to make. The circumstances surrounding every survival situation is different. It is not possible to spell out a list of requirements for every emergency situation you find yourself in. Snow, as a shelter, is often overlooked or is last to be considered. In any case, the campsite should be selected an hour or two before sunset, if possible. A downed aircraft may provide shelter from the wind, but that is all. It will be cold, cramped, and hazardous to cook within.

Snow Trench (Figures 7.1–7.8)

In open country, when snow is shallow and the temperature is not too cold, a snow trench makes a good shelter. *The principal tool for building any snow shelter is a large, strong snow shovel.* Trenches are the quickest and easiest shelters to build. Dig the trench deep enough to allow head room when sitting up. Cover the ground or snow floor with anything available, such as boughs, sticks, grass, and/or tarp and ensolite pad. *You must have insulation between yourself and the snow beneath you.* Build a roof over the trench using cut blocks of snow, tree limbs and boughs, or a tarp supported by skis and poles, etc. carefully cover the roof of the trench with an additional layer of snow for insulation. Close the entrance of the trench or cave with a packsack, snow blocks, or a door made of branches laced with boughs.

When snow is very shallow, it can be piled up before a trench is dug into it. If the snow is very cold and fluffy, a situation typical of interior Alaska, you may have to allow the piled up snow to sit-up for a few hours. In very cold temperatures, the snow trench should be just big enough to accommodate the number of people using it. This allows body heat to actually warm up the dead air space within the shelter.

Figure 7.1 Snow Trench Construction. Smooth surface and excavate trench with snow shovel.

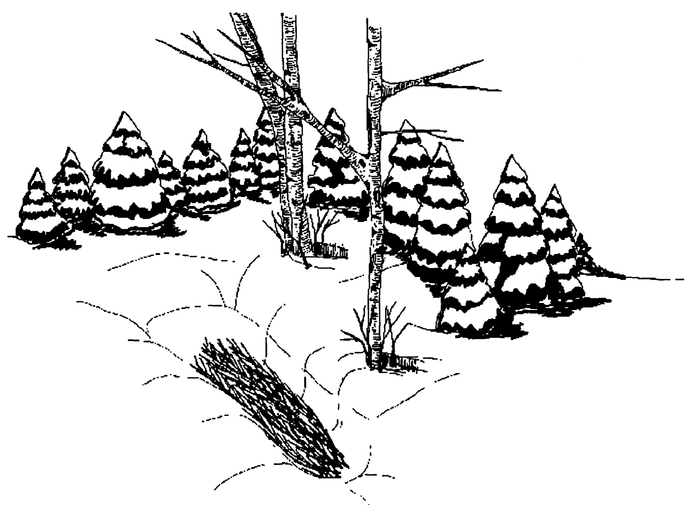


Figure 7.2 Snow Trench Construction. Line trench with evergreen boughs.

Figure 7.3 Snow Trench Construction. Place poles across trench to support roof.

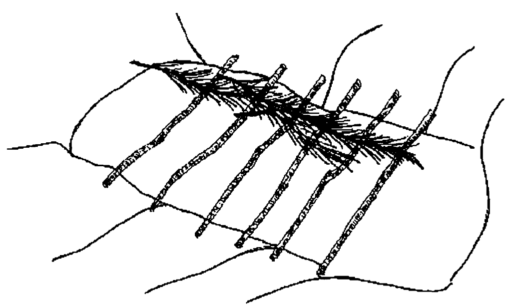


Figure 7.4 Snow Trench Construction. Cover roof poles with evergreen boughs.

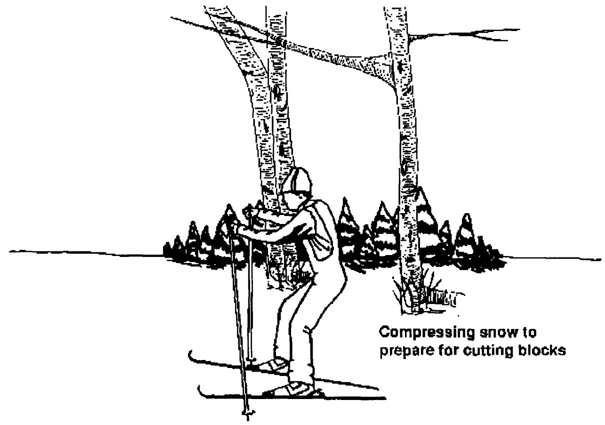


Figure 7.5 Snow Trench Construction. In areas where no trees are available, compress snow with skis or snowshoes to prepare snow blocks.

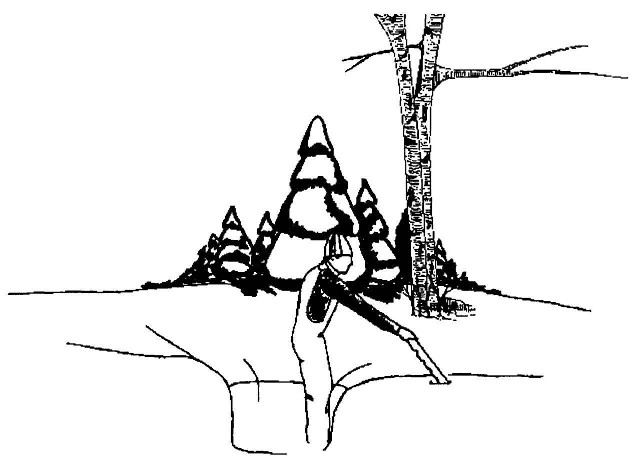


Figure 7.6 Snow Trench Construction. Use ice saw to cut snow blocks.

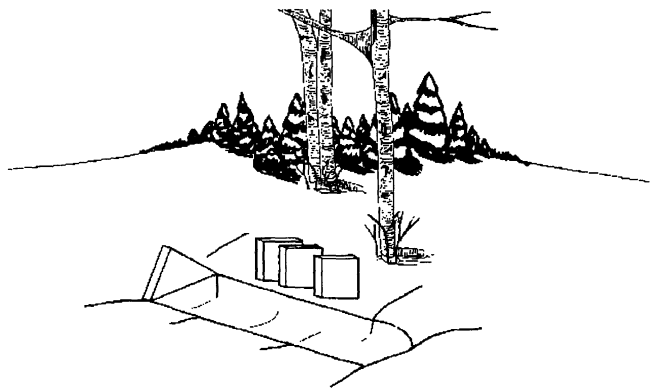


Figure 7.7 Snow Trench Construction. Place a snow block on each side of trench and lower the trench side of the blocks until they meet to form a peaked roof.

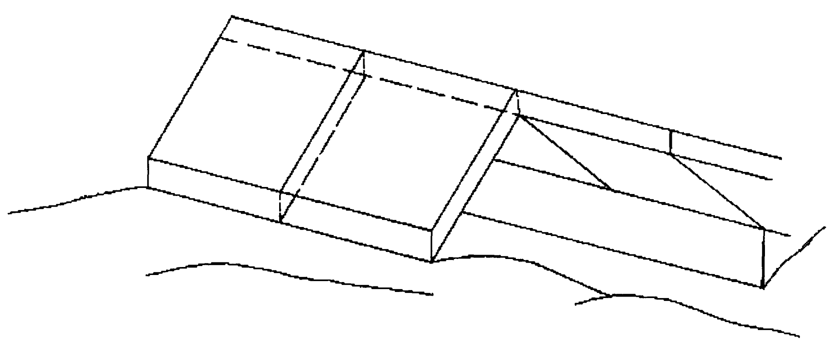


Figure 7.8 Snow Trench Construction. Continue placement of blocks for roof. Close one end with a block, use other end as an entrance.

Snow caves (Figures 7.9–7.12)

Snow caves are the warmest of all shelters and, therefore, they can afford to be somewhat larger and roomier than snow trenches. Caves require much deeper snow than trenches and are usually dug on sloping ground. Disadvantages are that it takes more time, and more physical effort is required to build one. The best place to dig is into the side of a deep snowdrift which faces away from the wind. Be sure the location is not under an overhanging drift (cornice) or in an avalanche path.

Caves are sometimes dug by burrowing into the snowdrift with a fairly small entrance tunnel, then enlarging the cave from within. This method is very laborious and the digger winds up becoming quite damp. A much easier method is to trace the shape of a person's body with arms extended on the snow surface. Dimensions of the outline are two-feet wide by 5-6 feet tall. This is called the "t" method. The "t" shape is then burrowed into the snowdrift several feet. Then begin enlarging a cave area within the drift by throwing the snow out through the horizontal arms. Once the cave is complete, the horizontal arms are closed in as well as the top half of the vertical portion so that a small entry way remains.

Take care not to make caves too large (wide) so that the roof becomes weak. If you wish, poke an air hole up through the snow with a ski pole or stick. Usually, there is enough air in the snow and leakage to provide ample oxygen.

The inside of a cave may be shaped in such a way that two sleeping platforms are dug out on either side of the entry way trench. The platform area is elevated so that, when sitting up, the feet hang over the side into the trench that leads to the crawl-through opening. The main cave area as well as the sleeping area, is higher than the cave entrance to retain warmer air within the cave. The beauty of the snow cave is that the air temperature, once warmed up by the people inside, will nearly always be within 25 to 32 degrees, even though the temperature outside may be 40 to 50 degrees below zero. The striking difference between inside and outside temperature can make the inside temperature appear luxuriously comfortable, and layers of outer clothing soon comes off.

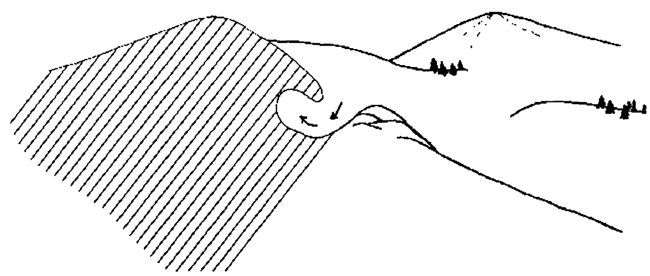


Figure 7.9 Snow Cave Construction. Begin excavation in the side of a snowdrift which faces away from the wind. Use "t" method.

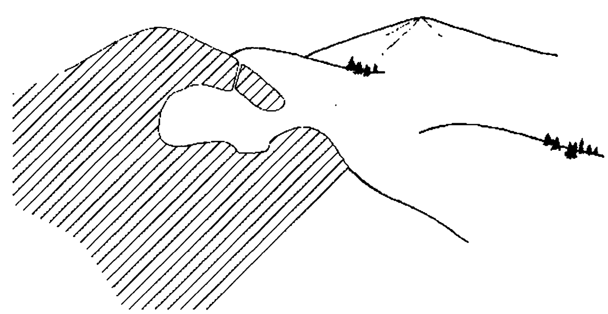


Figure 7.10 Snow Cave Construction. Shape inside of cave to allow for sleeping platforms, cooking platform, and cold sump. Use ski pole to bore air hole through roof.

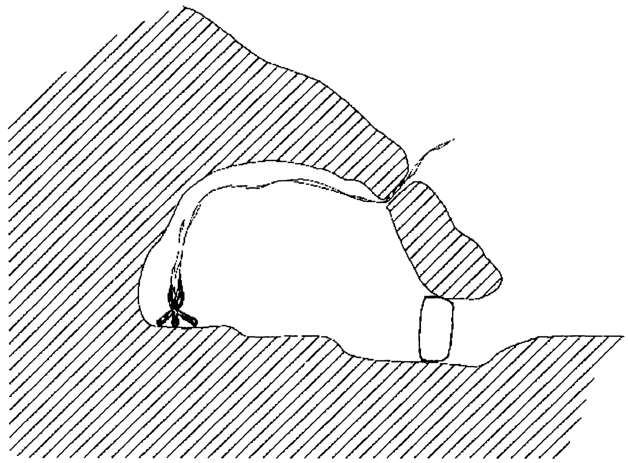


Figure 7.11 Snow Cave Construction. If a small fire is planned, locate it at back of cave higher than the sleeping platform. Construct cold sump lower than cave entrance.

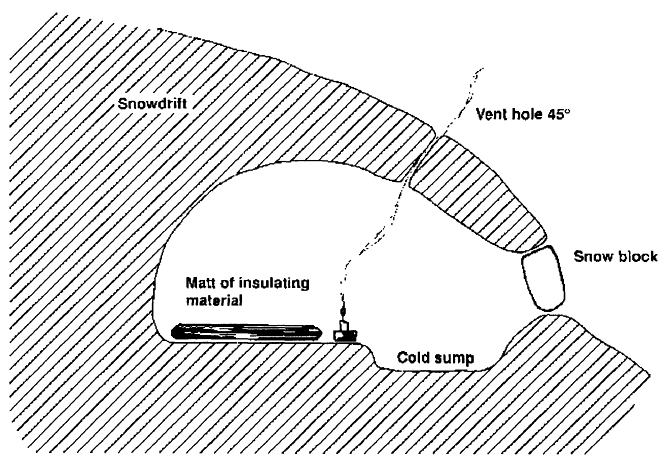


Figure 7.12 Snow Cave Construction. Basic layout of sleeping platform, vent hole, cold sump, and entrance.

Alaskan igloo (Figures 7.13–7.14)

Another type of snow shelter is the classic Alaskan igloo. This shelter is rarely used as a survival shelter except in the Arctic and Antarctic regions where incessant winds pack a sparse snowpack into extremely dense drifts. *The principal tool in constructing an igloo is a snow saw rather than a shovel.* This shelter is not covered in this course since proper snow conditions are rarely encountered except above timberline, and at these locations, a trench or cave could be built as well.

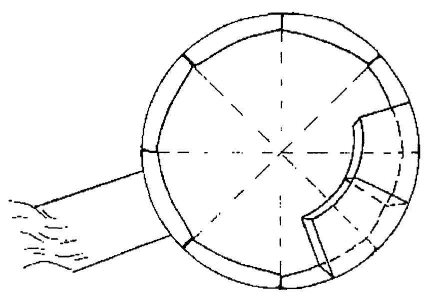


Figure 7.13 Alaskan Igloo Construction. Overhead view showing shape of snow blocks for roof and sleeping and cooking platform.

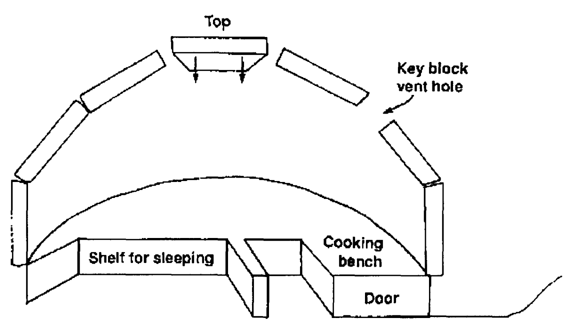


Figure 7.14. Alaskan Igloo Construction. Side view showing arrangement of roof blocks, shelf for sleeping and cooking, and door.

Thawing temperatures

Snow shelters may not be the best when temperatures are near thawing. Body temperature will soon have the inside of the shelter above freezing, and the roof of the cave or trench will drip or sag if great care is not taken during construction.

Lean-to (Figures 7.15–7.18)

In forested areas, a lean-to shelter can provide good protection.

- Select a level wind-protected spot.
- Tramp down the snow with your skis or snowshoes.
- Select two poles with a fork at the top, about 1 inch in diameter and four feet long, for the front corners. Shove them into the snow about six feet apart with the forked end up.
- Lay a ridge pole across the two forks. Lean additional poles against the ridge pole on the upwind side to form the lean-to.
- Cover the poles forming the roof and sides with boughs. Evergreen boughs readily snap when frozen. Push the broken end into the snow at an angle, all pointing the same way. The thicker the better.
- Next, construct a bed mattress using small springy boughs.
- You should allow several hours to build an adequate lean-to shelter.
- Most shelter engineers, given enough time and materials, end up closing in both sides so the shelter may resemble a pup tent. No two are ever alike.

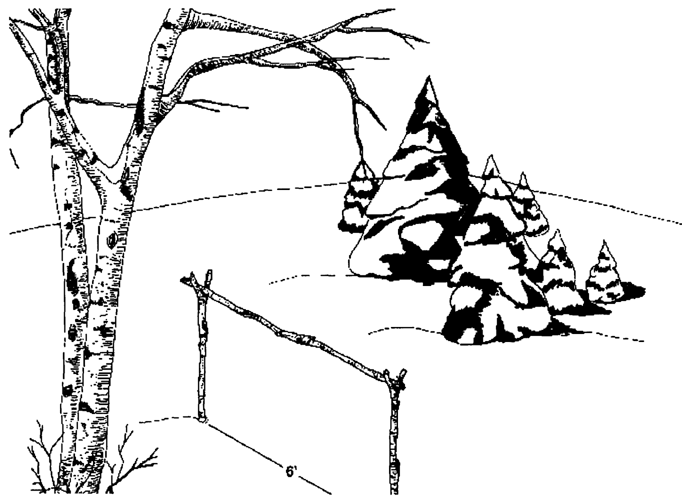


Figure 7.15 Lean-To Construction. Shove 1" diameter, 4' long ridge support pole into snow about 6' apart. Note fork at top of support ples. Lay ridge pole across the two forks.

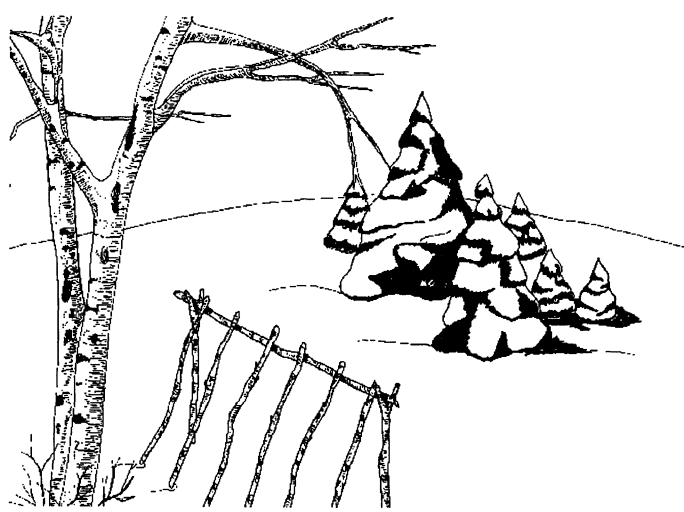


Figure 7.16 Lean-To Construction. Lay additional poles at an angle across the support pole.

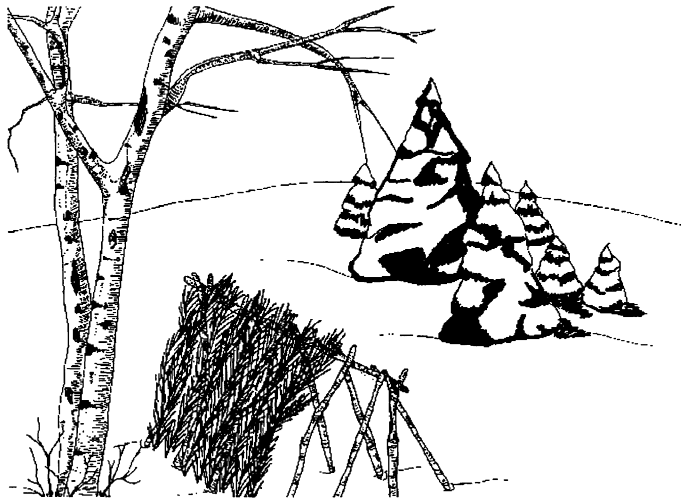


Figure 7.17 Lean-To Construction. Push broken end of evergreen boughs into snow and lean against ridge pole, the thicker the better.

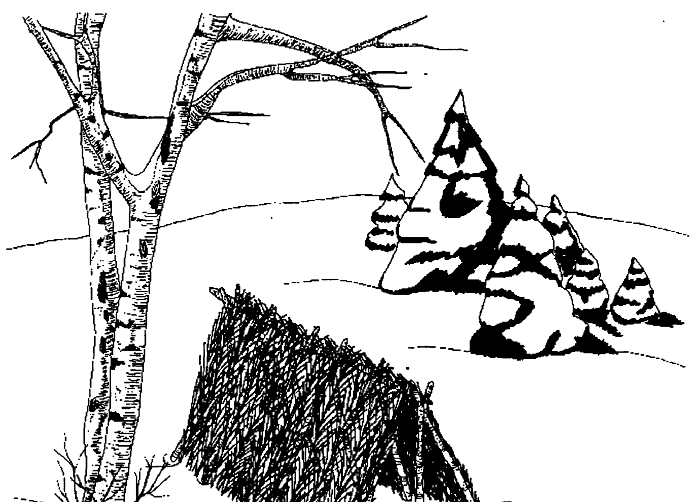


Figure 7.18 Lean-To Construction. A finished Lean-To.

Ready-made shelters

In late winter, a fairly easy place to produce a shelter is adjacent to the trunk of large spruce trees. The shape of spruce trees and density of the branches are such that, as the snow is shucked off, it tends to build up on the ground at the outer parameter of the branches away from the trunk. This can create a hollow at the base and provide a nearly ready-made shelter. A hatchet or small saw may facilitate enlarging the hollow on one side of the trunk by cutting away some of the lower branches. Level out the floor of the hollow by tramping the snow with skis or snowshoes. Thatch any holes or thin spots much the same as the lean-to. Downed trees provide other versions of halfway ready shelters.

Campfire

A big plus for the timbered country is the campfire which may provide as much benefit from warming the spirit as it does from warming the body. Lay a bed of green poles on which to build the fire and keep it fairly small and close to the lean-to. That allows the wood pile to last longer, and the fire won't disappear into a crater as fast. When evergreen boughs are available for a bed and wood for a fire, a person could spend a reasonably comfortable night with no more equipment than a match.

Signals

Once the shelter is secured and the party is warm, work towards being rescued.

When you fail to return on schedule, a search party will normally be dispatched the next morning.

Be ready with all possible signals to attract searchers, and be ready on a moments notice.

Prepare signals that will be recognized from the air. Tramp out huge letters 20 to 30 feet high in the snow with boughs for contrast.

Have materials ready for a smoke fire by day or a bonfire by night.

Be ready with flares, signal mirror, whistles, or gunshots. Beat on metal equipment to attract searchers.

Review "Staying Alive in the Arctic" for more tips and detailed instructions on signaling methods.

Water and Food

You can live for weeks without food as long as you have water.

- You should drink at least two to three quarts of water a day in order to stay healthy. ***Dehydration is life threatening. An early sign of dehydration is dark colored urine.***
- Do not eat snow. This causes a huge drain of body heat and cools the body's inner core temperature.
- Water obtained from snow, ice, or a flowing stream should be warmed before drinking. If fuel is unavailable, snow or ice can be packed into a water bottle and placed inside your parka. Escaping body heat will slowly melt the contents.
- Snow can be melted on a dark surface when the sun is shining.

Food carried in the survival kit should be readily digestible and balanced between fat, protein, and carbohydrates. Many dehydrated foods have a high calorie value, are lightweight, and keep for long periods of time. Soups and bouillon cubes are highly desirable since they assist liquid intake. Your provisions should not be raided on routine trips, but saved for their intended use.

Rabbits are often abundant in the winter. Rabbits are easily caught with a copper wire snare and a little practice; so be prepared.

Fire

Every emergency kit should contain moistureproof matches plus an alternate method for starting fires. There are many methods available. One method uses a "metal match", raw cotton, hemp rope, and a small vial of Kerosene. *These will take up no more room in a pack than a bar of soap.* Fires may be easy to start in very cold weather because of low humidity and dehydrated fuel. However, they can be extremely difficult to start during adverse conditions. First, spend some time getting ready:

- Round up a good supply of varying fuel sizes. Clumps of small, dead spruce twigs obtained near the trunk are excellent starting materials.

- The metal match, when scrapped by a knife or other sharp metal edge, will produce a huge supply of sparks. Convert the sparks to flame by striking them into a small wad of raw cotton. The cotton will ignite instantly, but lasts only a short time.

- The flaming cotton is used to ignite something with more staying power, such as several inches or strands of hemp rope.

- Next, add a small amount of dry spruce twigs, then carefully build the fire by adding more and larger fuel. When conditions are damp, a few drops of Kerosene to the spruce twigs will provide all the assistance needed, if care is taken in selecting the initial, dry, starting fuels. You may even have to cut away the outer wet portion.

- Take great care to make the fire starter materials last as long as possible.

Sleeping

A down sleeping bag should be "fluffed" by shaking it vigorously to get as much air as possible into the down filling. Clothing worn inside the bag should be no more than necessary — the same as during the day. It is easy to overdress and sweat inside the bag. On the other hand, if you wake up at night feeling cold, you should "bicycle" — pumping your arms and legs — inside the bag to warm up. Even if you are "underbagged," you can get a decent night's sleep with periodic cycling.

Cycling works great for warming up the bag when you first get into it, and eases the shock when getting out in the morning. Keep felt inner boots, liners, or innersoles inside the bag with you. Also, keep some of your clothing "layers" inside the bag for putting on in the morning.

Travel

If your mechanical transportation has failed, think twice before leaving to walk out. A good rule is to stay put! *Your main objective is to stay alive. The surest way to accomplish this by waiting for rescue.* You should not travel alone nor leave someone else alone. If you are still intent on leaving, ask yourself the following questions:

- Is the weakest member physically fit?
- Do you know where to go, how to get there, and that you can stay on-course in bad weather?
- Can you handle adverse weather, build a shelter and fire, and procure water enroute?
- Will your food last the trip?

If you do leave, post a conspicuous note telling which way you are going and your intended destination. *Be sure to mark your track so you can be followed by searchers or find your way back if necessary.*

Summary

- In a survival situation, you must help yourself. *Your own head is your best survival tool.* Don't depend on someone else to think and plan for you.
- Make definite plans each day as to what you are going to do, and stick to it.
- Continually analyze the party's resources and how to use and conserve them.
- Make a real effort to keep your own spirits high and help others in the party to do likewise. Depression can undermine the will to live.
- Keep busy throughout the day by improving the camp and preparing emergency signals, but do not over exert or use energy needlessly.
- Avoid perspiring and, if possible, keep a fire going.
- If you are involved in an aircraft failure, stay with the aircraft. It is much easier to find an airplane than people.
- *Above all, you can be certain that search procedures will already be started.*

8. Travel-Surface

Chapter 8—Travel-Surface

Objectives

Upon completion of this lesson, participants will be able to:

- List and describe three methods of foot travel used by snow survey teams.
- List and describe three types of mechanized travel vehicles and discuss their operation and maintenance.
- List five factors that contribute to a successful cross-country trip and explain the part attitude plays.
- Construct or explain how to construct rope ski climbers and rescue sleds.
- List and demonstrate maintenance and safe handling of oversnow machines.

References

West-Wide Snow Survey Training School Workbook

Oversnow Machine Maintenance Manuals

Time

Classroom: 1 hour, 15 minutes

Foot Travel

Nonsnow

Horse

Logistics for pack trips should be worked out with the packer in charge.

Foot

Foot travel will be subject to the normal limitations of any hiking as far as weight of load and speed of travel is concerned. Proper foot gear and foot protection is imperative. A safe route should be traveled to avoid injury. Detailed planning will be needed to select clothing, survival, and job equipment which can be carried. Terrain and elevation must be considered.

Oversnow

Foot

During the snow season, foot travel may be necessary.

- Terrain
    - — Over glacier or other ice.
    - — Over terrain where extreme care is needed due to hazards of travel.
    - — Over areas of intermittent snow cover.
- Equipment
    - — Hiking or climbing boots, cross-country boots, mountaineering boots.
    - — Crampons.
    - — Ice ax.

Snowshoes

- Models. Snowshoes come in many models and sizes. The model and size used depends on: (see figure 8.1)
    - — Size of person and load to be carried.
    - — Steepness of terrain.
    - — Softness and depth of snow.
    - — Open terrain vs. timber or brush.
    - — Distance to be traveled.
    - — Individual preference.

- Materials. Snowshoes are constructed from a variety of materials.
    - — Frames
        - Wood
        - Metal alloy
        - Plastic
    - — Webbing
        - Rawhide
        - Neoprene
        - Plastic
- Bindings (see figure 8.2)
    - — Types
        - "A" type
        - "H" type
        - 3-pin cross-country type
        - Cable type

Figure 8.1

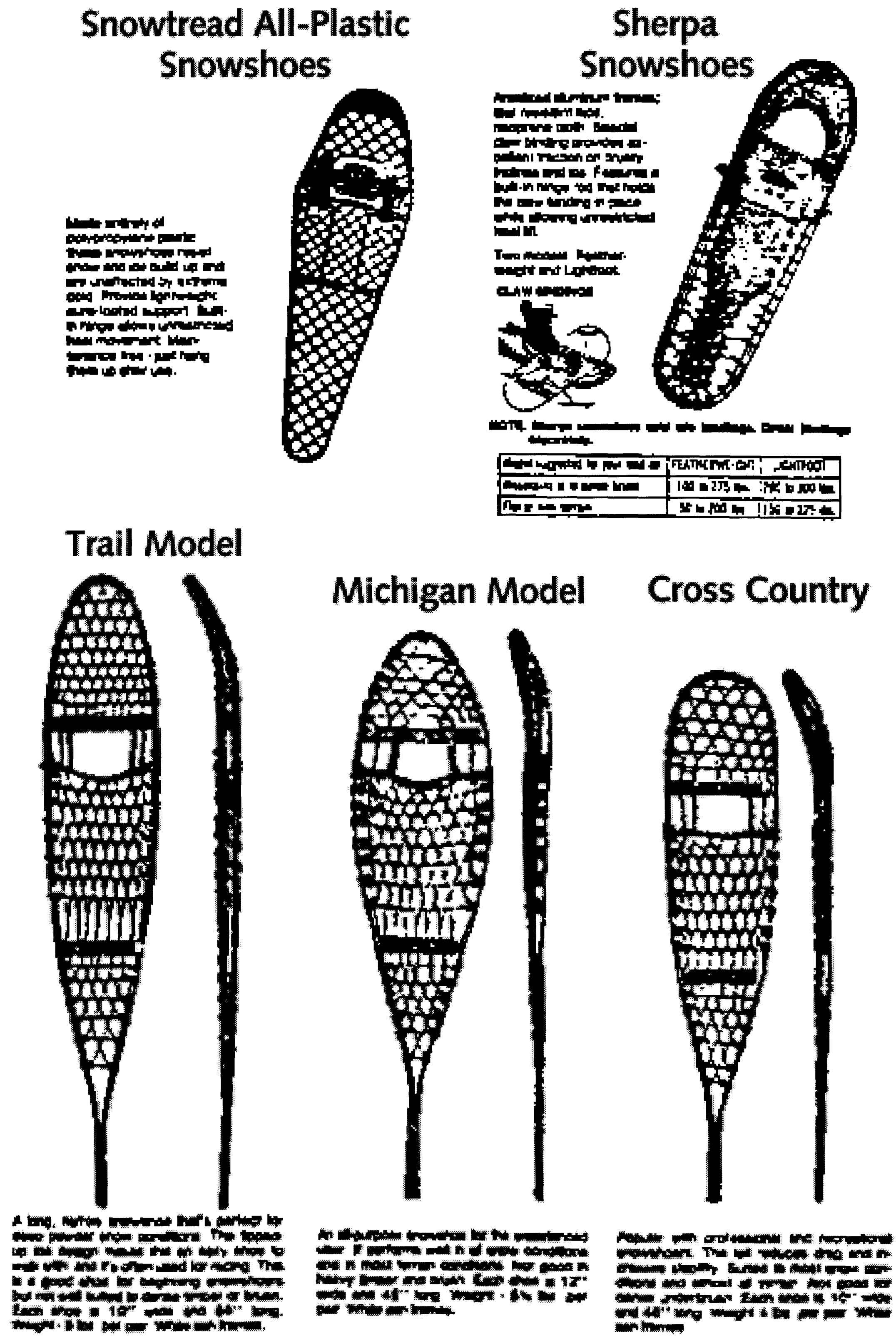
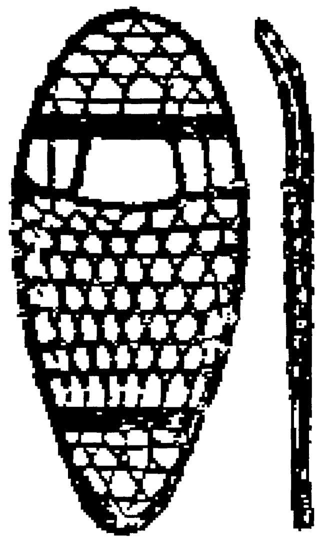

Snowtread All-Plastic Snowshoes
Sherpa Snowshoes
Trail Model
Michigan Model
Cross Country

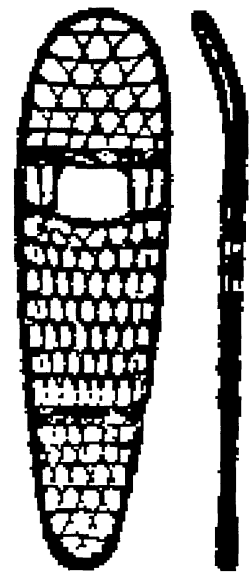
Figure 8.2

Bear Paw Model



The ideal snowshoe when maneuverability counts. It works well in heavy timber and brush. The short design allows for tight kick turns. Ideal for beginners. Each shoe is 13" wide and 28" long. Weight: 4 lbs. per pair. White ash frames.

Green Mountain Bear Paw



A most versatile shoe with a unique design well-suited to beginners. Very maneuverable in brush. Each shoe is 10" wide and 36" long. Weight: 4½ lbs. per pair. White ash frames.

Bindings

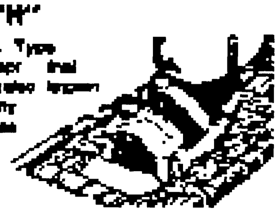
Type "A"

A parallel-type binding of moderate control. The heel strap and sandal-type toe piece provide excellent support.

[illegible]741 Neoprene per pair.
[illegible]742 Leather per pair

Type "H"

Same as Type A except that Type H (also known as the Army binding) has a solid toe piece.



  - Materials
    - Leather
    - Neoprene
    - Metal alloy
- Accessories
  - Climbers to grip on slopes or hard snow.
  - Tapping pad for use with federal snow sampler.
  - Ski poles for stability.
  - Boots. Type used mainly personal preference—rubber/leather, pac, leather hiking boot, cross-country or light mountaineering boot.
- Maintenance
  - The best maintenance is preventive maintenance.
    - Inspect snowshoes and accessory items for damage well in advance of using to allow time for repairs, if needed.
    - Make repairs with the same or similar materials used in original construction.
    - Replace any items which cannot be made serviceable through repair.
    - Keep wooden frames and rawhide webbing well varnished to prevent absorption of water.
  - Field maintenance
    - Use care to prevent equipment damage in the field.
    - Carry basic repair items on the trip (i.e., rawhide, wire, screws, tape, small, etc.).

Skis

Types:

- Downhill
- Mountaineering
- Cross-country

Factors in selecting type and size:

- Size of person and load to be carried.
- Softness and depth of snow.
- Steepness of terrain.
- Open terrain vs. timber or brush.
- Distance to be traveled.
- Individual preference and skill.

Most skis today are laminations of these materials:

- Wood
- Metal
- Plastic
- Fiberglass

Characteristics (general)

- Downhill: Wide ski; metal edges; flat bottom waxed; boot in solid, full release-type binding.
- Mountaineering: Medium width; usually metal edges; flat oil textured bottom, waxed or unwaxed; heel release binding with or without clamp-down capabilities.

- Cross-country: Narrow width; usually nonmetal edges; flat or textured bottom; waxed or nonwaxed; heel release binding.

Bindings

- Solid downhill type
- Modified downhill-release type
- Mountaineering heel release type
- Cable cross-country type
- 3-pin cross-country type

Accessories

- Climbers—Seal skin, mohair, rope
- Tapping pad for use with federal snow sampler.
- Poles
- Boots—Style depends on type of ski and binding.

Wax vs. Nonwax

The choice of waxing vs. nonwaxing mountaineering or cross-country skis, usually, is determined by personal choice and/or ease of operation. Techniques of waxing can be easily learned, but are time-consuming. Skis with climbers or specially textured bottoms will allow uphill and general cross-country travel without waxing.

Maintenance

- Preventive maintenance
  - Inspect skis, bindings, poles. etc. for damage before the field trip.

- — Tighten screws, adjust bindings, add base wax, etc. at the office.
- — Have specialized repairs made at a competent ski repair shop.
- — Replace any items which are too badly worn or damaged for repair.

- Field maintenance
  - — Use care to prevent equipment from being damaged in the field.
  - — Carry basic repair items, i.e., screws, extra cable, extra 3-pin baal, replacement ski tip, ski splintering material, tape, wire, etc.

Mechanized Travel

Road type vehicles

Since a great amount of time is spent on summer maintenance, consideration must be given to the use of vehicles on back country roads.

- Drive carefully to prevent vehicle damage.
- Use four-wheel drive to get you out of trouble, not into trouble.
- Carry emergency repair items, i.e., tools, tape, water or coolant, spare belts, spare radiator hose, spare electronic ignition module, jack, spare tire, etc.

Large oversnow type vehicles

Machines capable of carrying several people and large loads.

- Use care in operating to prevent damage.

- Carry emergency repair items similar to those carried in road type vehicles.

Snowmobiles

One to two person, light load.

- Twin track, single ski
  - — Larger track bearing surface, thus greater flotation on deep, soft snow.
  - — More area to carry larger loads.
  - — Less maneuverable
  - — Generally, best adapted on flat to moderate slopes with few obstacles.
- Single track, double ski
  - — Generally faster, more maneuverable.
  - — Load space and capacity limited.
  - — Climbs steeper slopes if snow is firm.
  - — Less stable than twin track machines.

Operation

Instructions from the manufacturer or dealer, usually in the form of an owner's manual, should be followed.

- Experimentation to get correct carburetor jets or adjustment for your elevation will be necessary.
- Practice to develop operating skill will be necessary.

- Experimentation in packing equipment properly will be necessary.

- Auxiliary racks can be built for equipment hauling.

Maintenance

- Preventive maintenance

  — Follow procedures outlined in the owner's manual.

  — Inspect spark plugs, track tension, control cables, fuel tanks (leaks), drive belts, gauges. Check oil, perform lubrication. Check coolant, check battery, etc.

  — Follow owner's manual instructions for summer storage.

  — Set up some schedule for dealer inspection and service if there is no one else to do detailed maintenance.

- Field maintenance

  — Operate with care.

  — Carry basic repair items, i.e., tools, belts, spark plugs, control cables, extra fuel, come-along winch, tape, wire, etc.

The Cross-Country Trip

Many factors contribute to a successful cross-country trip. Already mentioned were:

- Conditioning

- Planning

- Training and skill development

- Proper equipment and maintenance

Another factor of paramount importance is *attitude*. A cross-country trip for snow survey work is intended to get the job done safely. The attitude of the personnel involved should reflect this.

Basic Attitude Items

- Do not assume invincibility.
- Do not travel alone.
- Select the safest routes possible—avoid avalanche terrain, steep or rocky slopes, unsafe snow bridges over streams.
- Do not take chances to impress someone or to attempt to save time.
- Anticipate what to do in case of equipment failure or need for an overnight bivouac.
- Do not ignore or shortcut the safety and survival rules you have learned.
- Stop and think. *Use common sense.*

Every trip will have its own peculiarities. This must be recognized and handled accordingly by the individuals involved. The basic rules apply to all cross-country travel and should not be ignored. Conditions may be encountered where combinations of motorized, ski/snowshoe, and foot travel may be necessary. Plan accordingly.

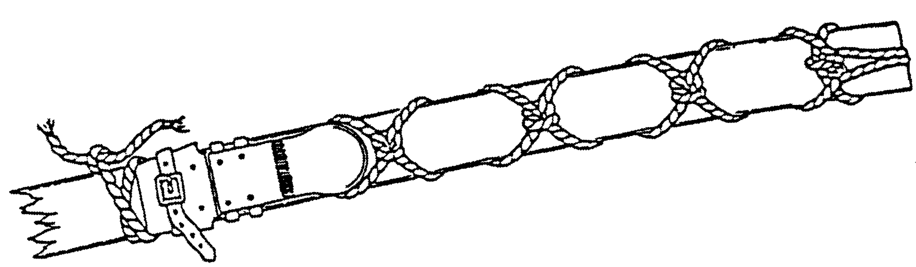
How to Construct Rope Ski Climbers (Figure 8.3)

After measuring snow for 32 years and traveling countless miles on skis this was the first year and the first time I have had an opportunity to use a pair of Seal Skin climbers on my skis for an uphill trip that lasted the better part of all day. After a couple of hours, I had the feeling that I was carrying a couple of six-inch logs on each foot. The snow was NOT sticking to the skins, it was just the added weight which made the skis clumsy to handle. Fortunately, I had thrown my rope climbers in my pack before leaving home. I stopped; lit the old pipe and pulled off the skins; dug out the rope climbers and slipped them onto the skis; tied them up and mounted the trusty steeds. WHAT A RELIEF, and light as a feather. I soon overtook my companion and we traveled on up the trail. Soon I was breaking trail. My companion stated that he had never seen a set of rope climbers tied like mine and did not believe that they would hold so well; and I mean we were going up, and how. That night in the cabin we found some 1/4 inch hemp rope and I tied a pair for him. The next day on up to the snow course (Reference: 1948 Snow Surveyors Forum illustration on page 15) my companion stated that he was through with skin climbers and was going to use the rope climbers from then on.

Advantages—Good Traction; Light weight; easy to dry and easy to carry; useful for other uses besides climbers; cheap and easy to replace.

Disadvantages—Not too good on icy side hills. But what is?

Figure 8.3 Rope Ski Climbers



How to Tie Rope Climbers

- Two lengths of 1/4 inch Hemp rope 13 feet long (each).
- Double one rope and tie the rope together with a SQUARE knot 8 inches from the midpoint fold. Pull knot very tight.
- Bind this loop together with several wraps of twine or string just behind the knot and towards the folded end. Make a second bind about 3 1/2 or 4 inches from the first and towards the folded end. This makes a loop that will come over the tail of the ski.
- Place the first square knot under the ski near the tail and bring the ends of the rope up around on top, one on each side, and tie another square knot on top of the ski, and pull up very tight. (If the rope is now slid off, this knot should be about 5 inches down from the first knot. Slip back on ski in place.)
- Now with the rope tied around the tail of the ski and knot No. 2, on top of the ski, bring the wrapped loop over the end and pass the loose ends of the rope around and down through the loop and pull up tight against knot No. 2.
- From here on all is easy. Part the ends of the rope around the ski tying square knots under and over, under and over about 6 to 8 inches apart. Do not pull these knots up too tight until you have them well spaced with the next to the last knot just behind the heel plate and the last knot under the ball of the foot. The ends of the rope are brought up from under the foot in front of the toe irons of the ski binding, and tied in another square knot. This knot should be placed on the outside of the ski and the ends tucked in so you don't tramp on them. If there is excess rope it should be cut off and the ends neatly wrapped or tied with a rosebud or something to keep the ends from fraying.

- To remove the climber, untie the knot in front of the toe irons (ONLY) and slide the ropes off the ski. Do not untie all the knots.

- To replace the climber on the ski put the last solid knot under the ski over the tail end. Then thread on, one under, one over, until the tail of the ski slips into the wrapped double loop. Take up all the slack and tightly tie around in front of the toe irons. It may be necessary to file a small notch in the tail of the ski to assist in keeping the rope loop on the back end. However, if the climbers are kept tight and if loop behind knot No. 2 is not too close, this is not necessary.

Like a sailor, any good Niphometrologist can tie one of these in a few minutes provided he/she does not get his/her fingers all bound up in the knotty problem. And he/she certainly will not have fifteen dollars tied up in a pair of skins either. I know we don't use them very often, but when you need a pair of climbers they are needed very badly.

Note—A rope that is slightly used and limber is better than a new stiff rope because the knots can be pulled up tighter and the knots will not work loose, they will stay put.

Building a Rescue Sled

A V-shaped rescue sled Model No. 1 (figure 8.4) is easily built. It is suitable for hauling short distances and downhill across steep slopes.

For a long haul, particularly on flatter slopes, make sled Model No. 2 (figure 8.5).

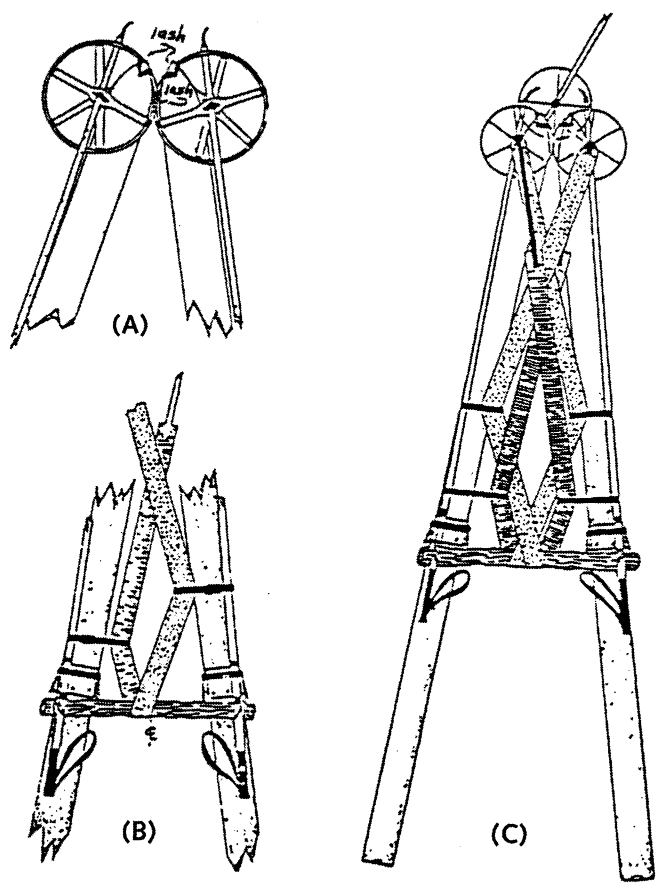
Model No. 3 (figure 8.6) is the most satisfactory rescue sled. It requires an extra pair of skis to make it, however.

Remember, all sleds must be built strong and knots made tight.

Model No. 1 (Figure 8.4)

Place a ski pole snow ring over the tip of a ski with the pole to one side of the ski and with the ring lying on the ski and under the pole. Thread the hole in the ski tip with 3 feet of copper wire and lash the snow ring firmly to the ski. Do the same with the other ski. Place ski tips side-by-side, poles on the outside, and lash overlapping snow rings with wire or nylon cord 10 or 12 inches long (A).

Figure 8.4 Model No. 1



Spread heels of skis to inside width of about 2 feet. Cut a tree limb about 2 inches in diameter and 20 inches long. Place limb behind toe irons and under ski poles. Lash poles and bough to toe irons of each ski with a piece of wire 3 feet long. Place ski loop of a climber over the left ice prong. Pull climber back firmly, wrap once around bough spacer, slightly left of midpoint, extend to right ski tip, pull firmly, and tie tail-end strap to right ice prong. Buckle climber to ski poles (B).

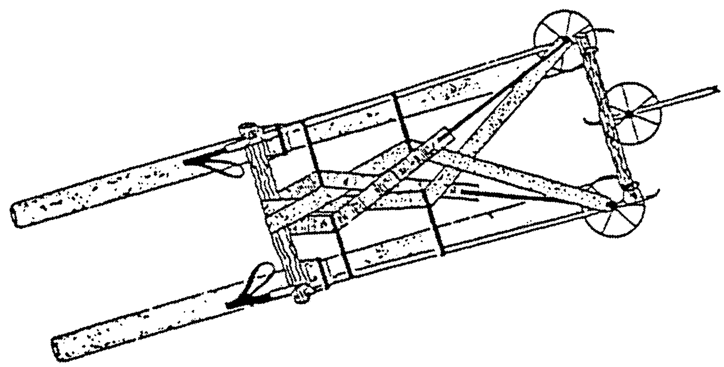
Attach the other climber in the same way, starting with the right ice prong and working to the left. If available, fasten boughs, blankets, or other material on this cross webbing. Lash one of your own ski poles to the snow rings at ski tips (C).

If necessary, lash the injured person to your rescue sled. Wrapping nylon cord completely around the sled will not rough lock excessively. If the injured person can sit up and ride forward, a pack-sack can be fastened to the sled as a backrest. If he/she must be laid down, he/she will fit on the sled best with his/her head forward, although this may make going down steep slopes more difficult. The person towing the sled should have climbers on his/her skis for braking and pulling.

Model No. 2 (Figure 8.5)

Make this sled similar to sled Model No. 1, but spread your ski tips until skis are parallel. Cut a second tree limb about 1 1/2 inches in diameter and 20 inches long and lash ends securely to ski tips. Lash the snow ring of one of your ski poles to the center of the front bough, with the snow ring over the bough and the ice prong under it.

Figure 8.5 Model No. 2

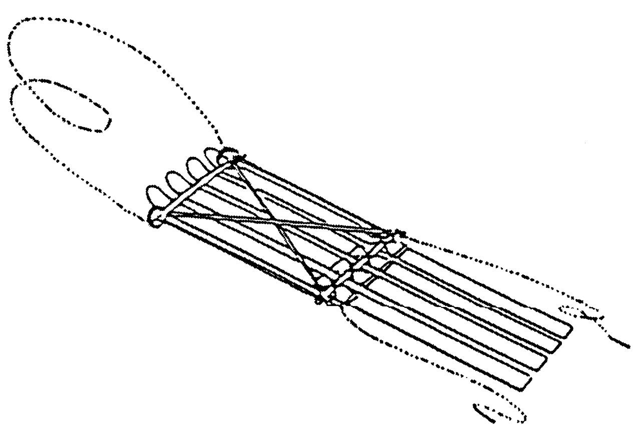


Model No. 3 (Figure 8.6)

This sled requires four skis and a long piece of stout rope. It takes several people to pull the sled and guide it with side ropes.

Make two cross sticks from poles or from brush branches cut to fit across the four skis. Place one cross stick at the tip end of the ski and the other at the center lashed to the bindings. Lash each stick to the cross sticks. Make the forward cross stick fast to the tips where they begin to curve upward. Here again, holes in the tips of the skis are handy. Diagonal cross lashing helps keep the riggings in shape. Cover the sled frame with boughs or clothing, especially at the metal bindings. Tie the injured person onto the sled to keep him/her from rolling off and suffering more injury. Take particular care in braking on downhill slopes.

Figure 8.6 Model No. 3



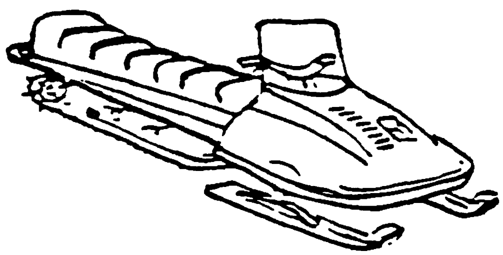
Oversnow Machines

Introduction

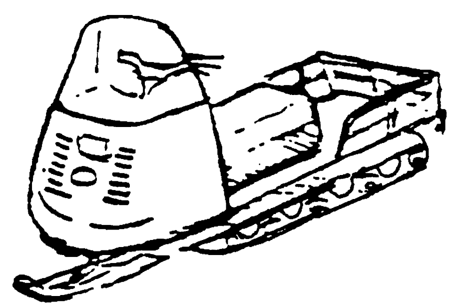
The inaccessible snowbound countryside has been opened up to people by power-driven, high-flotation, oversnow vehicles. Oversnow machines now provide transportation for work and recreation access to locales once not regularly visited by people in winter.

Snow vehicles are complex machines—the result of years of design, experience, and development.

Figure 8.7 Snowmobiles



Single tracked—double ski type snowmobile (recreational)



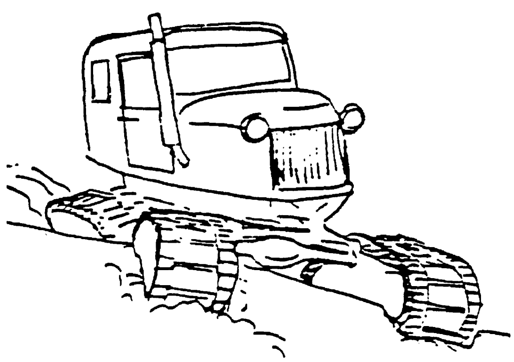
Double tracked—single ski type snowmobile (utility)

Today's oversnow machines are closely engineered with efficiency in mind; most snowmobiles are powered by lightweight, air-cooled, two-cycle engines. Structural body, drive trains, and tracks and skis are all of sufficient, but not excessive, capacity to meet the design loadings and intended uses. The keys to successful operations are your knowledge of the vehicle, your acceptance of it as a machine with limitations, and your personal good judgment, experience, and driving abilities.

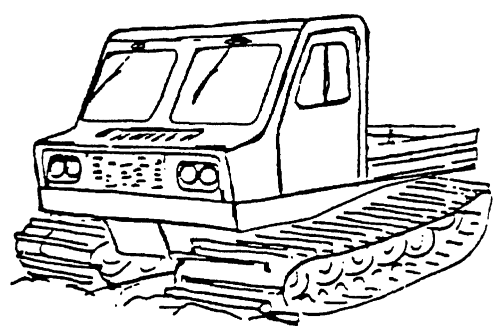
You will be responsible for the snow vehicles and associated transport equipment; i.e. flatbed trucks or trailers. These special purpose vehicles are generally expensive and will require extra and specialized maintenance. Your personal attention to these special operational and service and repair matters is essential.

Thirty minutes of travel in a good snowmachine can place you nearly a day's return walk from your beginning point. Therefore, we must stress becoming familiar with and learning proper driving habits and other behavior that will ensure your personal safety, successful mission accomplishment, and continued good service from the oversnow vehicle.

Figure 8.8 Snowcats



Four-tracked style snowcat



Two-tracked style snowcat

Operation of Oversnow Transport Vehicles

This section will be largely a listing of important do's and don'ts of snowmachine operation with accompanying discussion or visual aids as needed. Matters of importance to single passenger, open snowmobiles will be covered first with additional discussion at the end of this section on large snowcats, (multiple passenger, enclosed cab vehicles).

- Review operators manual before operating first time. Unique features and operational instructions are already explained here for your benefit.

- Develop your own checklist to use before you start up each day. These items should be included:

  — Are fuel and/or oil tanks full?

  — Do you need extra fuel for the day?

  — Check throttle. Depress and release several times to ensure smooth operation. It should return to the idle position.

  — Check brake operation. Note: On double-track machines with shifting transmissions, check both brake adjustments—it is imperative that the brake that controls movement of the transmission shafts be a little tighter than the other. You must be able to stop all movement in the transmission before you attempt to shift the gears.

  — Check steering operation.

  — Check skis and ski legs (are carbide runner bars in good shape)?

  — Check ski alignment (steers best with 3/8" – 3/4" toe-in at front).

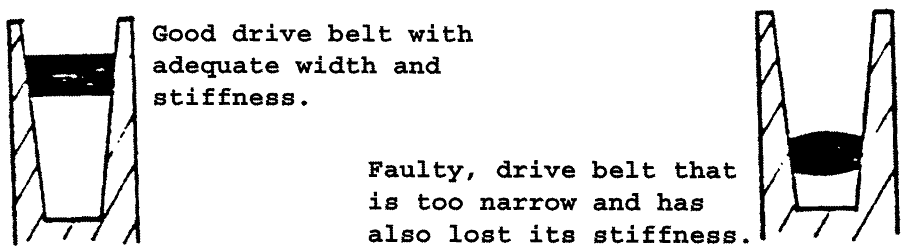
  — Are tracks free rolling, centered on sprockets, and not stretched too tight?

  — Do all lights work?

  — Are safety kill switches operable?

  Is drive belt in good condition? It is free of cracks and breaks, or is it too narrow from wear? After a belt has been used a while, it will become soft, and light pulls will cause lateral compression, making it impossible for the clutch to work properly. A belt whose cross section has been "burned" away by excessive clutch slipping will also not work properly.

Figure 8.9 Cross sectional view of drive sheave.



— Are all emergency and work items loaded and fastened securely?

— Does any of your load pose potential hazard to you or the machine?

- Match operating speed to the conditions.

— Machine will not steer or break normally on icy surfaces.

— Drifting snow may cause very choppy, hard, and irregular surfaces.

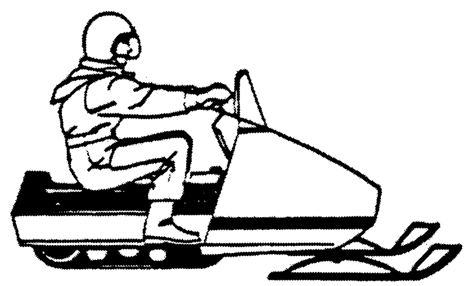
— Do not out-drive your range of visibility.

— Maintain machine speed sufficient to get through soft unpacked snow without bogging down and becoming stuck.

- Riding your snowmobile is relatively simple, but let's review three important fundamentals: Riding position, balance, and momentum are the basic principles of making your snowmachine go where you want it to go. The balance principle is quite simple, as you can shift your body weight to stabilize your machine on a hillside or lean into a turn to improve your machine's turning ability. Experience will tell you how much to use. The riding position for best balance and control depends upon certain conditions:

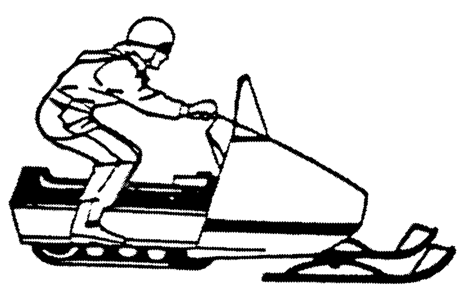
— *Sitting*: Feet on *running boards,* body midway back on seat; the best position when operating the snowmobile over familiar, smooth terrain or groomed trails. In this position, the legs should not be fully extended under the hood. Knees and hips should remain flexible to absorb shocks.

Figure 8.10 Sitting



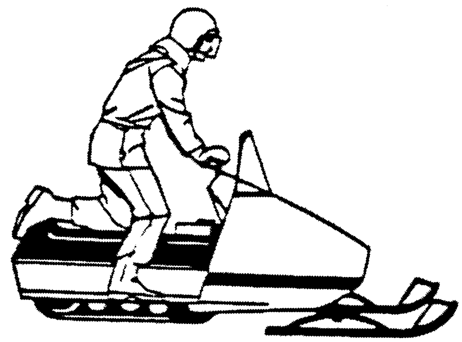
— *Posting*: A semi-sitting position with the body off the seat and the feet under the body in a sort of squatting posture, thus the legs can absorb shocks when traveling over uneven terrain. Quick stops can be dangerous.

Figure 8.11 Posting



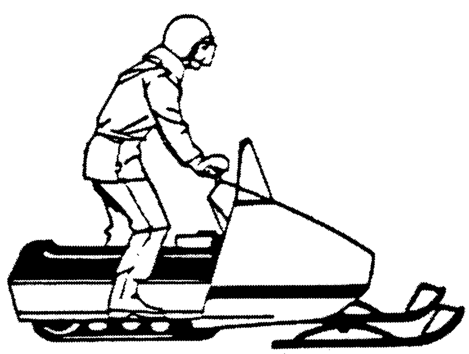
— *Kneeling*: This position involves placing one foot firmly on the running board and the opposite knee on the seat. Quick stops must be avoided.

Figure 8.12 Kneeling



— *Standing*: Place both feet on the running boards. Keep knees flexed to absorb the shock from the surface bumps. This is an effective position to see better and to shift weight as conditions dictate.

Figure 8.13 Standing

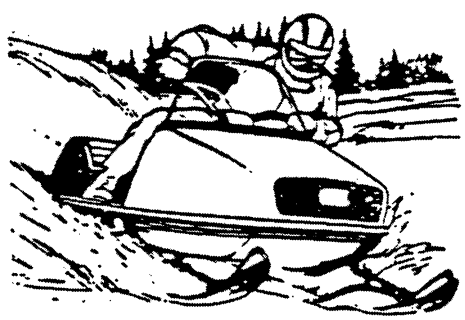


The third principle, momentum, is critical to successful climbing, turning, and generally moving through unpacked snow.

The flotation of the front skis and weight shifting of your body are all more effective at the correct operating speed. If a driver hesitates out of uncertainty, these effects diminish rapidly.

Do not maintain momentum that is hazardous to you or your vehicle. However, only miles of experience will prepare you to judge momentum that will not be hazardous in some circumstances.

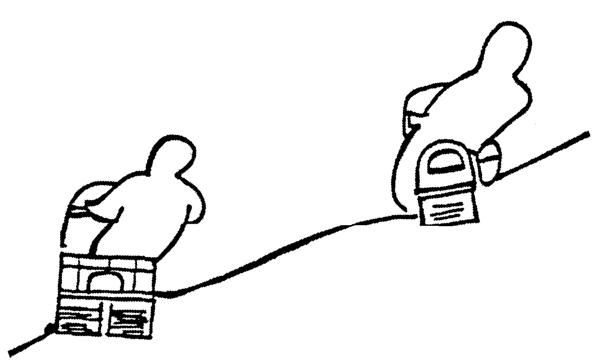
Figure 8.14 Momentum



Likewise, you will soon realize from experience that the full capacity of your snowmobile will not be realized until you can smoothly coordinate and apply proper balance, body position, and momentum.

Use of body weight to hold snowmachine on hillsides.

Figure 8.15 Body position



For soft powder snow, single track machines will perform best with the front track suspension adjustment set to cause the track to go deep into the snow. On double tracked machines, use the lower forward gear. Always take turns breaking the trail to avoid overheating or drive belt abuse.

Ascend steep hills diagonally across the slope if space permits.

If the hill requires a direct straight-up ascent:

- Select an open, smooth part of the hillside.
- Approach with maximum safe speed.
- Before you lose momentum and traction, make a turn across the slope returning down the slope for a repeat attempt, which will be greatly enhanced as you return on your packed track.
- Double tracked machines, of course, can be shifted to reverse, backing down the hill for another attempt.

Reduce speed on ungroomed trails.

Avoid frozen lakes and streams.

Be continually cautious in unpacked snow for obstacles just under the surface of the snow; i.e, rocks, logs, wires.

Be extremely careful loading and unloading machines from the trailer or truck.

Observe all winter survival rules applying to clothing with emphasis on water and wind resistant outer layers. Severe chill factors may be encountered at cruising speeds even on moderately cold days.

Figure 8.16 Wind Chill Chart

U. S. CUSTOMARY WIND CHILL CHART												
Combined Speed Of Wind and Snowmobile In MPH	Actual Thermometer Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Temperature (°F)											
0	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-21	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-36	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-124
25	30	16	0	-15	-29	-44	-59	-74	-86	-104	-118	-133
30	28	13	-2	-18	-33	-46	-63	-79	-94	-108	-125	-140
35	27	11	-4	-20	-35	-49	-67	-82	-96	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(wind speeds greater than 40 mph have little additional effect)	LITTLE DANGER* *(FOR PROPERLY CLOTHED PERSON)				INCREASING DANGER*			GREAT DANGER*				
	*DANGER FROM FREEZING OF EXPOSED FLESH											

Wear a good fitting helmet with a face shield and adequate hearing protection. Use ear plugs as well, if needed.

If you're stuck, think it out first. Use your shovel or your partner's machine before you start pushing a 400 to 800 pound snowmobile around by hand. Best of all, think smart ahead of time—don't get stuck!

Follow all emergency operation procedures; i.e, establishing contact person and estimated time of return, as well as rescue plans.

Be on the lookout for avalanche conditions.

Faithfully perform all maintenance recommended by the manufacturer.

Observe all local laws governing snowmobile operation.

Practice all rules of courtesy to others snowmobiling; i.e. use driving lights, do not tailgate, allow recreationists to pass, (they will often have faster and lighter machines), and do not create hazard by your operations.

An important part of snowmobile operation is being aware of the remote possibility of having to abandon the snowmobile while in motion or being ejected as a result of operator error. Be conscious of this as you select your protective helmet and other outer ware—as you select possible routes, and the relative closeness and potential hazards of fences, trees, rocks, overhang, road ruts, steep drop-offs, stream channels, and many others. You must be alert to all possibilities and think about the "what ifs...?" Have escape patterns in mind. Remember to fasten the kill-switch card to your coat so that the machine's engine will stop if you are thrown off.

Additional things to know about larger multiple passenger enclosed cab snowcats:

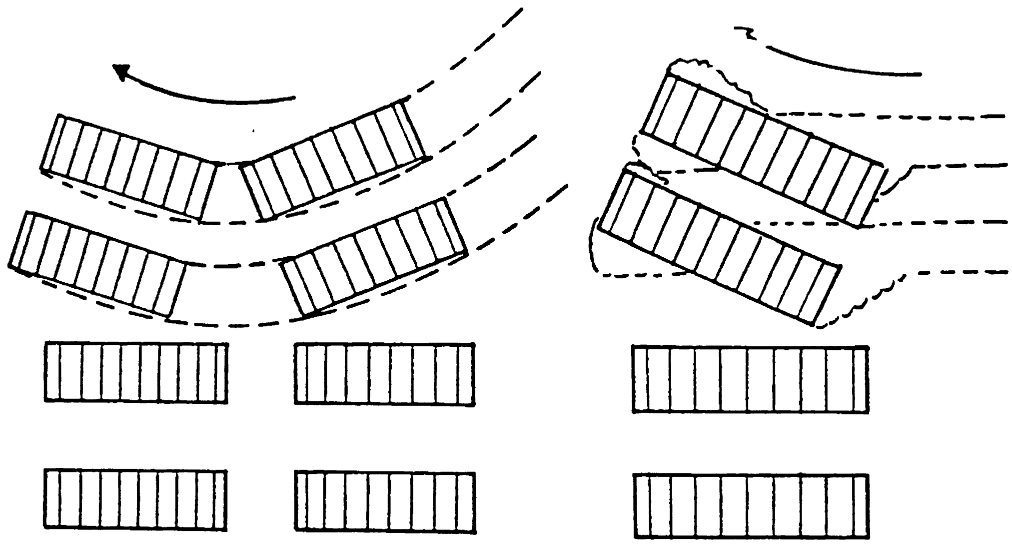
- Many different manufacturers and designs are available but, from an operational point of view, keep in mind that the primary intended use for these vehicles as they were developing during the 1940's and 50's was for light duty reconnaissance and rescue type work. This design is still superior for snow survey work because of our travel on unpacked trails into remote areas. The winter recreation industry has boomed during the last 20 years causing major manufacturers to concentrate their recent technology development on large, tractor-type vehicles for grooming slopes and trails. These tractor-type snowcats generally resemble a caterpillar tractor with very wide (4-6') tracks and operate similarly. The older lighter type vehicles typified by the Tucker 443 model or Thiolkol Imp are better suited to unpacked snow and long distance trips. More modern designs are also available, applying lightweight fiberglass bodies and hydrostatic drive.

- Be very cautious loading and unloading your snowcat from the truck or trailer. Always park in a level area with ramps, securely seated and fastened.

- Select your routes carefully as these vehicles are not as maneuverable as snowmobiles and are much less forgiving of your driving errors.

- Sidehilling may be challenging since these vehicles are too big to be influenced by your body weight. Some vehicles have limitations in that their tracks will slip sideways in the snow. In these vehicles, you are safest using a straight-up straight-down driving technique. You may be forced, in emergencies, to shovel a cut across a steep slope. Steering across the slope in a 2-tracked vehicle is additionally challenging as the steering actions itself will be typically turning the vehicle up the slope to overcome the sideslipping. This means that the uphill track stops or slows as additional power/speed are applied to the downhill track—this, in turn, can cause the lower track to dig deeper resulting in increased slope to overcome. This is handled better by stopping the vehicle and backing it around until it is headed uphill. This puts the tractive force on the uphill track. The 4-tracked snowcats are easier to control on sideslopes as the tracks can be steered without loss of power or traction.

Figure 8.17 Turning motions of two-tracked and four-tracked snowcats.



- Prepare yourself to travel at slower speeds. Safe non-track abusing speeds range from 7-10 mph for the older steel-tracked Tucker snowcats to a top speed of 15-18 mph for the latest rubber-tracked vehicles. Excessive speed will bring premature breakdowns.
- Carry an extra battery if staying out overnight.
- Be cautious of carbon monoxide poisoning when riding for long hours in enclosed snowcat cabs.
- Do not overload your vehicle or have the load unevenly distributed. This will cause traction and steering difficulty.
- Learn from an experienced person.
- Avoid spring melt holes around trees and near stream channels.

- If you get stuck:
  - Think first.
  - Shovel next.
  - Get vehicle out under its own power without abusing it.
  - If stranded, stay with the vehicle. It should have a week's worth of survival supplies, and a rescue team should be on its way.
  - Use radio communications, if available.

Service and Repair of Oversnow Machines

Regular preventative maintenance and repair is of equal importance to proper snowmachine operation in conducting successful snow surveys.

It is not the intent of the Service to train you to be a snowmachine/snowcat mechanic, nor is it required. However, as the responsible operator, you should know a few basic maintenance needs that will prepare you to procure and evaluate proper service/repair. Any knowledge you have about the machine will be useful in performing emergency field repairs when you and your partner are on your own in the back country.

Manufacturers specific maintenance items will be noted in the maintenance manual provided for each machine. A maintenance section follows (chapter 10) that is applicable to all small snowmobiles and snowcats.

9. Travel-Air

Chapter 9—Travel-Air

Objectives

Upon completion of this lesson, participants will be able to:

- Explain how to obtain authorization to fly as a passenger in a helicopter for the purpose of performing a snow survey.
- Describe helicopter safety rules and signals.
- List helicopter capabilities and limitations.
- List and explain items of personal protective clothing and safety equipment needed before flying.

References

West-Wide Snow Survey Training School Workbook

Fire Proof Safety Clothing Catalogs and Books

Private Industry Helicopter Safety Manuals

Time

Classroom: 2 hours, 15 minutes

Operational Considerations for Helicopter Use

In addition to the normal safety precautions taken by our people working in and around helicopters, there are a number of other considerations that must be taken into account. Some of them are required because of written policy statements. Others are considered sound operational procedure, while still others are just good common sense.

Not too many years ago. fixed wing aircraft with skis were used predominantly for access to the more remote snow courses. As helicopters became more reliable and as more back-country data sites were located in terrain lacking fixed wing landing sites, the use of helicopters for snow surveys became almost commonplace. Early helicopter operations were haphazard at best. Radio communications were poor, weather forecasting was chancy and pilots were just beginning to learn about the effects of mountainous terrain on aircraft performance.

The past ten years have seen dramatic changes in both our utilization of helicopter services and the number of people that are being flown. At some data collection locations, virtually all snow course measurements and ground truth sampling are done with helicopter.

It followed then that, as the number of flight hours in helicopters increased, the likelihood of flight related incidents also increased. The seat-of-the-pants operational philosophy gave way to a structured, 100 percent safety oriented policy which, although not perfect, does provide the snow surveyor with certified aircraft, competent pilots, and proven safety and survival equipment. Operational procedures stress safety and are designed to minimize hazard and maximize survivability both on the ground and in the air should an accident occur.

One of the primary building blocks of a good winter flying program is the training you are receiving here this week. Most

NRCS helicopter contracts for snow measurement state that the pilot, snow surveyors or both must attend this schooling. The winter survival, mountain medicine and helicopter safety portions have proven invaluable in past accident situations.

In addition to attendance at this school, there are other requirements to be satisfied before NRCS snow surveyors can fly. Authorizations for each flight must be secured. General Manual, Subpart L, Section 420.110, states:

"NRCS employees shall not be authorized to fly as passengers on other than commercial airlines without the approval of officials having delegated authority. Blanket aircraft authorizations for NRCS operations shall not be granted. Authorizations to use chartered, contract or personal owned aircraft will be on an individual trip basis."

At the state level, only the state conservationist or the state administrative officer have approval authority.

In addition to these restrictions on you as a passenger, there are some that apply to the pilot and helicopter as well.

The U. S. Forest Service and Bureau of Land Management have both adopted carding programs for pilot certification based on his/her demonstrated ability and experience. Aircraft are certified based on capability, installed equipment, and airworthiness.
The NRCS relies heavily upon both these carding systems when applicable. The General Manual provides similar guidelines for our use in situations involving aircraft not under BLM or USFS contract. Some of the minimum requirements are listed below:

Pilot

- 1000 hours total flying time.
- 500 hours in class, category, type and model aircraft.
- 200 hours extended cross-country.
- 200 hours operation in terrain and landing facility typical of those anticipated for the proposed trip.

Aircraft

- Current airworthiness certificate.
- Color distinguishable against a snow background.
- Signal flares.
- Radio equipment.
- Emergency locator transmitter.
- Shoulder harnesses.
- Emergency equipment for the pilot.

You, as a passenger, have some common sense responsibilities also. Become familiar with the helicopter in which you will be flying. If the pilot does not answer all your questions during his/her preflight briefing, do not hesitate to ask. Find out where the emergency locator transmitter is secured. Know how to use it. Locate the battery switch and know how to operate the fuel shutoff valve. Familiarize yourself with the emergency procedures for both front and rear passenger seats and know how to buckle the seat belt and shoulder harnesses.

Each agency differs somewhat in the kind and amount of personal protective and emergency equipment that it will provide for you. In the NRCS it varies from state to state. Personal protective flight gear should consist of a minimum of the following:

- Helmet (SPH-4C or equivalent).
- Fire retardant clothing (NOMEX or equivalent).
- High-topped leather boots.
- Gloves (leather or NOMEX flight).

Similarly, each agency has set up minimum guidelines for emergency gear that it will provide and that you must carry while flying. The list should include, but is not limited to the following:

Sleeping bag	Flashlight
Ground pad	First aid kit
Tent	Rucksack or pack
Small shovel	Snowshoes
Hatchet	Stove and fuel
Compass	Seasonal clothing
3-day food supply	

As you assemble this gear and pack it away, weigh it. The pilot or helicopter manager will need this information, as well as your equipped weight, to do load calculations and aircraft weight and balance determinations prior to takeoff.

Frequent storms during the snow season make flight planning difficult, but still an absolute necessity. Whenever possible, work with the pilot during route selection. Make him/her aware of possible landing sites when you are familiar with the terrain at your destination.

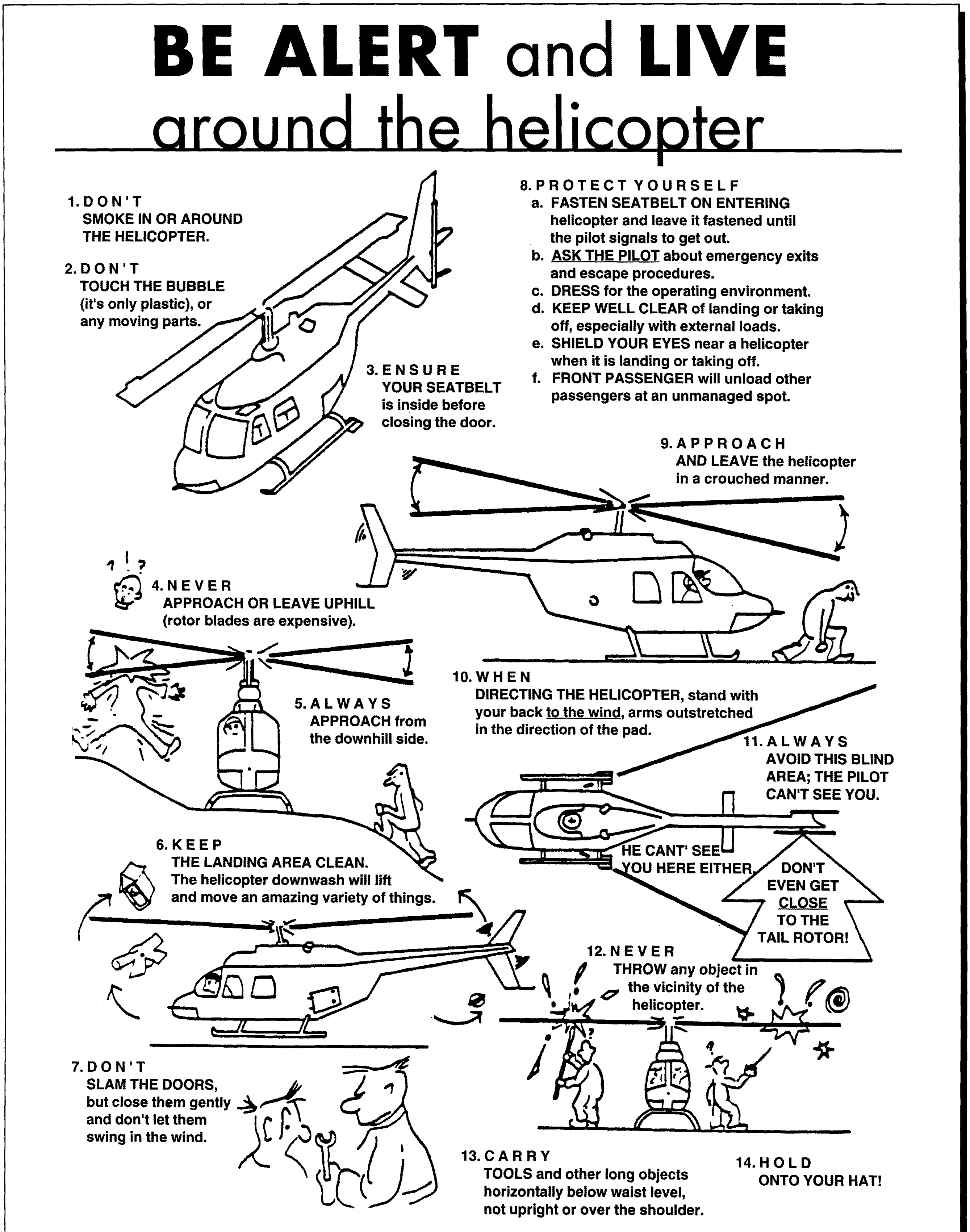
Keep abreast of changes in the weather prior to your departure. Destination weather is just as important as departure weather. Conditions can improve or deteriorate rapidly in the mountains.

The pilot is completely in charge and the decision whether or not to fly because of weather rests entirely with him/her.

The pilot is also responsible for filing a flight plan and for "flight following." Depending upon the final destination, a flight plan must be filed with the FAA or his/her own agency. "Flight following" using frequent radio position checks is a sound procedure and is required for most flights. Broad aerial coverage of USFS, FLM, NPS and NRCS radio nets makes this a relatively simple procedure and cheap insurance should problems develop during the mission.

Snow measurement and data site maintenance using helicopters is a very safe, efficient method for getting the job done. By observing the rules, following the regulations and using good common sense, your flights will remain enjoyable, will be completed safely and will become memorable experiences for many years to come.

See booklet entitled: Basic Aviation Safety, Department of Interior, September 1991 (to be reviewed in class).


BE ALERT and LIVE
around the helicopter
1. DON'T
SMOKE IN OR AROUND THE HELICOPTER.
2. DON'T
TOUCH THE BUBBLE (it's only plastic), or any moving parts.
3. ENSURE
YOUR SEATBELT is inside before closing the door.
4. NEVER
APPROACH OR LEAVE UPHILL (rotor blades are expensive).
5. ALWAYS
APPROACH from the downhill side.
6. KEEP
THE LANDING AREA CLEAN. The helicopter downwash will lift and move an amazing variety of things.
7. DON'T
SLAM THE DOORS, but close them gently and don't let them swing in the wind.
8. PROTECT YOURSELF
a. FASTEN SEATBELT ON ENTERING helicopter and leave it fastened until the pilot signals to get out.
b. ASK THE PILOT about emergency exits and escape procedures.
c. DRESS for the operating environment.
d. KEEP WELL CLEAR of landing or taking off, especially with external loads.
e. SHIELD YOUR EYES near a helicopter when it is landing or taking off.
f. FRONT PASSENGER will unload other passengers at an unmanaged spot.
9. APPROACH
AND LEAVE the helicopter in a crouched manner.
10. WHEN
DIRECTING THE HELICOPTER, stand with your back to the wind, arms outstretched in the direction of the pad.
11. ALWAYS
AVOID THIS BLIND AREA; THE PILOT CAN'T SEE YOU.
HE CANT' SEE YOU HERE EITHER
DON'T EVEN GET CLOSE TO THE TAIL ROTOR!
12. NEVER
THROW any object in the vicinity of the helicopter.
13. CARRY
TOOLS and other long objects horizontally below waist level, not upright or over the shoulder.
14. HOLD
ONTO YOUR HAT!

Office of Aircraft Services Helicopter Use Training

Helicopter Safety

Introduction

The helicopter can be a potentially dangerous machine. It continually requires the thinking and practicing of safety by all personnel who work with it. Agency personnel must be aware of these inherent hazards and practice these principles to insure safe operations.

General Safety Precautions

- Helicopter operations will comply with the applicable general safety rules for aerial operations and practices prescribed for specialized helicopter operations in the agency manual and Federal, State and OSRA standards.
- Safety training of ground personnel should include items requiring special care in and around helicopters on the ground or in the air.
- The pilot is responsible for the safety of the helicopter and passengers at all times.
- Prior to each day's operations, a briefing shall be conducted with the pilot.
- Operation of the helicopter at night will be conducted only after the requirements in DM 351 and Federal Aviation Regulations have been met.
- Helicopter pilot duty limitations and flight time limitations have been established by the agencies as an effort to reduce accidents caused by pilot fatigue. **Follow them!**
- Personnel trained in helicopter use will be stationed at each helicopter landing area during flight operations to supervise loading operations and enforce safety regulations.

- Helijumping is not permitted from a helicopter in any phase of flight nor is hovering without the necessary qualifications, equipment and training. One-skid landings or hovering landings with only the front portion of both skids touching the ground will not be used for off-loading passengers and cargo.

- Permit only necessary flights. Never carry unauthorized or unnecessary passengers and cargo.

- Only qualified and trained ground crew personnel will be used during hover hook-ups. Crew must be briefed by the pilot prior to the start of any hover hook-up operation. Emergency procedures must be established between pilot and ground crews.

- All aircraft accidents or incidents must be immediately reported to responsible authorities.

- Flight plans are required for all flights except local training and maintenance test flights within a 25-mile radius of the base of operations for all flights conducted by DO aircraft. An FAA or equivalent agency flight following procedure is required. The flight plan should state the names of people on board, destinations, type and color of aircraft, N-number, fuel available, time of departure and return time. Make regular position reports if possible and don't deviate from flight plan except in emergencies.

- Before any flight, check pilot and aircraft data cards. Brief pilot on the mission and be sure a flight plan is prepared.

Precautions on the Ground—Hazardous Points Around Helicopters

- Never approach a helicopter without the pilot's knowledge and approval. When approaching, approach at a crouch from the front or side in full view of the pilot. Main rotor blades can tip below the six-foot level. Never enter the landing area until the helicopter has completed landing.

- Do not approach a helicopter from an area where the ground is higher than where the helicopter is standing or hovering. Main rotors can easily reach below head height on the uphill side of even moderate slopes. Never run when approaching or leaving a helicopter.

- When walking in front of a helicopter, be sure not to strike any part of the helicopter such as pilot tube, antenna or mirrors, with body or cargo. Keep all long-handled tools clear of the rotor system. A recommended procedure is to not load or unload any object over four feet in length under turning blades.

- Keep landing areas clear of all unauthorized personnel as well as light materials that may blow around. Unless required to go nearer, stay 100 feet from helicopters at all times. Larger helicopters can create wind velocities as high as 60 MPH.

- Make the pilot aware of any baggage or cargo being placed in or on the helicopter. Always report the correct weight of all personnel and equipment to the pilot before the flight. Cargo packages should be weighed separately so the pilot can distribute the weight as he deems necessary. Explosives, flammables and other hazardous materials can only be transported when the pilot and Government personnel have complied with HMR Part 175, CFR 49. If these regulations are not complied with, all parties involved can be cited.

- All cargo in external racks must be tied down securely. Bring tie-down cords through handles on cargo if possible Never leave loose tie-down cord in cargo racks. Never stand erect on cargo racks or on door sill.

- When entering a helicopter, hold on to the door to prevent wind from slamming it against the helicopter. Do not use the door to hold your weight or to pull yourself in. Place your foot on the step first, then have your head and shoulders enter the passenger compartment before your other foot is placed inside. The front passenger must remain clear of all flight controls.

- Sliding windows or air vent holes on helicopters should not be used to close doors since they may easily be broken. Close doors gently, do not slam shut. Keep hold of papers and all materials that may interfere with flight controls.

- Before takeoff, fasten and adjust seat belt and shoulder harness. Shoulder harness is required for all front seat passengers. Keep seat belts fastened until after landing is completed. Be sure you know how to unfasten the shoulder harness and seat belt.

- After landing, unfasten seat belt. Refastening the seat belt behind you before getting out of the helicopter is recommended. Never let the seat belt hang outside through the door. Extensive damage will occur as a result of seat belt being left outside the door during flight.

- Never throw objects out of helicopters while in flight or on the ground. Hold maps and papers securely, especially if flying with the doors off.

- All personnel working around helicopters must wear hearing protection, goggles and hard hat with chin straps. All pilots, crew members and DOI employees must wear NOMEX clothing, approved aviation helmets and other protective equipment as required by Departmental policy.

- Always wear your hard hat with chin strap during takeoff, landing and flight if flight helmets are not available. If a chin strap is not available, hold your hard hat securely under your arm or in your hand while entering or exiting.

- The following procedures will be observed when refueling helicopters at landing areas:

  — Helicopter engine will be shut off and rotor blades stopped.

  — Helicopter and fuel containers will be grounded.

  — There will be no passengers aboard.

  — No smoking or unauthorized personnel within 100 feet.

  — Fire extinguishers will be available.

  — All passengers should know the location of the emergency exits, first-aid kits, emergency locator transmitter (ELT), fire extinguisher, and survival gear. You should read all instructions and use these items only in an emergency. These items are required on all DOI contract aircraft. Rental aircraft may or may not have a survival kit or first-aid kit.

Precaution in-Flight

- Keep all safety belts fastened and snug during flight. Do not move around during flight unless absolutely necessary.

- Cigarette smoking during flight is allowed only at pilot's discretion. No cigar or pipe smoking is allowed. No smoking is permitted during takeoffs or landings. No smoking is allowed within 100 feet of heliports.

- Keep alert for hazards, particularly power and telephone lines. Inform pilot of their presence, he may not be aware of them.

- Assist pilot, when requested, in watching tail rotor clearance during rough field landings.

- Keep your body, equipment and seat belts clear of controls at all times.

- Never request a pilot to perform a mission that he or his aircraft have not been approved for. Check pilot qualification card and aircraft data card if in doubt.

- Your pilot should approve all missions, his/her word is final as to whether or not a flight can be made. Do not put any undue pressure on the pilot to fly in adverse weather. Undue influence to go beyond these limitations may well result in an accident. Stop any flight if there is a doubt that continuing will endanger your safety.

- Wind restrictions have been established to ensure safe and successful helicopter flights. Helicopter operations will be shut down when winds exceed limitations established or any time the pilot decides that the wind conditions are such that the safety of continuing flight operations is in question. Radio communications or hand signals (see page 9.18) should be used to aid the pilot when needed. Other methods of indicating wind direction and speed are cloth or paper streamers, wind socks and throwing dry dirt into the air.

- While in flight you should always be prepared for a sudden emergency landing by properly wearing all available personnel protective gear, keeping your seal belt snug, keeping clear of all controls, securing loose gear and checking emergency exit locations and operation. During an emergency landing, assume the proper seating position in order to reduce the risk of injury.

  — Never approach a helicopter from behind or without the pilot's knowledge.

  — Observe the Do's and Don'ts that we have pointed out.

— Know the location and use of all emergency and survival kits.

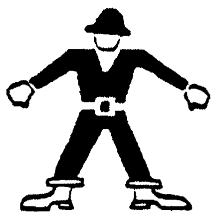
— Be sure the pilot is aware of types and weights of all cargo placed in the helicopter.

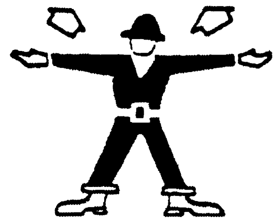
— Always wear your seat belts and protective gear.

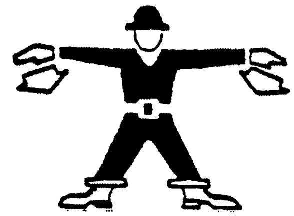
— Stay clear of all rotor blades.

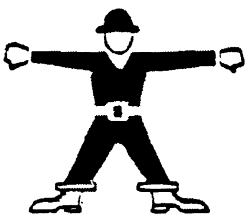
Helicopter Hand Signals

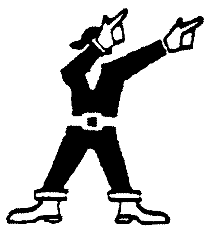

CLEAR TO START ENGINE
Make a circular motion above head with right arm.

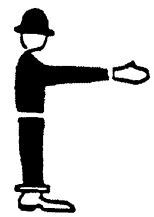

HOLD ON GROUND
Extend arms out at 45, thumbs pointing down.

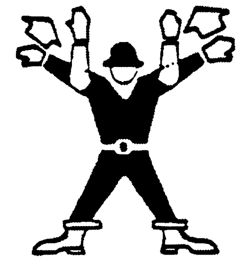

MOVE UPWARD
Arms extended sweeping up.


MOVE DOWNWARD
Arms extended sweeping down.


HOLD-HOVER
Arms extended with clenched fists.


CLEAR TO TAKE-OFF
Extend both arms above head, in direction of take-off.


LAND HERE, MY BACK IS INTO THE WIND
Extend arms toward landing area with wind at your back.


MOVE FORWARD
Extend arms forward and wave helicopter toward you.

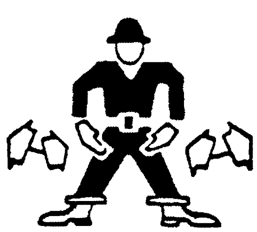

MOVE REARWARD
Arms extended downward using shoving motion.


MOVE LEFT
Right arm horizontal left arm sweeps over head.

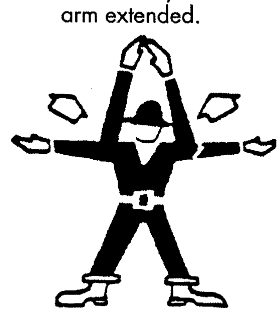

MOVE RIGHT
Left arm horizontal, right arm sweeps over head.


MOVE TAIL ROTOR
Rotate body with one arm extended.


SHUT OFF ENGINE
Cross neck with right palm, palm down.


FIXED TANK DOORS
Open arms outward, close arms inward.


RELEASE SLING LOAD
Contact left forearm with right hand.


WAVE-OFF
DO NOT LAND
Wave arms from horizontal to crossed over head.

Helicopter Capabilities and Limitations

Introduction

The helicopter has proven its value and versatility throughout the world. Its *ability to operate from restricted areas and to remain above* a *selected* spot are perhaps the helicopter's greatest attributes. Managed by *trained personnel* and treated with proper respect, it is as inherently safe as any aircraft in use today.

Helicopters have been utilized on an ever-increasing scale for thirty years and is a valuable tool for a wide variety of uses. To *properly manage* helicopters for *safe and efficient utilization*, we must know something of their *basic characteristics, capabilities and limitations*.

Basic Helicopter Design

A helicopter derives its ability to fly from one or more power driven rotating air foils or rotors; hence it is known as a rotary wing aircraft.

Single Rotor Helicopter

The most common design is a single main rotor which imparts lift and thrust and a smaller tail rotor which compensates for torque induced by the powered turning of the main rotor.

Dual Rotor Helicopter

Some helicopters have dual main rotors, mounted in tandem, or side-by-side. Usually, torque compensation is achieved by turning the rotors in opposite directions (add tail fins).

Helicopter Controls

There are four controls that are used in conjunction with each other when flying a helicopter.

Collective Pitch Stick

This changes the angle of pitch (or angle of attack) of the main rotor blades simultaneously. As the pitch of the blades is increased, power lift is induced causing the helicopter to lift off the ground, hover and/or climb.

Motorcycle Type Throttle

A hand-grip throttle is mounted on the collective pitch stick for coordinated use with reciprocating engines. As the pitch is increased, power must be added to maintain rotor RPM so the helicopter will lift or climb. On turbine engines this power coordination is accomplished automatically.

Rudder or Anti-Torque Control

Two foot pedals are provided to counter-act torque effect and provide heading and directional control. On dual-rotor helicopters, directional fins are used for stability and the pedals control tabs on the main rotor blades.

Stick or Cyclic Control

Directional movement of the helicopter and banked turns in forward flight are achieved by use of this control. The main rotor(s) is/are tilted in the direction of stick movement causing the helicopter to move in that direction.

Note: These controls are of no use if obstructed by loose gear, such as canteens or hard hats.

Helicopter Terminology

Certain terms are commonly used in reference to helicopter operations.

Being familiar with these is important to persons involved with helicopter use.

Ground Effect

A cushion of air beneath a hovering helicopter caused by air being pushed downward by the main rotor(s) and semi-compressed against the surface creating some additional lift. The additional lift from this ground cushion is normally effective up to a height equal to the radius of the main rotor (or 1/2 the diameter). This distance is from the plane of the main rotor blades to the surface.

- In-ground effect (IGE) is when the helicopter is hovering on this cushion of air.
- Out-of-ground effect (OGE) is when the helicopter moves off (or above) this cushion of air. A helicopter can lift less payload by sling because it is usually OGE.

Translational Lift

Lift that is gained when translating from a hover into forward flight. This additional lift is gained at about 18 MPH and is caused by the extra volume of air passing through the rotor system.

Autorotation

This is a nonpowered flight condition with the rotor system maintaining required flight RPM. The rotor RPM is maintained by the airflow moving upward through the rotors. The RPM of the rotor system can also be thought of as inertia and is used as the helicopter nears the ground to check the rate of descent and effect a landing.

- There is a built-in safety device which makes it possible to autorotate. The built-in safety device is called a *freewheeling* unit. This device releases the drive of the main rotor blades from the engine drive in the event of engine failure. During autorotation, the pilot adjusts the pitch on the main rotor blades so that the blades will continue to turn as the helicopter is gliding downward. During autorotation, the blades are turning similar to a windmill. The main rotor blades continue to turn as fast without engine power as with engine power and the pilot continues to maintain complete control of the aircraft.

- The sequence of events in which a helicopter enters autorotative descent without engine power is as follows:

  — The helicopter enters an autorotative descent and is in what we call stabilized autorotative flight.

  — As the aircraft approaches the landing area, the pilot flares the helicopter by gently lifting the nose. This slows his *forward* and *downward* speed.

  — By this time during the autorotation most forward motion of the helicopter has stopped.

  — The pilot will now use stored-up blade inertia to cushion the aircraft onto the landing area.

  — The helicopter touches down on the landing area and the autorotation is completed.

Height Velocity Curve

This is a chart developed for flight tests for each type of helicopter showing the comparative combination of air speed and altitude required to execute a safe autorotational landing (usually about 475' AGL at *zero air* speed). (For Light Copters.)

Density Altitude

Density Altitude

Density Altitude is a given block of air (or atmosphere) with a measured pressure and temperature translated to an "altitude above sea level" for use in figuring the air's capability to support an aircraft in flight. (Relative humidity has some additional effect, but not to the extent that it would materially affect our calculation for flight loads.)

- Three factors, (pressure, temperature and humidity) affect Density Altitude, but in varying degrees, i.e.:
  - If we change the pressure 10 points, like from 20% to 30%, we will have affected the Density Altitude by only another 10 to 15 feet.
  - If we change the temperature 10 points like from 70 degrees to 80 degrees on the same altitude reading, we will have changed the Density Altitude 500 feet.
  - If we change the relative humidity 10 points, like from 20% to 30%. we will have affected the Density Altitude by only another 10 to 15 feet.

How To Calculate Density Altitude

If the three variables were always standard and constant, Density Altitude would be the same as Pressure Altitude, and they would be the same as *actual terrain elevation*. However, this very seldom happens, so we must have an *in-the-field* method of calculating Density Altitude. (Since relative humidity has the least affect on Density Altitude, and is very seldom available to us in the field, we will consider only the primary variables—Air Pressure and Temperature.)

- *Measure the existing air* pressure at the point of interest with a barometer.

— Usually, the only barometer available is the aircraft altimeter. This is a manually variable barometer, so we must use a standard reference point. The reference is 29.92" hg, the standard sea-level atmospheric pressure. Set this reading (29.92) in the "colsman window" of the altimeter. Now read the altitude indicated on the face of the altimeter. Since an altimeter converts barometric pressure to altitude readings, we are now reading pressure in terms of altitude, PRESSURE ALTITUDE!

- *Measure the existing free air temperature* with a thermometer.

  The thermometer should be in the shade with free air movement around it. (Most aircraft have a free air temperature gauge, but it is not reliable if in direct sunlight.)

- *Apply the pressure and temperature readings* to a *Density Altitude Chart* and read the conversion to *Density Altitude*. (Density Altitude Charts may be furnished separately or may be found in any aircraft operator's handbook.)

(Note: With no barometer (or altimeter) available, you could use a "known or fixed elevation" (such as a reading from a topographic map) plus the existing free air temperature, plus a Density Altitude Chart to get an approximate Density Altitude. Due to pressure variations, you may have an error of anywhere from 100 to 600 feet, but this would be usable and much better than having no reference to a Density Altitude.)

How Density Altitude Affects Aircraft and Flight

The only altitude an aircraft knows or uses (as far as performance is concerned) is Density Altitude. Thin air reduces the lifting capability of aircraft by loss of lift for the wing and less oxygen available for the power plant; e.g., compares to the decreased performance of automobile engines at higher altitudes due to lack of oxygen.

- *Rotary Wing Aircraft*—Helicopters rely on the movement of a wing through the air at a speed sufficient to create enough lift to become airborne. Since this is a rotary wing and helicopters start into flight vertically, we cannot extend a ground run to increase the speed of the rotary wing through the air. Also, we are operating at a fixed allowed rotor speed, which cannot be increased to compensate for the thinner air at higher Density Altitudes. All we can do is reduce the gross weight of the helicopter to a point where a fixed rotor system is capable of lifting the helicopter into flight. This can be accomplished only by reducing the fuel supply or the payload, or both.

Helicopter Loading

Center-of-Gravity (CG) Effects

Consideration of CG limitations is important in the loading of all aircraft, but is particularly critical in helicopters. In fixed wing aircraft, the load is balanced over a horizontal wing area and has a comparatively wide range. In a helicopter, the load is carried under a single point like a pendulum; therefore, even a little "out-of-CG" loading can greatly affect the controllability of the helicopter.

It is important to properly secure all materials loaded on or in a helicopter.

Helicopter Loads and Weight Definitions

- *Certified Gross Weight*—This is the maximum total weight that the helicopter was certificated for by the FAA to safely perform flight at sea level on a standard day. It makes no allowance for weight reductions for higher altitudes. It is also considered as the total weight of the aircraft existing on any one flight.

- *Empty Weight*—The weight of the helicopter including the structure, the powerplant, all fixed equipment, all fixed ballast, unusable fuel, undrainable oil, total quantity of engine coolant and total quantity of hydraulic fluid.
- *Equipped Weight*—Empty weight of the aircraft plus the weight of accessories required for the mission (or contract), plus weight of oil.
- *Useful Load*—The helicopter's adjusted weight minus the equipped weight.
- *Payload*—The weight of passengers and cargo that can be carried for any mission. The weight will not include the weight of pilot(s) and fuel.

Helicopter Load Calculation—10% Reduction Method

- Prior to each flight a helicopter load calculation will be made. Items (1) through (11) will be completed by the pilot. Your responsibility will be to complete items (12) and (13) and to make sure that the pilot is not given more weight than the allowable payload as shown on Line (11).
- It should be noted that Line (3) reads maximum computed gross weight. This is a figure the pilot will obtain from the helicopter's FAA approved flight handbook for existing atmospheric and flight conditions.
- Line (6) on the form shows 10% of useful load. What this means is that 10% REDUCTION of the total useful load will be made at this point. This is to allow for a safety margin.
- Keep in mind that the aircraft flight handbook will be the only document for actual flight planning purposes; e.g., Helicopter Performance Charts.

Helicopter Load CalculationFixed Amount Method

The pilot completes Items 1 through 13. You complete the balance of the form.

Item

- Departure Base—Read altimeter when set to 29.92
- Destination Base—Use mean sea level elevation.
- Helicopter Equipped Weight—Empty weight of aircraft plus weight of accessories required for mission plus weight of oil.
- Flight Crew Weight—Weight of pilot and any additional crew members plus their personal gear.
- Fuel—Av Gas - 6.0 lbs/gal. Jet Fuel (JP) - 7 lbs/gal.
- Operating Weight—Add helicopter equipped weight, flight crew weight, and fuel weight.
- Computer Gross Weight—Obtain weight from aircraft Hover-in- Ground Effect (HIGE) Chart using External Load Chart if available. Sling load missions and adverse terrain, weather, etc., flights will be computed from aircraft Hover-Out-of-Ground (HOG) Charts.
- Weight Reduction—Enter applicable weight reduction for helicopter model as shown on Weight Reduction Chart.
- Adjusted Weight—Computed gross weight minus weight reduction.
- Takeoff and Landing Limits—Enter applicable takeoff and landing limit as found in LIMITATIONS section of handbook.
- Selected Weight—If adjusted weight is greater than takeoff and landing limits, adjusted weight may be used for JETTISONABLE loads. However, the lowest weight, adjusted weight or takeoff and landing limits, will be used for NONJETTISONABLE loads.

- Operating Weight—Helicopter weight plus flight crew weight plus fuel weight.
- Allowable Load—The maximum allowable weight (passenger and/or cargo) that can be carried for the mission.
- Passengers and/or Cargo—Enter passenger weights and/or type and weights of cargo. Manifest all passengers by name for each flight.
- Actual Payload—Total of all weights listed for passenger and/or cargo.
- Actual Gross Weight—The total of weights in operating weight and actual payload.

Weight Reduction Chart

Model	Weight	Model	Weight
AS-350D	130	206B III	130
SA-315B	180	205L-1	150
SA316B	170	212	390
SA-318C	80	214B-1	380
SA-319B	210	UH-12E	90
47-3B	90	UH-12 Soloy	100
47-3B-1	90	FH-1100	100
47-3B-2	90	H-500C	110
47-G-Soloy	120	H-500D	120
204B	200	BO-105C W/250-C20	150
205A-1	260	BO-105C W/250-C30B	180
206B II	100	S-55T	170

Personal Protective Equipment

DOI Policy and Requirements

Department of the Interior (DOI) Policy

The purpose of this policy is to establish personal protective equipment standards for selected aviation operations conducted within the DOI, (ref. OPM 81-4).

Personal protective equipment is that protective equipment which the individual would bring to the flight and does not include equipment or devices installed on the aircraft or furnished as a part of the aircraft operating equipment. Personal protective equipment includes, but is not necessarily limited to: boots, gloves, protective headgear, and fire-resistant clothing.

Personnel Requirements

Personnel required to adhere to this policy are as follows:

- *Pilots*—All pilots of aircraft involved in the selected operations, including DOI professional, dual-function, incidental and contractor pilots. Pilots used on occasional charter or rental are exempt from this requirement.
- *Crew Members*—All personnel, including contractor and DOI employees, who are considered a part of the crew complement and are necessary for the accomplishment of the mission. This includes technical observers and equipment operators normally involved in the selected operation, but does not include occasional passengers or observers.

Requirement Criteria

The general considerations used to determine necessity for personal protective equipment are:

- Operational conditions under which the flight is conducted, including terrain, altitude above the surface, and suitability of available landing areas.
- Nature of the mission flown, such as fire-related missions, survey missions, and missions requiring high density altitude (DA) and high gross weight operations.
- Type of equipment used.
- Environment in which flights are conducted.
- Employer responsibilities under the Occupational Safety & Health Act of 1970 (OSHA).
- Study of data from National Transportation Safety Board (NTSB) and U.S. military organizations relating to aircraft accident cause factors and ensuing injuries.

The following special use activities are identified for selected operations:

- All direct fire suppression missions.
- Agricultural application (seed/spray).
- Aerial game counting, wild horse herding, waterfowl hazing or counting and similar missions conducted below 500 feet above ground.
- Animal Damage Control (ADC). Standards for ADC are contained in OPM 81-3 "ADC Flight Operations (Fixed Wing and Helicopter)."
- Overwater flights which extend from the shoreline to a point beyond the autorotation or gliding distance of the aircraft.

- Powerline patrol.
- Helicopter sling and rappelling missions and paracargo (helicopter and fixed wing).
- Any flights requiring the transportation of dangerous articles as defined in code of Federal Regulations 49 revised as of October 1, 1979.
- Operation in mountainous terrain requiring flight in high density altitudes and landing in confined unimproved areas for helicopters and short dirt or grass landing strips for fixed wing.
- All operations requiring low-level reconnaissance below 500 feet above ground.

Those items of personal protective equipment required under the provisions of this memorandum are contained on page 9.32.

The requirement for items of personal protective equipment includes the requirements that such equipment be worn or otherwise utilized in the manner for which it is intended; e.g., personal floatation devices are to be worn, not just available.

Requests for deviations from, or exceptions to, this requirement should be addressed to Director, Office of Aircraft Services, ATTN: Safety Manager, 3905 Vista Avenue, Boise, Idaho 83705.

PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

ACTIVITY	EQUIPMENT REQUIREMENTS				
	[1]Protective Headgear	[2]Fire Retardant Clothing	Gloves	Boots	[3]Personal Flotation Device
1. All direct fire suppression missions	X	X	X	X	
2. Aerial game counting, wild horse herding, waterfowl hazing or counting, power line or pipe line patrol, paracargo, aerial ignition and similar missions conducted below 500 feet above the surface.	X	X	X	X	
3. Animal Damage Control (ADC).	X	X	X	X	
4. Aerial agricultural operations that will be conducted with government personnel aboard, which will include recon flights.	X		X	X	
5. Helicopter sling and rappeling operations.	X	X	X	X	
6. Operations in mountainous terrain requiring flight in high density altitudes (above 5000 foot density altitude) and landing in confined unimproved areas for helicopters and short dirt or grass landing strips for airplanes.	X	X	X	X	
7. All airplane operations requiring low level reconnaissance at less than 500 feet above the surface.	X	X	X	X	
8. Intended overwater flights in single-engine aircraft, which extend from the point beyond the gliding distance to the shoreline and all overwater flights in helicopters.	X				X

[1]Protective Headgear—Must be aviator's protective helmet to include protection for ears and temples.

[2]Fire Retardant Clothing—Polyamide or Aramide or equivalent clothing acceptable.

[3]Personal Flotation Device—FAA and US Coast Guard approved two-cell life vest inflatable by gas cartridge as well as by mouth.

Personal Protective Equipment—Use and Care

Introduction

Records maintained by the U.S. Army show that, within Army aviation, many deaths and injuries are caused by improper wearing of the protective clothing provided. Don't say it can't happen to you. Everyone involved in an aircraft accident has said at one time or another that "it can't happen to me." Many would have had less serious injuries or maybe would be alive today if they had worn their protective equipment correctly.

NOMEX flight suit

The NOMEX flight suit's primary purpose is to protect you during a fire. The flight suit provides a barrier to heat and flames and traps air for insulation between the cloth and the skin.

- Anything that provides a barrier to heat offers some protection. NOMEX is superior because of its excellent fire resistant qualities. It will withstand extreme heat without burning or melting, something not offered by cotton, wool, nylon or other synthetics. In addition, it is lightweight and comfortable.
- To better understand how NOMEX protects you, you need to know a little about burns. Burns are usually broken down into three categories.
    - — First degree burns are the least serious. A bad sunburn is a good example. It can be very painful for a while but causes no serious problems.
    - — Second degree burns are characterized by blistering of the skin. These take a lot longer to heal and there is danger from infection if the blisters break.
    - — The most serious are third degree burns. In these the tissue is actually destroyed and is charred. The burned

areas are extremely susceptible to infection. They can take two years or more to heal and countless skin grafts to correct. Even after this, the burned areas will never be as good as new and the whole process is extremely painful.

Note: First and minor second degree burns are much less damaging than third degree burns and NOMEX, if fitted and worn properly, will greatly reduce the chances of receiving third degree burns in the event of a fire.

Fitting and wearing of NOMEX flight suit

- Proper size important.
  - Regular size, 38 (S).
  - Regular size, 42 (M).
  - Regular size, 46 (L).
  - If these don't fit, they can be specially ordered through commercial sources to get the right size.
  - Get with safety officer or supply personnel to get right sizes issued to you.
- Fitting and Wearing Top of Suit.
  - Must fit loosely for best protection. Trapped air acts as insulation. Too tight allows heat to go right to skin causing more serious burns.
  - Shirt sleeves long enough to reach first knuckle on thumb.
  - Worn with sleeves rolled down and **fastened over gloves.**
  - Collar up and fastened with velcro tabs.

- Fitting and Wearing Bottom of Suit.
  - — Should reach to floor while standing, with pants not fastened at boots.
  - — During flight should always be worn *over* boots and fastened with velcro tabs or drawstrings.
  - — Gloves
    - Gloves are made of NOMEX and leather.
    - Leather offers protection from fire while not detracting too much from dexterity.
    - Protects hands from sharp objects during egress.
    - Leather shrinks when heated, NOMEX, on back of hand, stretches.
    - Never roll cuffs down. Wear under shirt sleeves.
    - If you want to see your watch, try wearing it over the glove.
    - Never take gloves off during flight.
  - — Boots
    - Should be all leather.
    - No zippers.
    - Never wear jungle boots. Nylon will melt into skin.
  - — Underwear: Another important factor to consider when flying is the type of underwear you're wearing. Underwear made of synthetics can be just as dangerous in a fire as not wearing NOMEX. It is really sad to see someone who has been in a fire wearing his NOMEX properly, only to receive severe or fatal burns because his sexy, nylon undershirt melted into his skin.

- Wear only cotton, wool, or cotton-wool blend underwear and socks. (Small amount of synthetic around collar and waistband is okay.)

- Long underwear should adhere to same regulations.

- Make sure the label says 100% cotton or wool.

- May be obtained at Sears, J.C. Penny or other establishments.

— Cleaning: To be 100% effective, flight suit must be cleaned and cared for properly.

  - Wash in warm or cold water. Liquid soap is preferred because powdered soap leaves a residue in the cloth.

  - Tumble dry at low heat or drip dry.

  - Dry clean occasionally to get out built-up grease and oil.

  - Tears, rips and buttons should be repaired using NOMEX thread.

  - Should never be worn with fuel or oil on them as suits would no longer be flame proof. Take off fuel drenched NOMEX suits only while soaking in water. Static electricity from taking off suit can start a fire.

  - Never starch. Starch burns and NOMEX would no longer be flameproof.

  - Gloves can be cleaned by putting them on and washing as you would your hands with soap and water. Rinse and let air-dry.

Internal Summary

If you take care of your NOMEX, keep it clean, wear the right size and wear it correctly, you will greatly reduce your chances of being burned severely in the event of an accident.

SPH-4 Helmet

NOMEX has you pretty well covered up from your neck down. The SPH-4 Helmet, if fitted and worn properly, gives your head excellent protection. It not only protects you from blows to the head, but also gives hearing protection and protects your eyes and face by providing a face shield; and it doesn't have to be uncomfortable to do all this.

How to fit the helmet and wear it properly and also some of the things to check periodically to insure your helmet is serviceable.

- Helmet sizes.
  - Regular: Hat sizes 7 1/4 and below.
  - Extra Large: Hat sizes 7 1/4 and above.
  - If you wear hat size 7 1/4, either size is okay. Whichever fits better and is more comfortable is advisable.
- Fitting.
  - *Suspension*
    - Helmet should fit with ears centered in earcups.
    - If not centered, adjust three suspension straps.
    - Check for equal tension after adjusting straps by placing helmet in lap and pushing on suspension with fist. Adjust straps for equal tension, pad should not touch the styrofoam inner lining.

        - If during flight you feel a burning spot on your head, it is probably caused by unequal tension on these straps—adjust them.

- Headband
    - Keeps helmet centered on head and prevents helmet from rotating
    - Should be adjusted snugly but not too tight.
- Earcups (Designed to keep out noise without being uncomfortable.)
    - Earcup seals.
        - Hardened by perspiration and body oils, they won't seal properly.
        - Replace when they become hard (approximately 90 days).
        - Position seal on earcup so that protrusion fits into soft spot at bottom of ear.
    - Earcup pressure strap.
        - These elastic strips hold earcups against head, not the chin strap.
        - Adjust to provide tension to hold the cups to head without being uncomfortable.
        - Additional pads are available to stick to back of earcup if more tension is required.
        - Elastic straps may lose their stretch after a while and need to be replaced.
- *Chin strap and nape strap* (two things you must adjust each time you put your helmet on.

- Snug up nape strap by pulling strap snugly but not too tight.
- This keeps helmet from falling down over your eyes and coming off.

  Note: New chin straps in the Army system have two (2) snaps to each side.

- Use only lower two snaps, preferably the bottom one.
- Upper two are for oxygen mask only.
- Do not use chin strap pad, for it will compress and allow helmet to come off.
- Snap at each side, lower snaps, snug up with adjusting strap. Snug does not mean tight enough to choke you.

- Face shield
  - Protects eyes from flying objects and keeps face from contacting hard objects.
  - Recommend that it be worn down at all times.
  - Clear for night and dim light and tinted for bright sunlight. Can be changed in a few minutes.
  - Keep clean and free of scratches. Be careful what you clean it with. Some cleaners may ruin visor. Recommend bubble polish.
- *Inspection*—Helmet should be inspected periodically to insure it is airworthy.
  - Inspect webbing for cuts, fraying, deterioration or any signs that it might be weakened.
  - Inspect chin strap snap area for snaps pulling out or stitching coming loose.

— Inspect earcup seals and earcup pressure straps.

— Inspect face shield for scratches and cleanliness.

— Inspect for loose or missing screws.

— Always store helmet in helmet bag. Don't drop or use as seat. Don't put flashlights or knee boards inside helmet. It can cause shock absorbent material to deteriorate.

— Take helmet to your safety officer at least once a year for thorough inspection or any time you have or suspect threre is something wrong with it.

The DOE SPH-4 helmet meets the Army SPH-4 specifications with the following changes:

- The chin strap has double snaps on both ends and the retention assembly has double snaps both to accommodate the changed chin strap.

- The chin strap is covered with a NOMEX pad for fire protection and increased comfort.

- The retention assembly has a Velcro adjustment under the nape strap for increased comfort.

- The earpads are covered with *nonhardening* polyurethane film rather, than polyvinylchloride on the Army SPH-4 which hardens and becomes uncomfortable after a few months of wear.

- The helmet color is white rather than olive-drab.

- The earphone circuit is 600 ohms (two 300 ohm H-143 earphones connected in series) to match standard civilian fixed wing-and helicopter audio systems.

- The microphone is an amplified capacitor microphone and has much better noise cancellation and linearity than any other available microphone making it ideal for aircraft use.

- The headset/microphone plug is a U-75/U to match the standard U-61/U high impedance socket in helicopters. An adapter cord for fixed wing use has a U-61/U socket on the helmet and with a PJ-068 microphone plug and a PJ-055 earphone plug on the aircraft end.

Summary

Even though we are having fewer accidents than in past years, aircrafts still crash. One of you may be the next to have an accident. Wear and care for your NOMEX and helmets as though your life depended on it. It may very well be that one day it will.

Source of Supply

Flight Suit and Gloves

Background—Information

An important factor to consider when ordering clothing is the type of NOMEX fiber used. The original NOMEX is now called NOMEX I. A later version is called NOMEX II and the latest version is NOMEX III.

The original NOMEX I shows considerable shrinkage when exposed to fire. NOMEX II has reduced shrinkage and NOMEX III has even less shrinkage when exposed to fire.

The hazard lies in the tendency of NOMEX I (and to a lesser degree NOMEX II) to pull apart at the elbows, knees or other points of stress during exposure to fire. Specify NOMEX III when ordering.

NOMEX III, Clothing and Gloves

Included is a list of suppliers who handle NOMEX flight suits. Prices are those furnished by the suppliers. Some prices from manufacturers are for quantity purchases and all need to be confirmed for the quantities and for the date you intend to order. Where prices are not shown, the supplier did not furnish a price.

The letters after a supplier's name indicate:

S .... Shirts
P .... Pants
SX .... Sox
GL .... Gloves
UN .... Long-Sleeved Undershirt
DR .... Long Drawers
UND ..... Long Underwear
FS .... Flight Suit

Any who stock shorts and pants have limited colors, such as navy blue and/or olive-green.

Angelica Uniform Co. 700 Rosedale Avenue St. Louis, Mo 63112 Attn: Ken Underhill (341) 889-1111	UN* SX* P .... $ 15.00 S .... $ 15.00 No-Mo-Stat Suits ... $163.00
Medalist Allen-A Company 803 N. Downing Street Piqua. OH 45346 Attn: Evan McCreedy (513) 773-3152	SX* UND*
Vidaro Corporation 333 Martinel Drive Kent. OH 44240 Attn: Steve Sutch (216) 673-7413	P .... $ 47.15 S .... $ 44.60 Coveralls .... $79.25 No-Mo-Stat Clothing Available
Flight Suits Ltd. 1050 Pioneer Way El Cajon, CA 92020 (714) 440-6976	FS $176.00

Boise Inter-Agency Fire Center (BIFC)
Fire Warehouse
3905 Vista Avenue
Boise, ID 83705
(208) 334-9462 FTS 554-9462

Lion Uniform Co. 2735 Kearns Avenue Dayton, OH 45414 (513) 278-6531	P .... $ 45.50 S .... $ 38.75 FS .... $ 48.50 G .... $ 29.30

Princeton Hosiery Princeton, KY 42445 Attn: Grayson Harrelson (502) 365-3551	SX .... $ 54.00 Doz
Sager Glove Co. 4030 N. Nashville Ave. Chicago, IL 60634 Attn: Richard Sager (312) 742-6888	G* P* S*
Work Wear Corporation 1768 East 25th Street Cleveland, OH 44114 Attn:Milton Kramer (216) 711-4040	P* S* Coveralls
Workright Uniform Co. 500 E. 3rd Street Oxnard, CA 93030 Attn: Nert Hudson (805) 483-0175	P...................... $ 45.00 S...................... $ 39.00 FS.................... $ 94.00 No-Mo-Stat Add 10%
Globe Fire Suits Co. Pittsfield, NH 93263 Attn: Courtland Freese (603) 435-8323	UN* DR* SX* GL*
Bowlers Shirts and Uniform Co. 1335 South Main Street Los Angeles, CA 90015 Attn: Fredrick Von Henkle (213) 749-6371	P* S* Coveralls
Yankee Silicon, Inc. P.O. Box 1098 Schenectady, NY 12301 Attn: Connie McIntyre (518) 3170-4177	NOMEX Suits .... $102.00 G .... $ 35.00 UN.................... $ 35.00 S....................... $ 10.00

ZIAMATIC Corporation *10* W. College Street Yardley, PA 19067 (215) 493-3618	SX* UN*
Simpson Safety 22638 S. Normandie Torrence, CA 90502 (213) 320-7231	SX* UN*

Call for current prices. Prices are subject to change without notice.

Helmets

- *Recommended Aviator's Protective Helmet*—The SPH-4 helmet offers the best crash protection combined with the best noise protection of any aviator's helmet for DOI helicopter and fixed wing operations calling for protective helmets.

  The Army SPH-4 helmet currently has low impedance earphones, a low impedance microphone and a U174/U plug. These earphones and microphone will not work with civilian fixed wing aircraft and with most civilian helicopters. To solve this problem, the manufacturer of the Army SPH-4 fitted the helmets with earphones and a microphone compatible with civilian aircraft.

- *Obtaining a Properly Equipped DOI SPH-4 Helmet*—DOI agencies or other U.S. Government agencies can order new properly equipped DOI SPH-4 helmets either from the BIFC Warehouse or directly from the manufacturer, Gentex Corporation. Gentex has also set up a repair facility at the factory to repair or update SPH-4 Helmets.

— *SPH-4 Helmets are furnished* in *only* two sizes: *Regular* for hat sizes smaller than 7 1/4; *Extra-Large* for hat sizes 7 1/4 and larger. Our experience indicates that most men require an extra-large helmet, so check the wearer's requirements *carefully before ordering a regular* size helmet.

— *Cost of SPH-4 Helmets:* Prices for new or refurbished helmets are subject to change. Best current cost information can be obtained by calling both sources of helmets, BIFC Warehouse (208) 334-9462, or Gentex Corporation (717) 282-3550.

— *Repair and updating SPH-4 Helmets*: Gentex will repair or refurbish Army SPH-4 Helmets. There is currently a $25.00 service charge for each helmet. The total cost will be calculated by adding the parts replaced plus the $25.00 service charge.

— A protective bag for the helmet is available from the military and one should be ordered for each helmet. The bag currently costs about $9.00 and provides good protection to the helmet when it is not being worn.
To order:

Defense Personnel Support Center
Requisition Processing Section
2800 South 20th Street
Philadelphia, PA 19145
Phone (215) 271-3181 (for information)
(215) 271-2013 (follow-up on orders)

10. Equipment Maintenance

Chapter 10—Equipment Maintenance

Chapter Objectives

Upon completion of this lesson, participants will be able to:

- Describe and/or demonstrate maintenance of snow samplers and SNOTEL site equipment and appurtenances.
- Describe and/or demonstrate basic maintenance that oversnow machines need in order to function properly.

References

West-Wide Snow Survey Training School Workbook

Equipment and Oversnow Machine Maintenance and Operation Manuals

Time

Classroom: 2 hours, 45 minutes

Maintenance of Snow Samplers

The proper care and maintenance of your snow sampling equipment is an absolute necessity. Properly maintained equipment will not only provide more accurate data, it will make your job safer and much easier. Proper maintenance will also prolong the useful life of your equipment which is an important economic factor, as this equipment is very expensive. A six tube sampling set, complete with accessories, now costs approximately $1,500.

There are 5 basic areas of consideration when we talk about caring for and maintaining sampling equipment. They are as follows:

- Inspection of couplings and snow tube walls for damage and wear.
- Inspection of cutter tip for sharpness and condition.
- Condition of wax or silicone finish on tubes.
- Inspection and calibration check of spring balance.
- Inspection of sampling bag for wear and sampling accessories.

A brief discussion of each area follows.

Inspection of Couplings and Tubes

Couplings should be inspected carefully for worn or damaged threads. If threads are worn down, stripped, broken or otherwise damaged, the coupling should be replaced. Also, examine the tube and coupling joints to be sure the coupling is not loose or slipping on the tube. If any of those conditions exist, consult your state office snow survey representative for instructions. In most cases, you will be requested to send the tube in for repair. In addition, examine each tube to be sure the tube walls are straight and free of dents. Small dents can be removed by inserting a round mandrel into the tube and lightly tapping on the outside of the tube with a rubber or wooden mallet. Never use a steel hammer as further damage may result. Tube alignment or straightness can best be checked by assembling several sections together and sighting down the tube. If the tube has several dents or appears to be bent or bowed, you should contact your state snow survey representative for advice.

Inspection of Cutter Tip

Cutter tips should be inspected for dullness and broken or bent teeth. Dulled teeth can be sharpened with a fine cut file. However, caution should be used to insure that the original pattern or angle is maintained on the cutter teeth. Some states sharpen the teeth to the inside while others do not. The method of sharpening can change the sampler bias by as much as 10%. Consult your state office if you are unsure which sharpening method to follow. Cutter tips with broken or severely damaged teeth should be replaced. Again, contact your state office snow survey representative for advice as this type of repair is generally done by experienced personnel.

Condition of Wax or Silicone Finish in Tubes

Sampling tubes must be waxed or siliconed on a regular basis to insure easy sampling and good measurements. The type of coating used and the number and frequency of measurements will dictate how often you need to coat the tubes. In general, paraffin wax or baked-on silicone will last longer then other types of applications but are more difficult to apply. Other recommended types of coatings include high quality auto waxes or silicone sprays. Varnishes and shellacs are not recommended for use.

Although procedures may vary slightly, depending on the type of coating, these basic steps should be followed. First, clean the tube sections thoroughly inside and out making sure all dirt, old wax and other foreign materials are removed. Commercial solvents and cleaners can be used to accomplish this. The inside of the tube is most easily cleaned with an electric drill, long cleaning rod, and large swab. However, a gun cleaning rod and large swab or just a large swab tied to the middle of a piece of rope will suffice. The swab should not be so abrasive as to gouge or scratch the tubing. Rags or fine steel wool are recommended as swabs. Do not use stiff wire brushes. Rinse and wipe dry each section before applying the new finish.

Next apply your desired wax or silicone finish to the tubes. Car waxes and silicone sprays can be applied to the inside of the tube by applying a generous amount on a clean, soft swab and running the swab through the tube using the same technique as in cleaning. Paraffin wax can be melted and dropped into the tube. A swab is then run through the tube to ensure a smooth and uniform coat. The tube will most likely have to be heated to remelt the wax as the swab is run through the tube. Baked-on silicone coatings require baking the tube in an oven for 24 to 48 hours. Most offices do not have the facilities to accomplish this. This type of finish is generally applied only by the manufacturer or state office.

After allowing the new finish to dry, the tube should be buffed and polished. This is a necessary step if car waxes are applied. A soft clean rag should be used.

The final step is to clean the coupling threads (both male and female) with a wire brush or thread cleaning tool. Wax or silicone buildup on the threads will make assembling the tubes difficult or impossible.

Inspection and/or Calibration Check of Spring Balance

The spring scale should be examined to assure that all screws are in place and tight and that the cradle hook is sound. The scaled barrel should move freely without catching or sticking and the scribed scale should be legible. Clean the scale with solvent as necessary to assure free movement and a legible scale. Do not apply grease or oil to the scale. If the scale does not move freely, it should be sent to the state office for repair. Calibration checks on the scales are normally handled by the state office and should be done annually. Contact your state office if calibration tests have not been made in the past year.

Inspection of Sampling Bag for Wear and Sampling Accessories

Sampling bags should be in good repair. Inspect the bag for rips or worn holes and repair as necessary. Straps, buckles and carrying harnesses should be inspected for wear and serviceability. Check stitching and thread where straps are sewn to bag to be sure stitching is sound. Badly worn bags should be replaced. Your state office should have a supply of new bags on hand.

The sampling kit should contain the following items:

- Driving wrench (if deep snowpacks are being measured)
- Spanner wrenches
- Pencils
- Snow Survey Note Forms SCS-EN-708 (2 books minimum)
- Snow Course Maps
- Snow Survey Safety Guide, Agriculture Handbook No. 137
- Snow Survey Sampling Guide, Agriculture Handbook No. 169

- Measuring tape (if sample points at snow courses are not marked)
- Cleaning rag with nylon cord
- Adequate number of measuring tubes
- Balance and cradle
- Thread protector
- Bread knife to remove earth plug

SNOTEL Site Maintenance

Introduction

In general, SNOTEL site maintenance refers to the maintenance required to keep SNOTEL sites in proper functioning condition and covers a wide spectrum of tasks. Remote site maintenance includes shelter houses, precipitation gages, antenna towers, fences, snow pillows, pillow pads, temperature sensors, electronic radios, transducers, and other sensors or external structures. SNOTEL maintenance used to be primarily a function of the state office snow survey staff. However, in recent years, more and more of this maintenance responsibility has been shifted to field office staffs and this trend will most likely continue. The extent that you may be involved in SNOTEL maintenance will depend on how your DCO leader chooses to operate his or her program. Also, the methodology or maintenance procedures vary from state to state. The following is a brief discussion of various aspects of SNOTEL remote site maintenance which should be used only as a general guideline. Consult you DCO leader for more specific instruction and guidance for the sites in your area.

General

Upon arrival at the site, fill out the SNOTEL data form which should be located in the shelter. The site name, observer, date, time, temperature, and all manometer readings should be recorded. This is to be done before any other work is started so that any change in manometer levels due to work at the site will be recorded. Next, inspect the area for any visible damage to the shelter, antenna, antenna tower, solar panels, temperature sensor, precipitation gage and pillows. Describe all damage on the maintenance form and make a guess as to whether it was caused by man, animal or nature. If possible, take pictures and send them to the Data Collection Office leader.

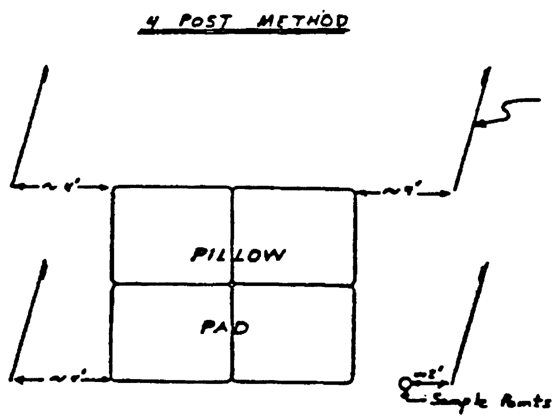
Pillow and Pillow Pad

Observe the pillows and pillow pad. The pillow must be firmly and evenly bedded on a level surface which extends a minimum of three feet beyond the parameter of the pillow configuration. If top dressing of the pillows is employed, this layer must completely and evenly cover the pillows. The pillow pad should be kept clean and free of litter and woody plant growth. If erosion by snow melt or rain damages the pillow pad, a drainage trench should be constructed on the uphill side. All hydraulic lines must be buried and on an even grade (sloping towards shelter) without kinks or sharp bends. If plumbing is exposed, check it for leaks before reburying the line. If a leak exists, try to make temporary repairs and notify the DCO leader so permanent repairs can be scheduled.

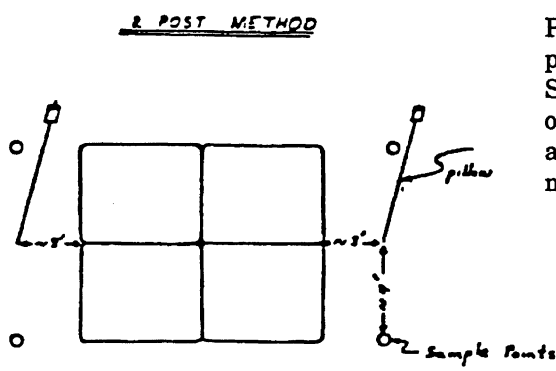
In addition to taking ground truth snow samples, be sure you record the pillow and precipitation gage manometer readings on the SNOTEL data form. Manometer readings are to be taken at the bottom of the meniscus of the top surface of the oil layer. If the site has a maximum thermometer, record the maximum, minimum and current temperature readings and reset the maximum index pointers. If the site has other sensors, ask your

DCO Supervisor what is needed. Forward the original data sheets to your Data Collection Office immediately after the site visit. Retain a copy of the data in your office in case the originals are lost in the mail.

Fig. 10.1 Common Methods of Marking Ground Truth Sample Points



Pipe or posts set approx. 4ft from each corner of pillow array. Sample numbers placed near top of marker facing pillows. Samples are taken on inside of markers toward pillows but no further than 8 ft. from marker.



Pipe or posts set approx. 8 ft from pillow on centerline of pillow array. Sample numbers are placed near top of marker facing corners of pillow array. Samples are taken 4 ft. from makers toward pillow corners.

Inspect pillow fittings and pillow edges for signs of leakage. If there is any sign of dye or stains on the pillow or ground, the pillow is probably leaking. Apply pressure to suspected area and watch for fluid or moisture seeping from the pillow. Notify the DCO leader if any leaks are found or suspected. The pillows should also be relatively free of air. If you can hear the pillow fluid slopping back and forth in the pillow when pressure is applied and released, the pillow contains excess air. Remove the valve stem from the air bladder valve located in the center top skin of the pillow and work as much air out as you can. A short piece of tubing should be clamped over the bleeder valve to prevent excessive fluid loss while removing the air. Use caution not to tighten valve stem too tightly when reinstalling it as it will seize in the fitting and cannot be removed for future air removal. It is also recommended that extra valve stems be carried in case one is damaged when removing it.

Ground truth sample markers should be installed around the pillows to identify the ground truth sample point locations. Markers should be tall enough to extend above the maximum snow depth and be properly numbered. See SNOTEL Ground Truthing for additional information about marking ground truth sample points.

Precipitation Gages

Precipitation gages should be kept operable in a clean, well-painted, and vertical position. If frost heaving or other phenomenon tilt the gage, notify the DCO leader so arrangements can be made to correct it. Also check the gage for evidence of leaks around welds or pipe connections and plugs. If leaks or seeps exist, repairs should be made and notification given to the DCO Leader.

Every year the precipitation gage needs to be drained and refilled or recharged with Glycometh (60% Methonal and 40% Ethylene Glycol). The methods and procedures followed to accomplish this vary from DCO to DCO. It is recommended that you request specific instructions from your DCO leader. In general, the procedure is as follows:

- Read the precipitation gage shelter manometer and record the reading on the SNOTEL data form prior to draining the gage.
- Drain the precipitation gage through the hose and faucet located inside the small door near the bottom of the gage. Note: Some DCO leaders prefer complete drainage of the gage while others prefer a small amount of fluid be left in the gage and recharge added to it.
- If you suspect leaves or other debris in the gage, remove the 3-inch bung near the base of the gage and clean out the gage. Reinstall the bung using pipe joint compound. Take care not to cross thread the bung. It is recommended that this bung not be removed unless necessary as it is often difficult to reseal and can be easily cross threaded.
- Close the drain faucet and open the 1-1/2" filler plug using 2 pipe wrenches to prevent applying excessive pressure to the precipitation gage side wall. (The precipitation gage side wall is aluminum and can be caved in if only one pipe wrench is used.) Recharge the gage with the proper amount of gylcometh and oil.
- Remove the precipitation gage manometer from the shelter wall. Lower the manometer, slowly allowing fluid to fill the manometer tube. Caution: Care should be taken not to inhale or ingest glycometh solution or fumes.
- Drain approximately 1 gallon of solution through the manometer into a jug to assure that no air remains in the line. Fluid should run freely and easily from gage. Remount the manometer on the shelter wall and pour the fluid in the jug back into the precipitation gage. Reinstall filler plug using pipe joint compound on the threads. Firmly tighten the plug, but use caution not to over tighten or future removal will be very difficult.

- Inspect the 1/4" poly-flow tubing leading from the manometer to the transducer for air. If bubbles are visible, bleed the line through the small bleed screw located on the transducer near the inlet. (See Figures 10.2 and 10.3 for bleeder point location on various types of transducers.) Use caution not to allow fluid to leak into the transducer housing. It should be noted that the old CIC and Edcliff potentiometric transducers do not have bleed ports. To remove air from lines leading to these transducers, loosen the line at the transducer inlet and allow fluid and air to drain through line. Reconnect line when finished.

- After allowing several minutes for the fluid to stabilize, record the new recharge reading on the SNOTEL data sheet. Forward SNOTEL data sheet to the DCO.

Shelter House

Shelter houses will be kept in sound condition. This typically requires painting plywood shelters at least once every 3 years or more often if necessary. As a minimum, the bottom 4 feet of the exterior walls should be covered with 1/4 inch galvanized hardware cloth to reduce animal damage. It is best to cover the shelter with hardware cloth to a height that is above the average maximum snow depth and then place a 12 inch strip of galvanized sheet metal around the shelter at the top of the hardware cloth. This will minimize porcupine damage. The shelter roof should be inspected for leaks. If necessary, repairs should be made with metal or asphalt covering. Do not use plastic or fiberglass corrugated roofing panels. Interior and exterior ladder rungs should also be inspected for soundness and replaced if needed. Plywood joints should be calked and sealed.

Check all plumbing lines and connections inside the shelter for leaks. If any of the brass, copper or poly-flow connections appear to be leaking, try tightening them. In most cases that will correct the problem. If it doesn't, shut off the affected line if you can and contact your DCO leader.

Check the poly-flow tubing running to the transducers for air bubbles. If air is found, bleed the transducer and line through the air bleed screw located near the transducer inlet. (See Figures 10.2 and 10.3.)

The manometers should be clearly labeled on the wall as to whether they are precipitation or pillow. A felt tip marker can be used to do this if needed. Manometer tapes and tubing should be easy to read and in good condition. Replace as needed.

Shelter door locks should function freely and be oiled or lubricated with graphite each year. Installation of rubber flaps over the locks will help prevent moisture from getting in the lock and freezing during the winter. If a flashlight is in the shelter, check the batteries and replace them if needed. Check the shelter date form book to ensure there are ample forms for the next winter's readings. Request replacement forms from your DCO leader. A pencil should be left with the forms in the shelter.

It is also a good idea to install a no-pest strip in the shelter house. This will help keep flies, spiders, bees, and other insects from taking refuge in the shelter.

When all maintenance is completed, record new manometer readings on the data form. Manometers are to be read at the bottom of the meniscus. Send data forms, maintenance sheets and other information to your DCO leader immediately.

Fences

Fences, where installed, will be maintained in good condition. If fences are let down in the fall, they should be raised as early as practical in the spring. Posts should be vertical and in good condition. Rotted or leaning posts should be replaced or straightened. Fence rails should be sturdy enough to withstand the anticipated snow loads. The area within the fence should be free of brush and debris.

Temperature Sensors

Temperature sensors should be mounted securely and in a vertical position. If the sensor has a rotating wind vane, be sure it rotates freely.

Antenna and Antenna Towers

Antenna towers should be vertical and firmly set in a concrete base. Leaning or unstable towers should be brought to the attention of the DCO leader. Check the vertical pipe member of the tower for freeze cracks or splits. Also check for loose or missing bolts. Towers should be painted as needed. The antenna and solar panels at the top of the tower should be free from tree limbs or potential damage from snow laden branches. Remove limbs, branches or dead trees as needed. If the antenna coaxial cable is not in conduit, check it for animal damage. Be sure the outside coating is not chewed through. If the coaxial cable is damaged, notify the DCO leader. Caution: It is recommended that the electronic radio system be turned off if you are working on the tower near the antenna transmit element. The system transmits with 300 watts of power and, if you are near the transmit element when a transmission occurs, electrical shock could result.

Electronic Maintenance

Electronic site maintenance will generally be done by the electronic technicians from the Data Collection Office and will not be addressed here. If you are going to be involved in electronic maintenance, additional training and instruction will be provided by your DCO leader.

Figure 10.2 Robinson Helpern Tranducers

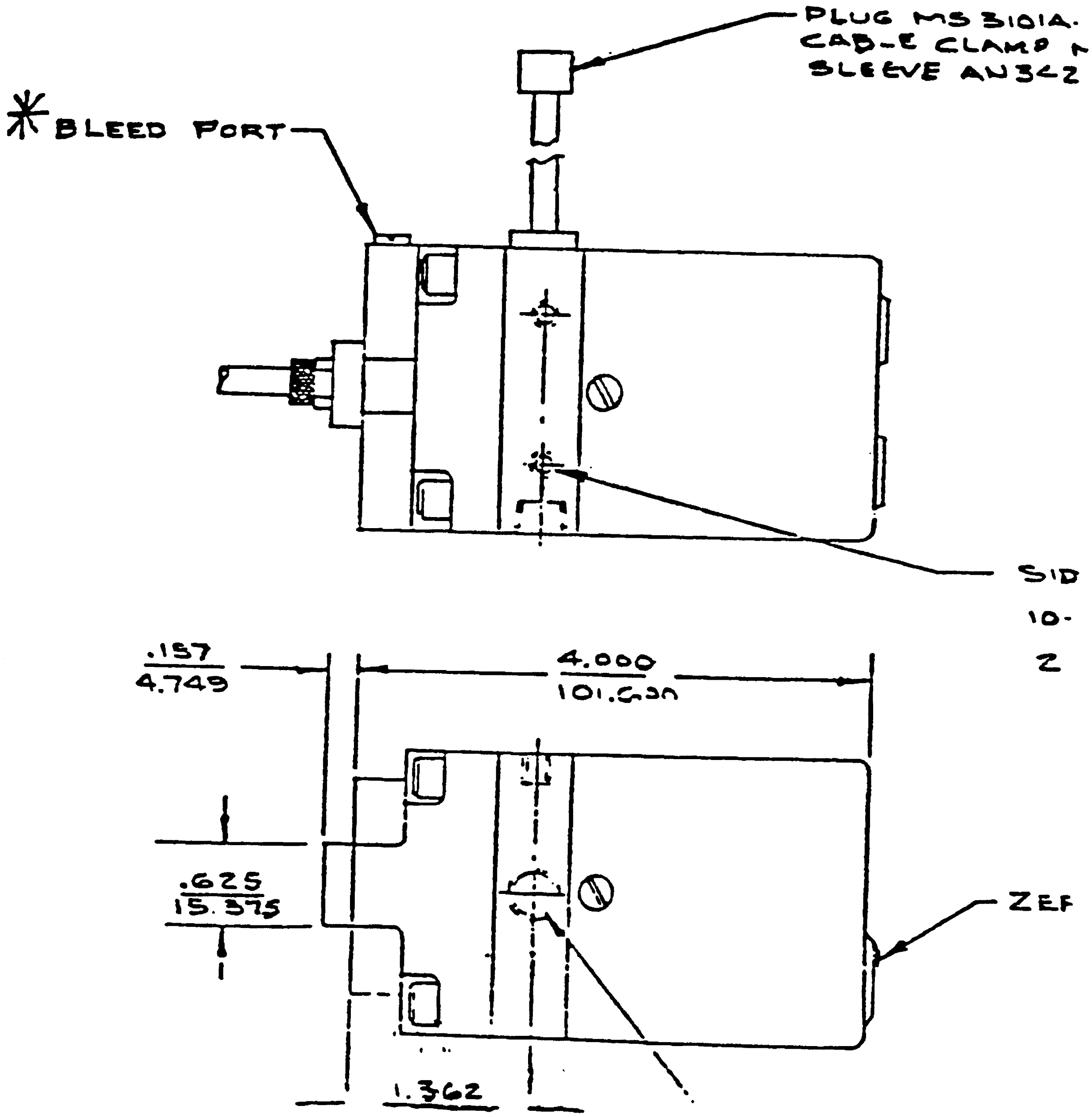
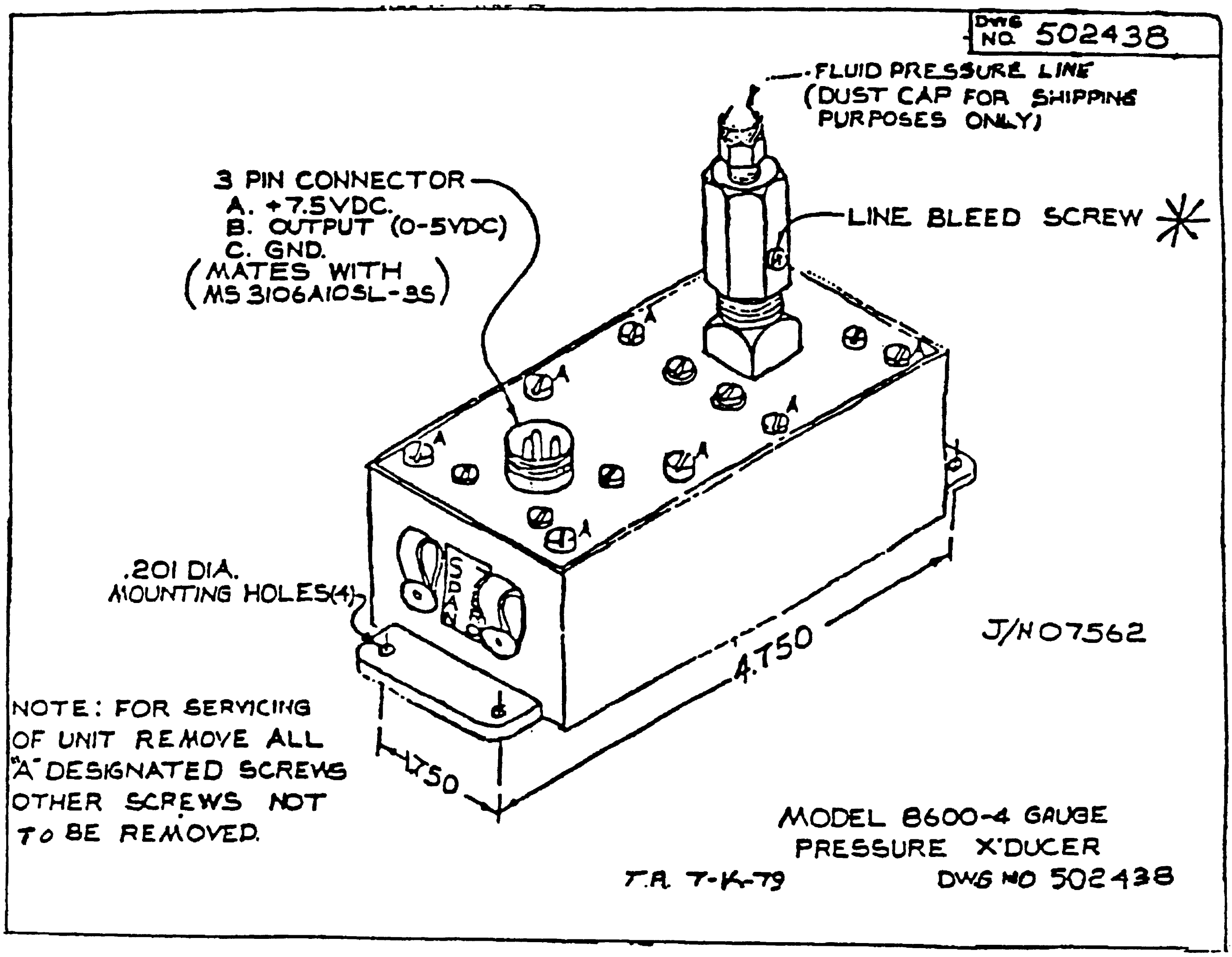


Figure 10.3 CIC Tranducers



Service and Repair of Oversnow Machines

Regular preventative maintenance and repair is of equal importance to proper snowmachine operation in conducting successful snow surveys.

It is not the intent of the Service to train you to be a snowmachine/snowcat mechanic, nor is it required. However, as the responsible operator, you should know a few basic maintenance items that will prepare you to procure and evaluate proper service/repair. Any knowledge you have about the machine will be useful in an emergency field repair when you and your partner are on your own in the back country.

A maintenance outline follows that is applicable to all small snowmobiles. Manufacturers' specific maintenance items will be noted in the maintenance manual provided for each machine. Maintenance needs for large enclosed-cab snowcats will be handled at the end of this section.

- Manufacturer's maintenance manual—this must be read and adhered to

- Steering and suspension systems

  - Check all bolts and connections for wear and looseness.

  - Check to see that all spindles and steering arms are solid.

  - Lubricate moving parts as directed by operators manual.

  - Adjust tie rods for slight toe-in of skis.

  - Replace carbide runners under skis as needed.

  - Check all wear rails, bogie wheels, and shock absorbers.

- Power unit

— Engine must be kept positioned properly and held tightly by the mounting bolts to assure proper drive belt alignment.

— Oil streaks on engine housing indicate loose bolts.

— Use spark plugs that are within specifications of operator's manual and consistent with local mechanics recommendation.

— Air cooling fan belts must be tight.

— Check liquid cooling system for fluid level and proper operation.

— Make sure that oil injector mechanism is working properly.

— Primer pump or choke control must operate effectively.

— Exhaust system must be free of leaks. Note—the comparative temperatures (detectable with your finger tips) of the surface of the exhaust tube coming from each cylinder of the engine is a handy way to check for a cylinder that is not firing properly.

— Carburetor adjustment requires a certain amount of skill and different procedures for different makes. Work closely with your local mechanic; he/she can make proper settings and give you tips that will help you make adjustments in the field. The following discussion gives you a general overview of carburetor adjusting: Manufactures of different snowmobile engines give a carburetor jet setting for high and low speed operation. These settings are a starting point. When these motors are tested, they probably are at a different elevation then where we operate. The octane of the gas is probably different, and most two-cycle engine oils burn a little different; therefore, it may be necessary to deviate from the manufacturer's settings a little bit. When adjusting the carburetor, always open up the jets until the motor starts to stall, then turn them in until the motor runs free. This should be done under load on the high speed if possible. When the motor runs free for a few seconds and burns excessive gas out, turn the jets back open just a small amount (1/16th of a turn) and you have a properly adjusted carburetor.

If, for any reason, you change gas or use a different manufacturer's two-cycle oil, you will have to re-check the carburetor adjustment. When pulling out a machine that has broken down in the field, always open up the carburetor jets (1/16th of a turn) on the machine that is doing the pulling to compensate for the extra load.

If you find it necessary to use "dry gas" in your snowmobile because of moisture, use it sparingly. Do not use more than three tablespoons to a 5-gallon can of gas.

- Check ignition, electrical starter, and battery/charging systems.
- Always strain your fuel into the tank and, as an additional safeguard against plugged fuel lines or carburetor jets, add one or two in-line type fuel filters in an easily accessible position on your vehicle.
- Lubricate throttle control cable with non-freezing (-40°F) lubricants.

- Drive train (figure 10.4)
  - Check on new machines with your local mechanic to see that adjustments are made in the clutch springs and carburetion to achieve proper clutch/engine RMP power relationship that will work at your typical operation altitude. If these altitude adjustments are not made, the machine will not deliver its full performance potential. Since most snowmobiles are manufactured at low elevations, these factory settings will cause the clutch to engage before the engine has achieved sufficient power.

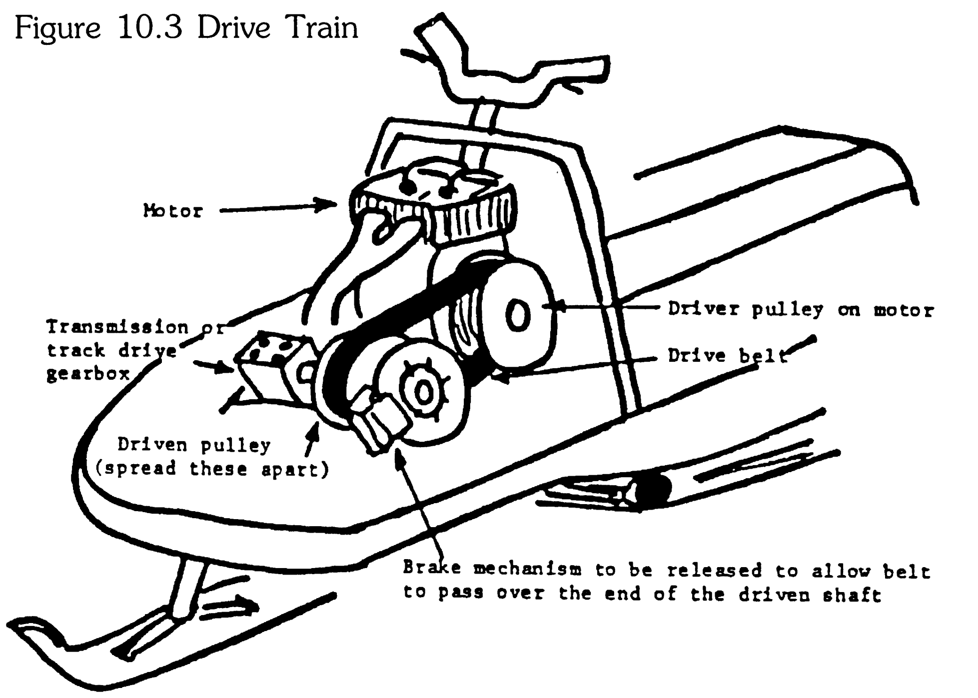
— Drive pulley on the engine and the driver clutch sheaves must be aligned properly for belt life.

— Drive belt must be of sufficient lateral width and resilience to work properly and smoothly. A soft or worn (narrow) belt will not give adequate performance and is a ready potential for failure in a tough spot.

The replacement of this belt in the field is probably the most common emergency maintenance required. Always carry at least one extra new belt. Most belts are changed basically by (1) Unfastening and moving brake mechanism and belt guards out of way near the clutch sheaves. (2) Spreading the clutch sheaves apart with your hands with a twisting motion. (3) Rolling the belt off the drive pulley. (4) Removing spent belt from the clutch sheaves. (5) Repeating process in reverse. Try this operation before you go into the field.

— Clutch adjustment and lubrication is important and should be done by your mechanics

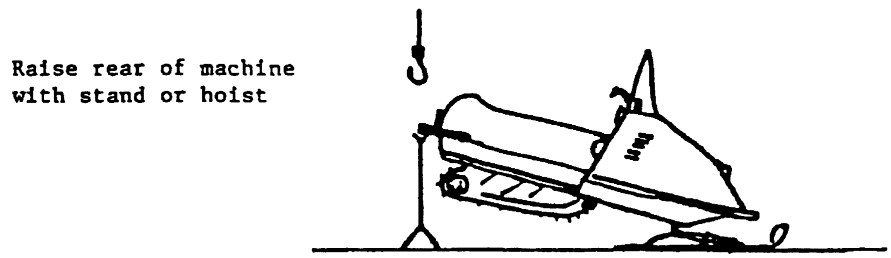
Figure 10.3 Drive Train



— Drive chains need to be tight and gearboxes filled to proper levels.

— The track will generally wear and break only if it is rubbing on the inside of the drive tunnel (rectangular chamber under the seat).

Figure 10.5 Track adjustment



With the rear of the machine raised off the floor with drive track clearing the floor (figure 10.5), the machine can be run in place. Make sure that the track runs in the center of the tunnel. This can be adjusted by repositioning the sprockets on either side at the rear of the tunnel. Equal adjustment on these sprockets also tightens or loosens the track as needed. It should only be tight enough to prevent these things: (1) slapping of top of tunnel, (2) jumping teeth on sprocket, and, (3) overturning of bogie wheels. Do not overtighten.

— Adjust brake so as to cause immediate stopping of the moving track. Use non-freezing (-40°F) lubricant on brake cables.

— Adjust shifting mechanism on machines with transmissions.

- Safety equipment
  - Be sure all lights are working.
  - Be sure all safety engine kill switches are operable.
  - Be sure that the hood fastens securely.
  - Windshields should be in place providing protection and adequate visibility and be free of cracks or sharp edges.
- Operator station
  - Seat and running boards should be in good condition.
  - All controls should be operable and positioned properly for the operator.
- Repairs
  - Always use manufacturer-acceptable replacement parts.
  - Replace any worn components that may fail during the next trip, thus causing needless and very expensive field maintenance or retrieval of vehicle, as well as personal risk.
  - A list of suggested tools and emergency repair supplies is included in this section.
  - The well serviced/repaired snowmobile will seldom require more than a minor carburetor adjustment, fuel filter equipment, or drive belt change in the field.
- Schedules of maintenance for snowmobiles
- Daily maintenance—after each trip
  - Grease drive pulley and driven pulley, if required.
  - Check for cracks on hub of drive pulley and governor weights.

  - Check drive belts for cracks or signs of excessive wear.
  - Check for loose bolts and nuts on steering assembly and bogie suspension.

- Weekly maintenance—after monthly scheduled snow surveys
  - Perform maintenance as required after each trip.
  - Check bottom runner bar on front ski and replace if worn excessively.
  - Check drive chain for tension and oil level in chain oiler reservoir.
  - Check brake and throttle cables for wear and make sure they move freely; spray with silicone, DO NOT OIL.
  - Check spark plugs. Set gap as specified in owners manual.
  - Check for brakes or cracks in exhaust system.
  - Check track tension and alignment.
  - Check for excessive track and slide rail wear.
  - Lubricate bogie wheels.

- Seasonal maintenance—before each field session
  - Perform maintenance as for daily and weekly periods.
  - Check points and timing. This should be done by an individual familiar with servicing small machines.
  - Check and adjust idle settings according to owner's manual.
  - It is good to run fuel out of the system for summer storage or run once a month during off season to prevent varnish buildup in the carburetor.

- Store vehicles in garage or shed if possible. Keeping a vehicle covered with a tarp or cover is important in order to keep controls free of dirt, ice, and snow and to preserve vehicle's seat and general appearance.

- A list of suggested emergency maintenance repair items to carry on your snowmobile follows. You should tailor this list to your type of machine, your mechanical abilities, distance, and possible needs you can anticipate. This supply should be in addition to your personal emergency survival items. Remember to not overload the machine.

- Owner's manual

- Standard tool kit (provided with machine)

- Tool kit containing:

  — Cable, long enough for throttle or brake

  — Small chisel

  — Copper tubing—small enough to fill in gas line in case of breakage

  — Copper wire

  — Adjustable wrench

  — Drive belt, extra

  — File

  — Flashlight, with good alkaline batteries

  — Hacksaw (miniature)

  — Pliers

  — Punch

  — Screwdrivers

- Spark plugs, 2 sets properly gapped
- Tape, plastic
- Vise grips
- Set of open-end wrenches
- Small hatchet
- First aid kit
- Gasoline, full tank and extra supply
- Hand winch
- Lubricant, small container for clutch
- Nylon braided tow rope with hooks
- Shovel

• Other service/repair considerations for large enclosed-cab snowcat snow vehicles:

- Follow manufacturer operator manual for engine, electrical, and drive train service which are generally similar to a truck or tractor. Keep battery fresh and well charged for cold starts.
- Pay special attention to lubrication on steel tracked models—timely lubrication keeps dirt out of bearings and extends life.
- Track adjustment is critical on steel tracked vehicles. This should be checked before each trip. Misadjustments, damage, or non-replacement of worn out parts will only lead to more costly repairs later. Most operators develop an "ear" for knowing what is happening all the time with the tracks.

- Vehicles with pneumatic bogie tires require periodic checking of air pressure.
- Ensure that heating, defrosting, and windshield wiper systems are in good order.
- Assure yourself that the steering system is in good shape; i.e., that hydraulic pumps, valves, lines, and cylinders, or planetary differentials, or clutches are all adjusted and in good condition.
- See that breaks are operable and effective. Be sure parking brake will hold on a hill.
- Check exhaust systems for carbon monoxide leaks into the passenger compartment.
- Carry a small supply of parts, oil, starting fluids, and tools that commonly may be needed to make emergency repairs.

11. Use of Information

Chapter 11—Use of Information

Chapter Objectives

Upon completion of this lesson, participants will be able to:

- List and explain twelve uses for snow survey data and water supply forecast information.
- Explain how water supply forecasting is handled in NRCS.

References

West-Wide Snow Survey Training School Workbook

Copies of printout information

Time

Classroom: 30 minutes

Introduction

The Natural Resources Conservation Service (NRCS) has responsibility for conducting the cooperative Snow Survey and Water Supply Forecasting program in the western United States. This program is administered by NRCS in eleven western states and provides prediction of seasonal water supplies based on current mountain snowpack and other hydrometeorological conditions. This information is primarily provided to the agricultural community for use in managing farming operations in a manner consistent with projected water supplies. In excess of 550 individual streamflow gaging points are now being forecast operationally; drainage areas range in size from under 100 square miles (25,900 hectare) to over 100,000 square miles (25,900,445 hectare).

Streamflow predictions are currently made monthly, January through June, and disseminated via state water outlook reports through dial-up computer access to an audience of over 15,000 organizations and individuals. Major interest groups benefitting from these forecasts include irrigators who derive their water supply from direct diversions or from reservoir, watershed associations, water conservancy districts, reservoir managers, ditch companies, units of government, water distribution administrators, and hydropower generation facilities. Runoff predictions are generated and issued in cooperation with five National Weather Service (NWS) River Forecast Centers (RFC's).

Water Supply Forecasting in the Natural Resources Conservation Service

Introduction

A major portion of the annual flow of most major rivers and streams in the western U.S. occurs during the spring and summer months. The principal source of this portion of the flow is melting snow which accumulates each winter on high mountain watersheds. Seasonal flows occurring during April-September typically account for from 50 to 85 percent of the annual runoff of these streams. Flow during this period is particularly beneficial because it comes at a time when rainfall is generally low and irrigation demands are high.

The Natural Resources Conservation Service (NRCS) administers the Cooperative Snow Survey and Water Supply Forecasting program in the western U.S. This program is conducted in the 11 western states of Alaska, Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. A similar program is conducted in California by the state Department of Water Resources. The aim of the program in all of these states is to predict seasonal water supplies based on current mountain snowpack and other hydrometeorologic conditions. This information is primarily provided to the agricultural community for use in managing farm operations in a manner consistent with projected water supplies. It is also used in many other areas of the economy where fluctuating runoff conditions impact decision making.

In the federal sector, the NRCS along with the National Weather Service are charged with the responsibility of generating streamflow forecast and releasing them to the public. Both agencies work cooperatively in sharing data, forecast techniques, and remote data collection sites. Forecasts are coordinated at state and river basin levels prior to release to insure consistency and comparability.

Beginning in January and extending into June, water supply forecasts are issued to interested parties. More than 550 individual streamflow gaging points are currently being forecast operationally and published by NRCS in state monthly Water Supply Outlook reports. Drainage areas for forecasted points range from less than 100 square miles to over 100,000 square miles. Water Supply Outlook reports are disseminated to about 25,000 individuals and organizations. Major interest groups benefitting from these forecasts include irrigators who derive their water supply from direct diversions or from reservoirs, watershed associations, water conservancy districts, soil conservation districts, reservoir managers, irrigation companies, units of government, water distribution administrators, and hydropower generation facilities.

Water supply forecasting is a complex technique which utilizes snow survey and other related antecedent and subsequent information to predict seasonal streamflow volume and other pertinent flow characteristics such as peak, date of peak, and number of days above a specified flow level. A water supply forecaster must have a working knowledge of several scientific disciplines. These include hydrology, engineering, geology, meteorology, mathematics, and automated data processing. In addition, a forecaster should have a broad knowledge of water use practices and administration in states and basins for which forecasts are made. Applying pertinent concepts from these disciplines, the forecaster analyzes and further refines streamflow, snow water equivalent, soil moisture, precipitation, temperature, reservoir storage, and diversion data to develop forecast procedures.

Forecast Theory

Snowmelt runoff is the dominant streamflow component in most western streams. Figure 11.1 shows the mean monthly hydrograph of the Rio Grande near Del Norte, Colorado, typical of most snowmelt streams. The annual variability in observed flow is large for many streams and is most closely related to the volume of water stored in the snowpack reservoir high in the mountains. Figure 11.2 shows April–September streamflow for the Rio Grande near Del Norte over the period 1951–1984 along with corresponding snow water equivalent for Wolf Creek Summit snow course near the date of maximum accumulation. The close relationship between snowpack and streamflow is clear. Departures from average conditions are well illustrated on individual years. It is this relationship that forms the basis for reliable streamflow forecasting.

Figure 11.1 Monthly hydrograph of Rio Grande near Del Norte, Colorado, showing time distribution of flow typical of most snowmelt streams.

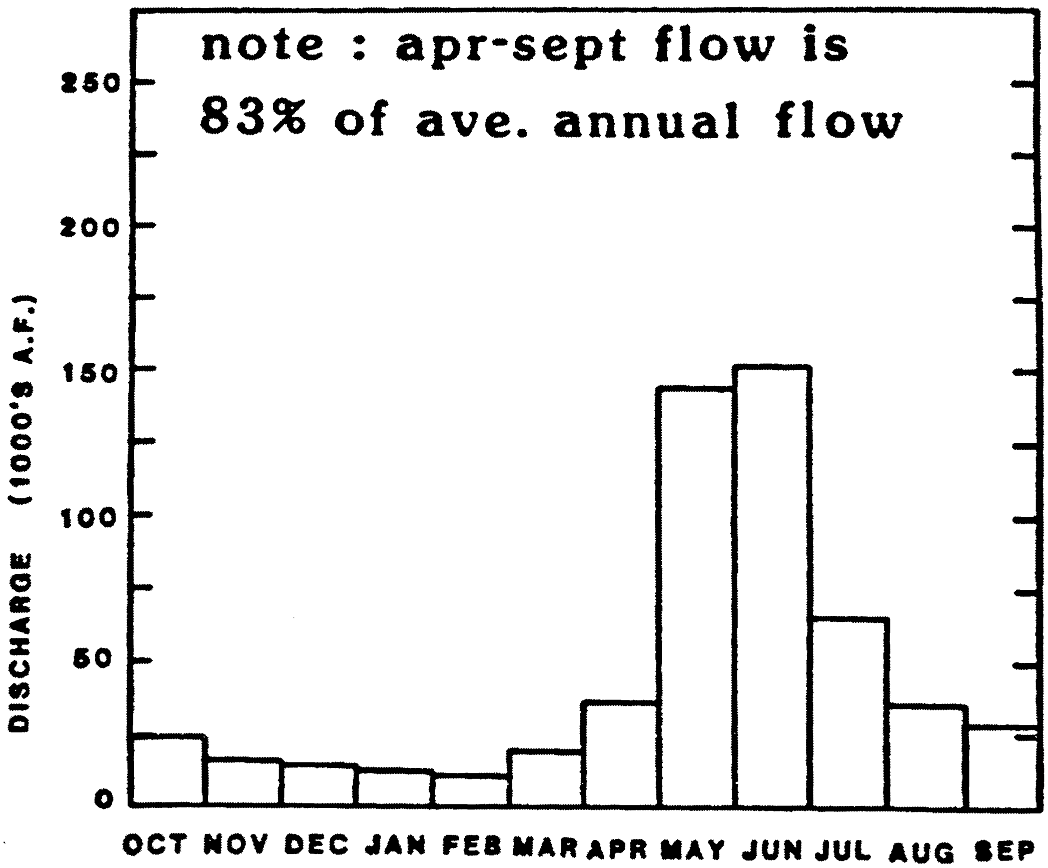


Figure 11.2 Line graphs of Wolf Creek Summit May 1 snow water equivalent (top), and Rio Grande near Del Norte, Colorado, April–September streamflow (bottom). Note the high degree of similarity in the two graphs.

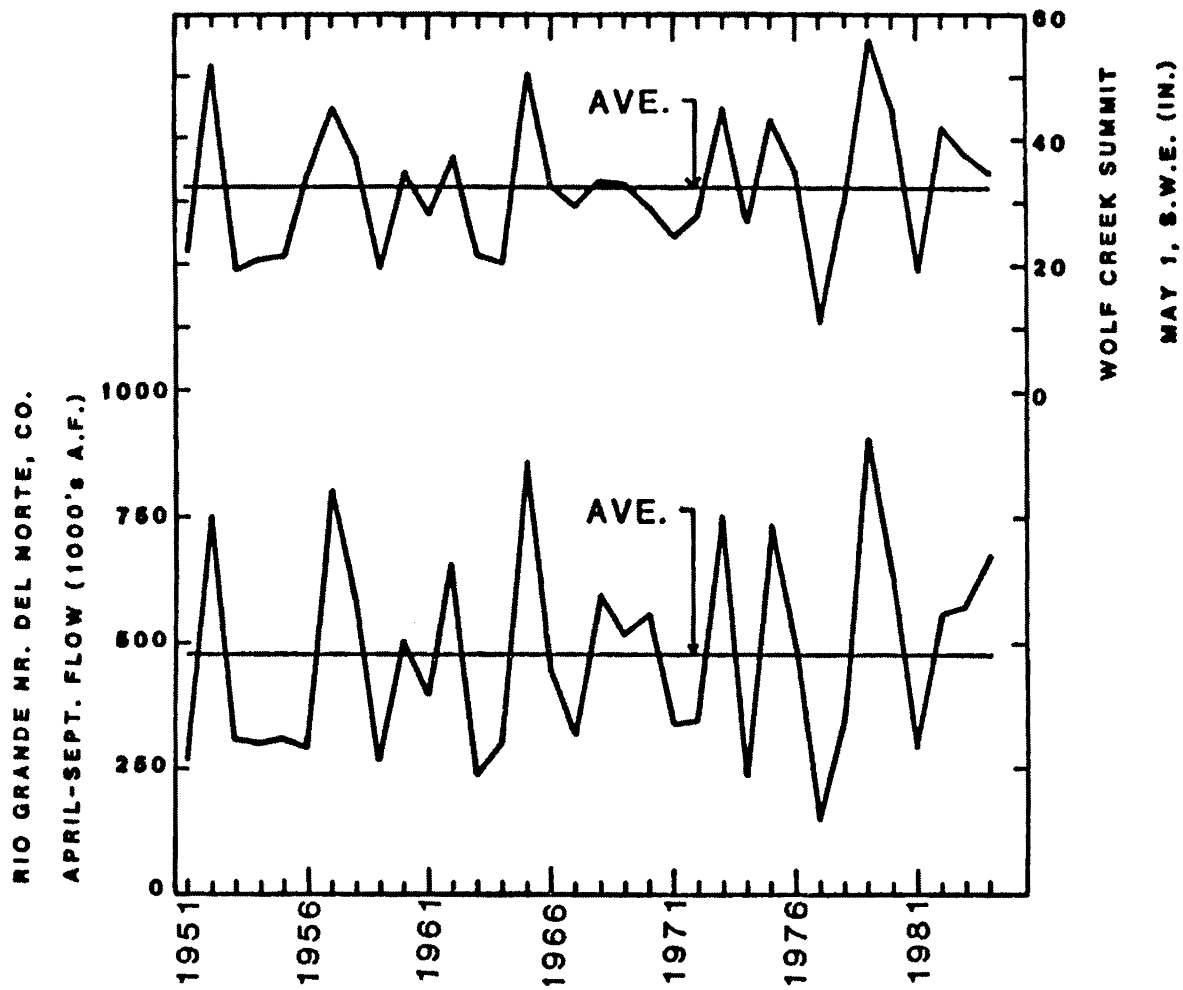
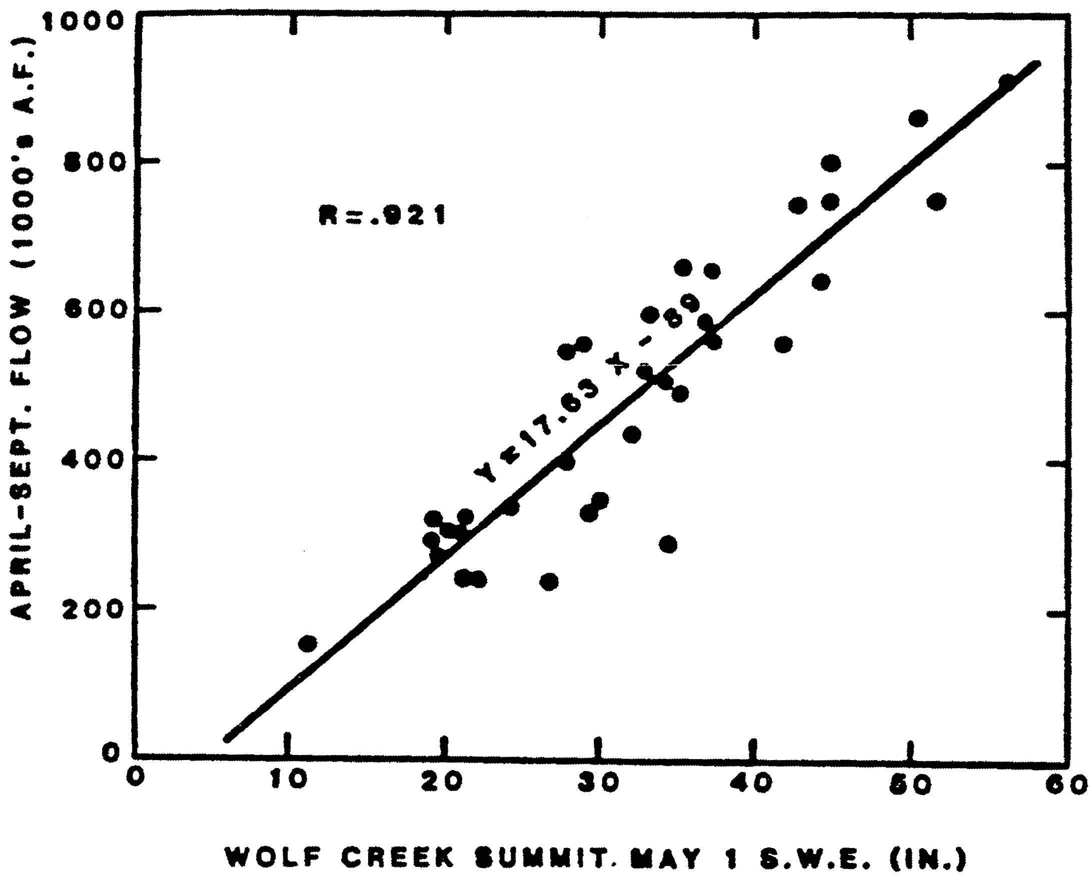


Figure 11.3 Simple forecast relationship for Rio Grande near Del Norte, Colorado, April–September streamflow based on Wolf Creek Summit May 1 snow course snow water equivalent. Solid dots are data points for individual years of figure 11.2. A correlation coefficient (R) of 0.921 indicates a relatively strong relationship.



When the data of figure 11.2 are plotted as a scatter diagram (figure 11.3) and a least squares line fitted to the points, a rudimentary forecast procedure results. Given a May 1 snow course measurement on Wolf Creek Summit, the equation of the line in figure 11.3 could be used to predict April–September volume with a reasonable degree of success.

In actual practice, more complex forecast procedures are used but all are adaptations of the hydrologic mass balance equation given by:

$$R - P + S - L \qquad (1)$$

Where,

R = runoff

S = change in subsurface moisture content

P = precipitation (rain or snow)

L = losses (evaporation, transpiration, sublimation, deep percolation)

It is necessary to translate this relationship into individual water supply forecast equations, each of which are unique to a specific stream, forecast point, and time period.

It is virtually impossible except in a densely instrumented watershed to precisely measure precipitation (P), subsurface moisture change (S), and losses (L). Therefore, most seasonal volume forecast procedures use indices to these physical variables. This results in equation 1 taking the following form:

$$R = PI + SI - LI \qquad (2)$$

Where,

PI = precipitation index

SI = soil moisture index

LI = loss index

The final form of the statistical forecast model derived from equation 2 that uses observable physical measurements at key index sites is given by:

$$Y = a + b_1\ BFI + b_2\ WPI + b_3\ WSI + b_4\ SPI \qquad (3)$$

Where,

Y = seasonal runoff in acre-feet

BFI = base flow index to basin soil moisture

WPI = winter precipitation index

WSI = winter snow water equivalent index

SPI = spring precipitation index

b_1 , b_2 , b_3 , b_4 = fitted coefficients

a = regression intercept constant

Equation 3 does not contain a specific index variable for losses because the assumption is often made that, in relation to the other variables, losses are nearly constant from year to year and thus do not help to explain variability in runoff. In those basins where this assumption is not valid, a loss index can be used as well. If used, it usually indexes the effects of temperature or wind. The constant and coefficients of equation 3 are generally found by applying multivariate regression techniques on digital computers to analyze data sets of 5 to 40 years length. Selection of the optimum set of coefficients for each equation involves performing thousands of correlations to screen out the least significant variables and group those remaining into hydrologically meaningful indices.

The exact composition of variables making up a forecast procedure is dependent on many factors including geographic location, regional climatology, topographic setting, geology, and availability of data sites. Variables other than those already mentioned that are on occasion used as predictors include soil moisture, radiation, temperature, wind, ENSO parameters, and groundwater levels.

Types of Forecasts

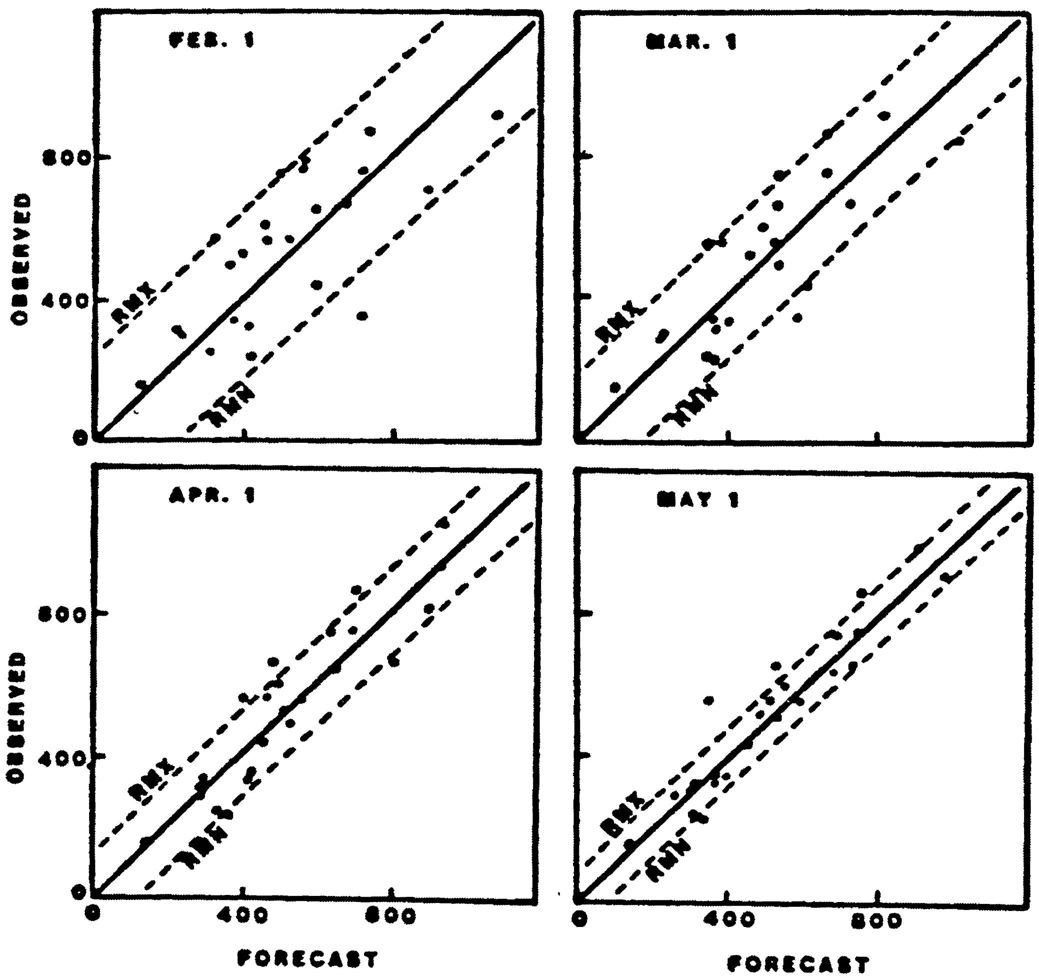
Forecasts issued by NRCS fall into four general classifications. They are seasonal volume, peak or stage, recession, and full hydrograph. Each is important in meeting the needs of water users in the West.

Volume Forecasts

Although there is some interest and need for annual water-year streamflow volume forecasts, the major interest and need of western water users is for seasonal volume forecasts. Depending on geographic location and when snow melt normally begins, the principal time periods for most seasonal forecasts are April-July, April-September, May-July, May-September, March-June, and March-July.

Volume forecasts are usually issued near the first of each month January through June. A few states issue an additional forecast near the middle of the same months. Forecast accuracy tends to steadily improve during this progression due to the increasingly greater proportion of known information compared to the influence of subsequent weather conditions (figure 11.4).

Figure 11.4 Comparisons of forecast April–September streamflows on the Rio Grande near Del Norte, Colorado, with observed flow for four forecast dates. Solid dots represent events for an individual year. The degree of scatter in the points reflects reliability of the forecast procedure. Note improvements in forecast ability progressing from February 1–May 1. The dashed lines bound an 80% probability of occurrence interval.



$$\text{FORECAST (X)} = b_1V_1 + b_2V_2 + b_3V_3 + b_4V_4 + b_5 + V_5 + a$$

Y = Rio Grand near Del Norte, CO, observed April–September streamflow (1000's ac.-ft.)

V_1 = Love Lake snow (2x April 1 + May 1) or current S.W.E.

V_2 = Pool Table snow (2x April 1 + May 1) or current S.W.E.

V_3 = Red Mountain Pass snow (2x April 1 + May 1) or current S.W.E.

V_4 = Wolf Creek Summit snow (2x April 1 + May 1) or current S.W.E.

V_5 = October–December base flow

In the past only a single forecast value—the flow deemed most likely to occur—was issued by NRCS. In the near future two additional values will be forecast giving a range which brackets the most probable (MP) forecast. This range is defined by the reasonable minimum (RMN) and reasonable maximum (RMX) forecasts. RMN has a 90 percent probability of being exceeded while RMX has only a 10 percent chance of being exceeded. MP is near the middle of the range and has a 50 percent probability of exceedance. The interval bounded by RMN and RMX represents an 80 percent probability of occurrence. That is, given the prevailing hydrologic conditions at the time of the forecast, in 8 out of 10 years the seasonal flow can be expected to lie within the stated interval. This approach is designed to help water users gauge the uncertainty in the forecast and plan their operation accordingly.

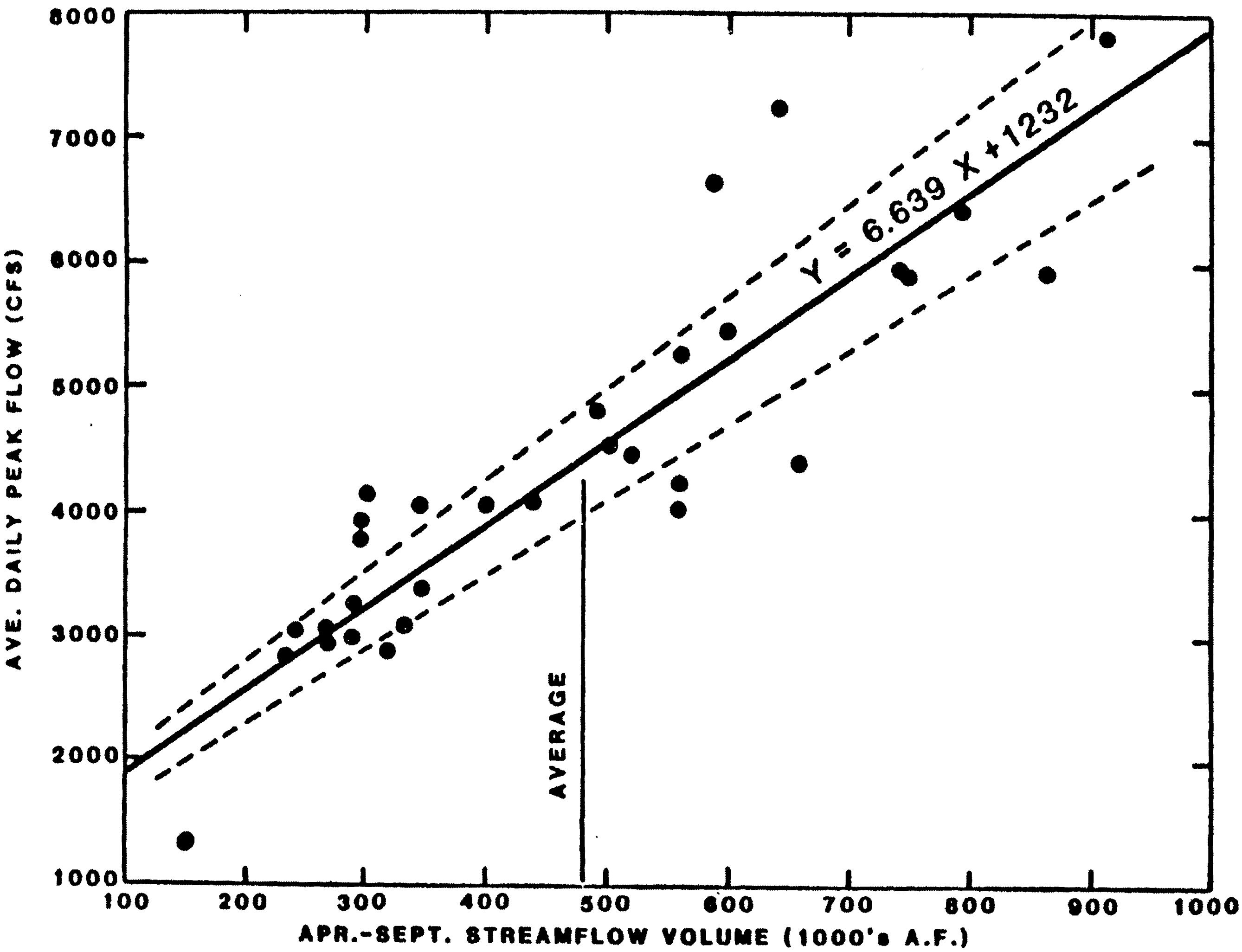
Peak Forecasts

A peak forecast is one which predicts the maximum one-day average flow during the irrigation season or other time period. The quantity is usually expressed in cubic feet per second (cfs) or stage level in feet above a reference datum. Peak forecasts are also made for lake levels. In these latter forecasts the amount of water held in storage at the time of peak, as well as the area covered by water, are sometimes predicted.

On a snowmelt stream, the seasonal volume is usually closely correlated with the amount of the peak; the larger the volume the higher the peak. Both temperature and precipitation during the melt season exert a significant influence on the size and timing of the peak.

Figure 11.5 shows the relationship between seasonal volume and seasonal peak for the Rio Grande near Del Norte. Note that substantial scatter occurs in peak flow values when seasonal volumes exceed average. This phenomenon is common and is a reflection of the impact temperature and precipitation can have on the flow regime during meltout of a heavy snowpack.

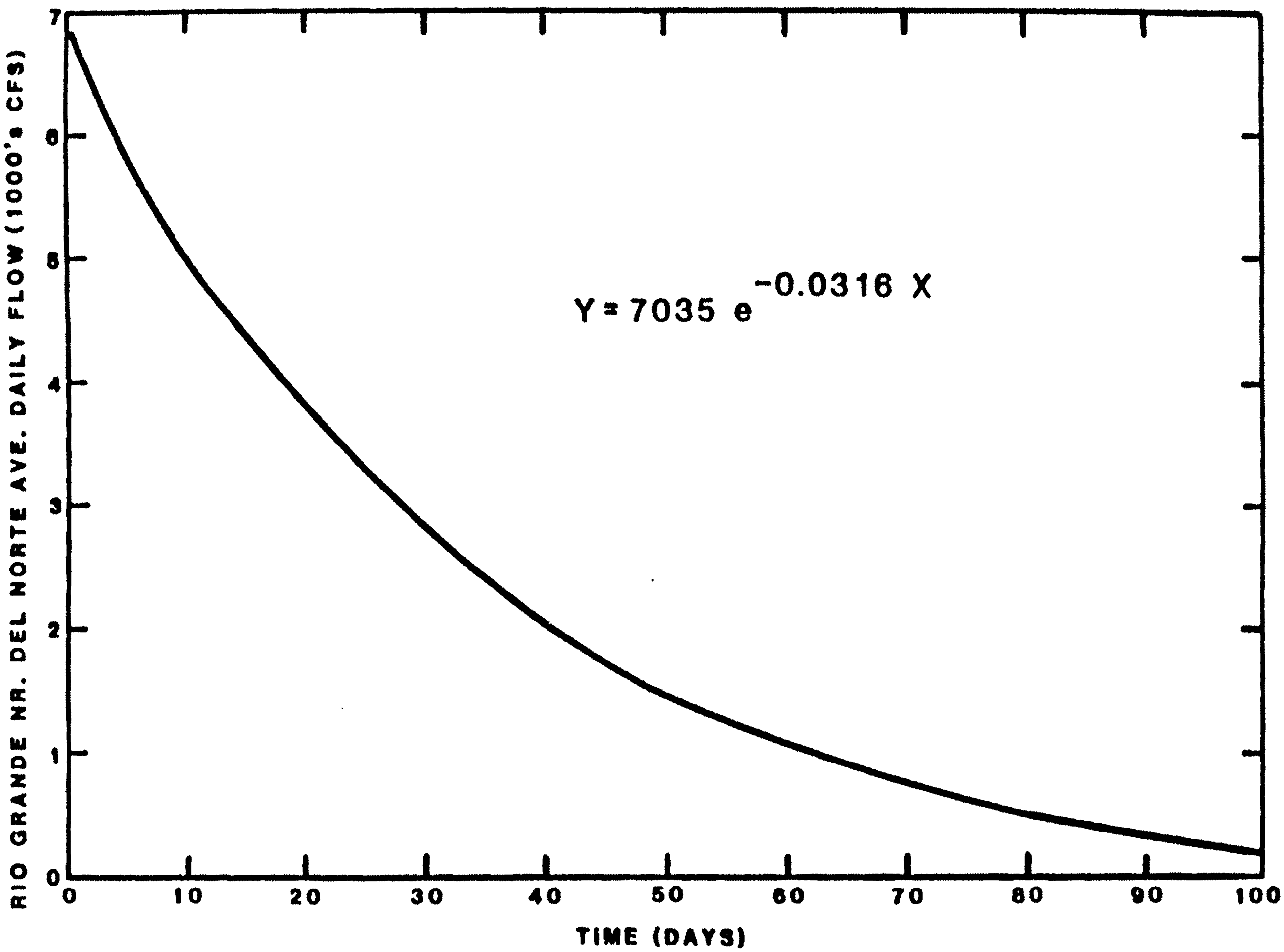
Figure 11.5 Peak flow forecast procedure for Rio Grande near Del Norte, Colorado.



Recession Forecasts

Frequently water users are interested in the number of days streamflow will be above a certain threshold value. This request is most often associated with the users' desire to divert water consistent with the seniority of his water right. It is possible, on some streams, to provide this information by constructing an average recession hydrograph (figure 11.6). Given the current or peak flow, this kind of relationship enables a forecaster to make a projection of how many days it will be until the threshold value of interest is reached in the absence of significant precipitation. This type of procedure is confined to the recession side of the hydrograph. Another similar technique uses a cumulative snowmelt index based on either SNOTEL data or a temperature index to predict flow rates several days in advance.

Figure 11.6 Hydrograph recession forecast procedure for Rio Grande near Del Norte, Colorado.

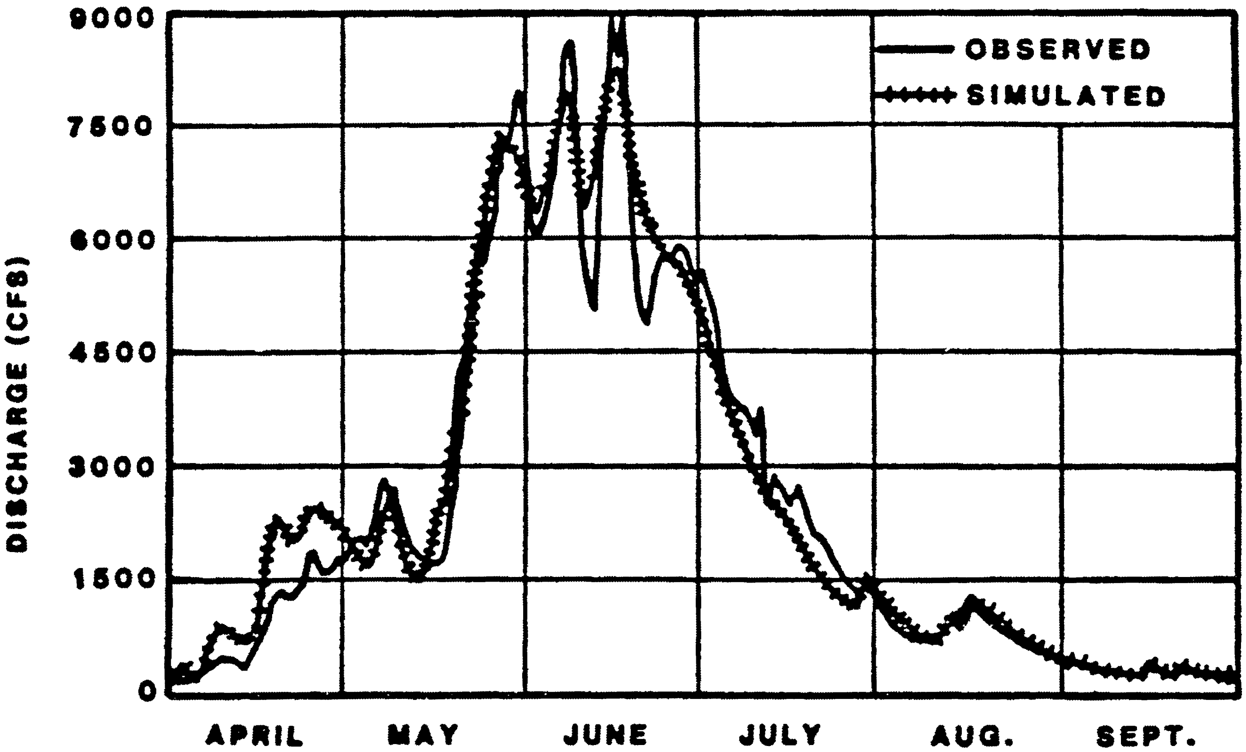


Full Hydrograph Forecast

Forecasts of all portions of the hydrograph on snowmelt streams are needed where intensive management of water is practiced. Reservoir operations, daily water administration, and flood forecasting are examples of this type of application.

Although crude hydrograph forecasting is possible using statistical techniques, physically based hydrologic process simulation models offer more flexibility and accuracy in short-term predictions on the order of days or weeks rather than months. With adequately calibrated simulation models, forecasters are able to synthesize a full season or annual hydrograph of the kind shown in figure 11.7 for the Rio Grande near Del Norte. Running such models operationally requires considerable human and computer resources to acquire, manage, and process the requisite daily input data and generate flow projections. They are therefore used only on streams where the extra effort is justified.

Figure 11.7 Comparison of simulated flow using the Snow Melt Runoff Model and observed flow for Rio Grande near Del Norte, Colorado, for 1979. When hydrologic simulation models are run in a forecast mode their accuracy depends on adequacy of model calibration, ability to forecast future weather conditions, and availability of input data.



The SNOTEL system has operated a sufficient length of time to begin the task of incorporating daily snowpack, precipitation, and temperature data gathered by the network into existing models. Because SNOTEL sites are normally located in primary water producing zones that lack any other kind of daily measurement system, utilization of this data is expected to substantially improve model output.

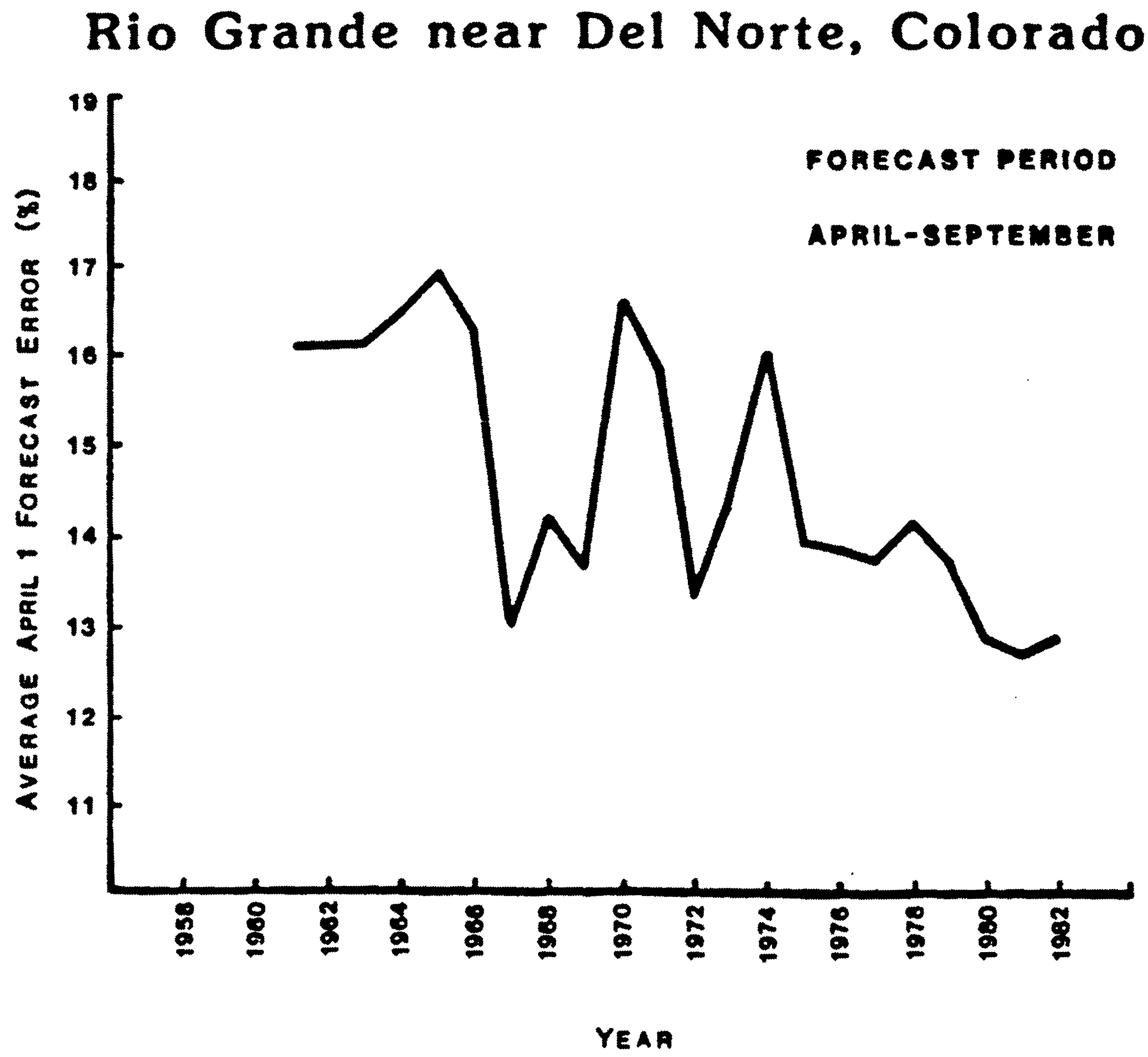
Value of Forecasts

Accurate forecasts of seasonal snowmelt runoff are vital for efficient management of a highly variable water supply. The major direct beneficiaries of good forecasts are agriculture and hydropower production. There are approximately 20 million acres of irrigated land in the West of which about 12 million acres benefit directly from streamflow forecasts. An NRCS snow survey program evaluation report issued in 1977 estimated that the benefits of forecasts to irrigated agriculture amounted to $43.4M annually. Benefits to hydropower production and other nonagricultural sectors were projected in that study to yield a comparable benefit for a combined annual benefit of over $80M.

Accuracy of streamflow forecasts is dependent on many factors including inherent streamflow variability, forecast model adequacy, input data sufficiency, as well as the forecaster's skill and experience. An NRCS forecast error analysis study has shown that the average forecast error for the western U.S. for an April 1 seasonal volume forecast is about 19 percent. Individual forecast points exhibited both larger and smaller average errors. Even small improvements in forecast accuracy can produce large benefits. A report prepared by the National Aeronautics and Space Administration as part of a snowcover mapping project estimated that a 6 percent relative improvement in forecast accuracy westwide would potentially be worth $26.5M to agriculture and $10M to hydropower generation annually.

No definite trends in forecast accuracy have been discernible over the past 30 years when the West is viewed as a whole. However, on individual forecast points some obvious improvements are apparent. Figure 11.8 shows a 15-year moving average of the absolute value of forecast error on April 1 plotted on the last year of the period for the Rio Grande near Del Norte. A downtrend in forecast error is evident although punctuated by large fluctuations. This type of analysis is performed for all forecast points and is useful in assessing which forecast procedures need updating. It also provides guidance when evaluating the adequacy of the data collection network providing input to forecast procedures.

Figure 11.8 Fifteen-year moving average of the absolute value of April 1 forecast errors for Rio Grande near Del Norte, Colorado, plotted on the last year of the period. Note the downward trend in forecast error indicating improvement in forecasting ability.



Forecasts in Farm Planning

Predictions of seasonal runoff at gaged locations on major streams are valuable to project water supply availability in a general area. However, to be of most benefit they should be localized to specific distribution systems or operating units. This can be accomplished by constructing a relationship between seasonal flow and water delivery to an irrigation canal or ditch from historical records. Figure 11.9 illustrates this methodology for the Prairie Ditch which receives its water from the Rio Grande below the Del Norte gaging station where a forecast is routinely made. For example, using the relationship shown in figure 11.9 and given an April-September forecast on March 1 of 420,000 acre-feet at the Del Norte stream gage, a flow of 12,000 acre-feet is predicted for the Prairie Ditch.

If historical records of on-farm water delivery are also available they can be plotted against canal flows to further localize forecast information to the farm level. Figure 11.10 demonstrates this procedure for the John Smart farm which gets its water from the Prairie Ditch. Taking the 12,000 acre-feet expected in the Prairie Ditch in the above example and entering figure 11.10 yields a projected delivery of 240 acre-feet to the John Smart farm.

The procedures described make it possible in many instances to focus water supply outlook conditions down to the level of the land manager who must make the final cropping pattern decisions. Computer programs are now available within NRCS to help the manager apply this information to good advantage. They can be used to assist the manager in quickly evaluating various alternatives and selecting the option which best fits his operational constraints. Probable water delivery is only one factor the manager must consider in his decision making process. But, if reliable estimates are available, intelligent choices are more easily make. In today's economic times the operator who effectively integrates water supply forecasts into an overall farm management plan has the competitive edge.

Figure 11.9 Relationship between April–September flow of the Rio Grande near Del Norte, Colorado, and April–September deliveries to the Prairie Ditch. Each open circle represents an annual event. This relationship enables water users on the Prairie Ditch to predict their probable delivery based on forecasts at Del Norte gauging point.

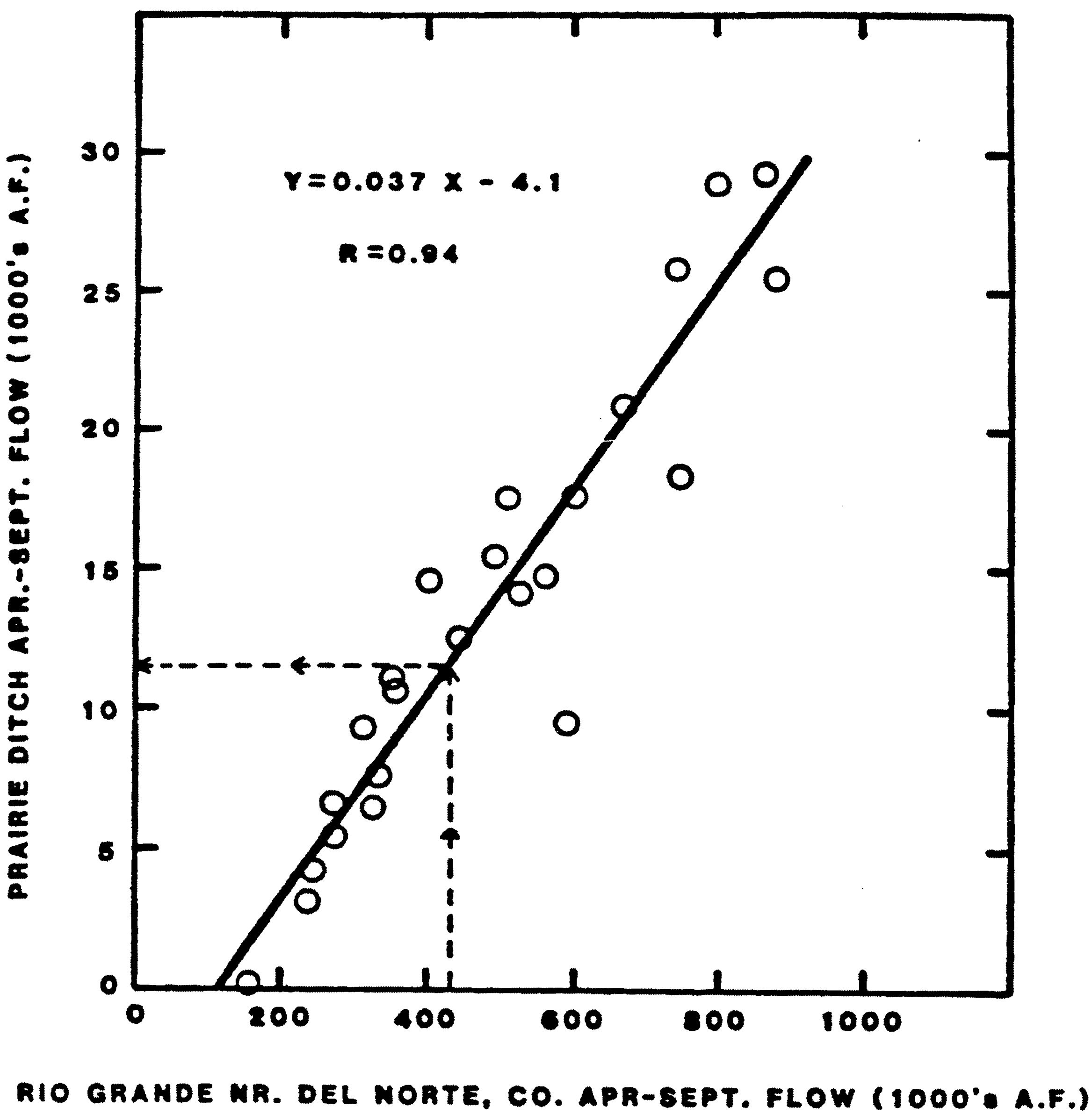
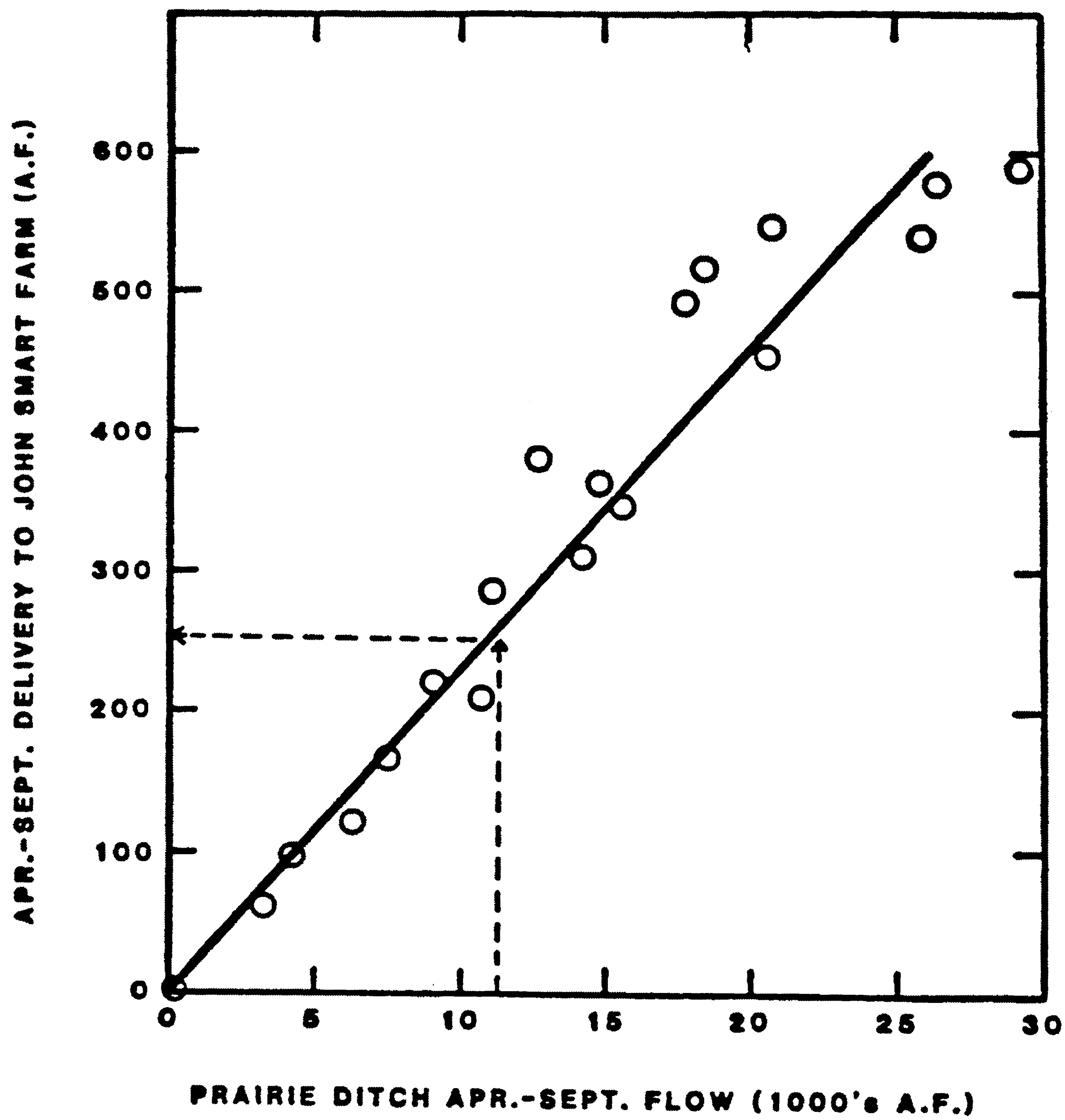


Figure 11.10 Relationship between Prairie Ditch April–September flow and water delivery to the John Smart farm during the same period. Each open circle represents an annual event. Using figure 11.9 and this relationship permits John Smart to localize forecasts at the Del Norte gauging point to his own farm.



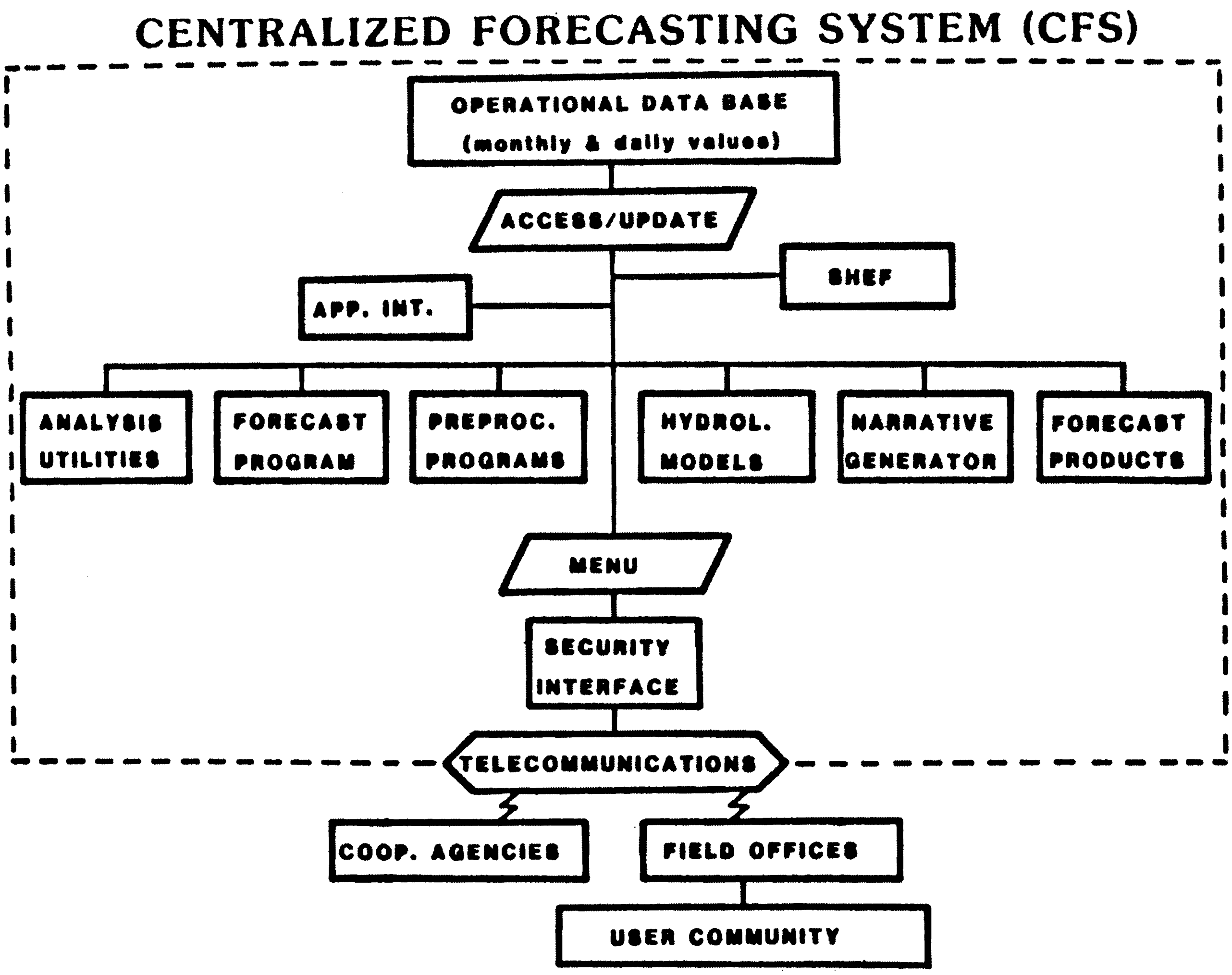
Forecasts Availability

Once field measurements of snowpack, precipitation, or other physical parameter are made, either by manual or automated means, it is important that they be verified for accuracy and used to generate forecast products on a timely basis. The value of these forecasts for planning purposes diminishes with time. It is thus important to disseminate both the data and forecast products as rapidly as possible to the user community.

A new menu-driven centralized forecasting system (CFS) operating in a minicomputer environment is being implemented at the National Water and Climate Center (NWCC) to expedite data assembly, forecast generation, and product dissemination to the public. The objective of this project is to make data summaries and forecasts available at the field office level shortly after readings are taken. This arrangement will enable NRCS to provide water managers at the local level with current planning information on a continuous basis instead of once per month as in the past. The key to successful implementation of this concept is the NRCS Field Office Communications and Automation System (FOCAS) which is intended to supply nearly all field offices with microcomputer equipment complete with telecommunication capability. Over 300 NRCS offices have been identified as having a significant need to access CFS when FOCAS is fully implemented.

Figure 11.11 is a block diagram depicting major components of CFS. The telecommunications link serving field offices will facilitate transmission of snow course measurements to the NWCC minicomputer as well as receipt of forecast products and data. Nevada is the first state to have fully converted to a system like the one described. Their experience has not only demonstrated proof of the concept but has also shown how well the local users accept and appreciate the improved service.

Figure 11.11 Block diagram of the major components of the Centralized Forecasting System (CFS) resident on the West National Technical Center minicomputer in Portland, Oregon. Dial-up access permits exchange of data and forecasts with field offices on a near-real-time basis.



Summary

Snowmelt runoff accounts for from 50 to 85 percent of the annual run off on most streams in the West. Manual and automated measurement systems are used in monitoring snowpack accumulation each winter to supply forecasters with data for making runoff predictions. Water supply forecasts are being issued by NRCS in cooperation with the National Weather Service over 600 forecast points in the West based on snowpack information as well as other hydrometeorologic data. Four categories of forecasts are made to serve the requirements of the user community. The procedures used to generate forecasts are still primarily based on statistical regression methods but a significant effort is being made to provide additional service through the use of hydrologic process simulation model that employ SNOTEL data directly. A centralized forecasting system is being implemented that will give field offices direct access to streamflow forecast products, data summaries, and applications programs to meet local needs. Integration of water supply forecasts into water management decision making is emphasized as being an important aspect of a sound conservation applications program.

Uses of Snow Survey Data and Water Supply Forecast Information

Introduction

Snow survey data have been collected in the mountains of the West on a systematic basis for over 50 years. In the Sierra Nevada Range above Lake Tahoe, snowpack measurements are approaching 75 years of record. Manually measured snow course numbers have increased from only a few hundred in the early 1930's to well over 1600 today. Beginning in the late 1960's, automated sites that measure snow water equivalent, total precipitation, and air temperature were installed to supplement the annually measured network. Presently there are about 600 of these automated sites in the SNOTEL network alone.

The body of data accumulated from both manual and automated snow measurement networks represents an extremely valuable treasury of natural resource information. It's value continues to grow with time. From the moment a piece of data is collected and verified, it begins a journey in time where it will be used repeatedly in both subjective and objective analyses and interpretations. It will in all likelihood be utilized by hundreds of people for a variety of applications. It may be used alone or in conjunction with other resource data by individuals seeking to unlock the knowledge it represents. Such knowledge is not yielded easily and is eventually conferred only to the persistent and inquisitive.

There is something both powerful and exciting in good data. The information that can be gleaned from data is limited only by the imagination and creativity of those engaged in scrutinizing and manipulating it. Although snowpack measurements have principally been collected to aid in forecasting water supplies, many additional uses have been found for the data. This paper discusses both primary and secondary uses of snow survey data and derived forecast products.

Water Supply Forecasts

The foremost objective for routinely surveying snow is to forecast water supplies for the community of water users who depend upon it for their livelihood. In most areas of the West, snowpack which accumulates each winter high in the mountains is directly responsible for from 60 to 85 percent of the annual runoff of the region's major rivers and streams. It is thus the dominant variable in runoff production.

Survey methods are designed to monitor snowpack growth and depletion both on a periodic and continuous basis. Snowpack observations taken at snow courses and SNOTEL sites are used in concert with other hydrometeorologic data including total precipitation, air temperature, and streamflow to make predictions of snowmelt runoff 3 to 6 months in advance. Typically, 3 to 8 snow measurement sites are selected for use in each forecast procedure along with a similar number of precipitation stations. Seasonal volume forecasts are the most common type of prediction made.

Responsibility in the Federal sector for making and publicly releasing streamflow forecasts is delegated to the Natural Resources Conservation Service (NRCS) and the National Weather Service (NWS). Both agencies currently use similar statistical forecast models incorporating snowpack, precipitation, and streamflow data to generate predictions of runoff. Several other major federal agencies, most notably the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and Bonneville Power Administration, also make streamflow forecasts using snowpack data to manage and operate their storage projects. State and local agencies in most western states are also active in producing runoff projections from snow data for intrastate and interstate water administration . Finally, there are a number of private entities who employ snowpack data in forecasting snowmelt runoff for their respective operations.

The NRCS has traditionally published forecast information and snowpack data in monthly state Water Supply Outlook reports. Currently, forecasts for 514 separate stream gaging locations in 11 western states are published in these reports. The interest in and value of the forecasts is attested to by the demand for the reports. Nearly 40,000 reports are issued monthly, January through June to about 25,000 addressees. Most of the recipients are involved in the agricultural arena and use the information to help plan and schedule their farming operations. Frequently, a single report services the needs of multiple individuals, e.g. irrigation districts, reservoir companies, and municipalities.

Other types of forecasts issued to meet special needs include amount and date of peak flow, occurrence of specific flow rate, amount and time of lowest seasonal flow, and rate of hydrograph recession. All of these forecasts rely upon accurate and representative snowpack and precipitation measurements either directly or indirectly.

Physically based hydrologic models operated in a forecast mode are being increasingly used to predict runoff. For the most part, these models do not objectively incorporate actual snowpack observations. Provision has been made in some models to allow subjective adjustment of simulated snowpack based upon observed conditions. Both operational and research agencies are making a substantial effort to incorporate and effectively use daily snowpack and precipitation data to improve the performance of conventional forecast models.

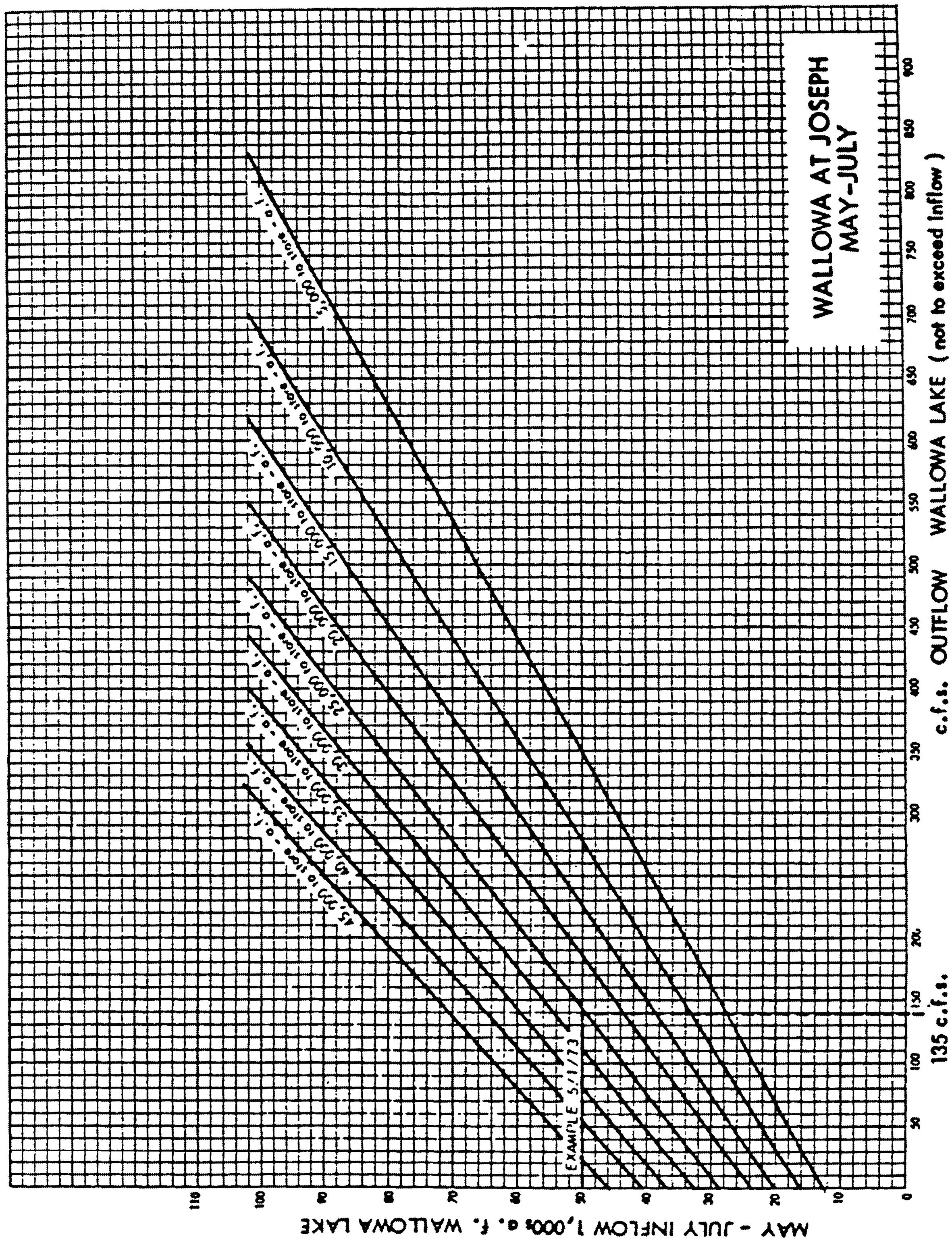
The magnitude and timing of most major flood events in the West is heavily influenced by snowpack distribution and depth. Recent snowmelt runoff events in the Colorado River, Tahoe Basin, and Snake River dramatically underscore the effect snowpack can have in producing record runoff volumes. For this reason, the NWS, which has flood warning responsibility, carefully follows snowpack conditions in order to be prepared to issue advice and guidance to the public when necessary. State agencies with emergency management responsibility seek snowpack data as an essential element in their flood preparedness activities. Individual snow course measurements as well as basin snowpack figures are vitally important in making accurate assessments of the flood potential, and in many cases, the probable timing of the impending event.

Reservoir Management Plans

In the West, there are hundreds of private reservoirs deriving most if not all of their water supply from melting snow. Although most of these impoundments are primarily dedicated to irrigation water storage they often must be operated to minimize downstream flooding, meet minimum instream flow requirements, or conform to other operational restrictions. Reservoir operations plans have been developed by NRCS to assist managers and operators in making systematic planning decisions based on available snowpack and forecast information. Each plan is tailored to provide the reservoir operator with options to better realize project goals whether for multipurpose or single purpose impoundments.

Multiple benefits of flood control, equitable agricultural water allocation, recreation, fisheries, and power generation can now be incorporated more readily and easily into a sound management scheme. With an accurate forecast procedure and timely snowpack and precipitation data, a family of operating curves can be used by the reservoir operator to set outflow level, given a volume forecast and knowing the volume of storage left to fill at any given time. An example of a reservoir operations curve for Wallowa Lake in Oregon is shown in figure 11.12.

Figure 11.12 Example of reservoir operations curve for Wallowa Lake, Oregon, showing how streamflow forecasts are used to set outflow levels.

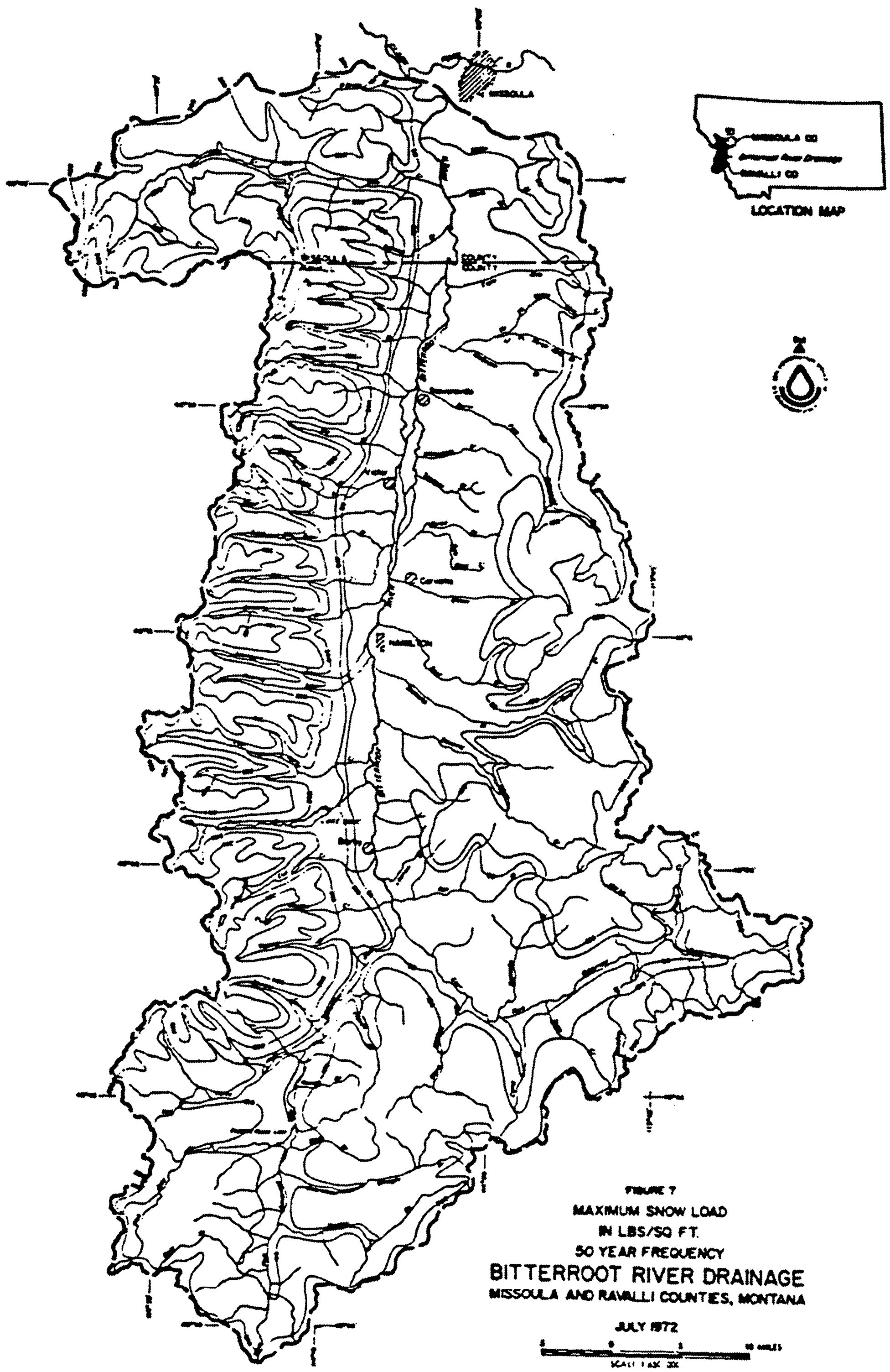


Snow Loads

The foothill and mountainous areas of the West are experiencing rapid development. This means, that new summer homes, recreation facilities, and even industrial buildings are located in and adjacent to heavy snowpack areas. Inadequate or a complete lack of good data to design roofs to withstand a winter's buildup of snow has resulted in many crushed or damaged buildings. Responding to this need, snow hydrologists in NRCS have developed maps and curves indicating snow loads in pounds per square foot.

The snow load analysis was accomplished in most states in the West using a frequency analysis of maximum snow water equivalent and converting 25 or 50 year frequency snow water equivalent amounts to ground snow load. Using knowledge of storm patterns, topographic and orographic effects, snow loads calculated at snow course sites were extrapolated to nearby regions where data was lacking. An example of a snow load map for the Bitteroot River drainage in Montana is given in figure 11.13. Design criteria and methods for converting ground snow loads to roof loads for various roof configurations has been published by the National Research Council of Canada. Accurate snow load information becomes a valuable tool to the architect, engineer and building official charged with the design or inspection of structures in new or existing developments.

Figure 11.13 Example of a ground snow load map for the Bitterroot River drainage in Montana prepared using snow course data.



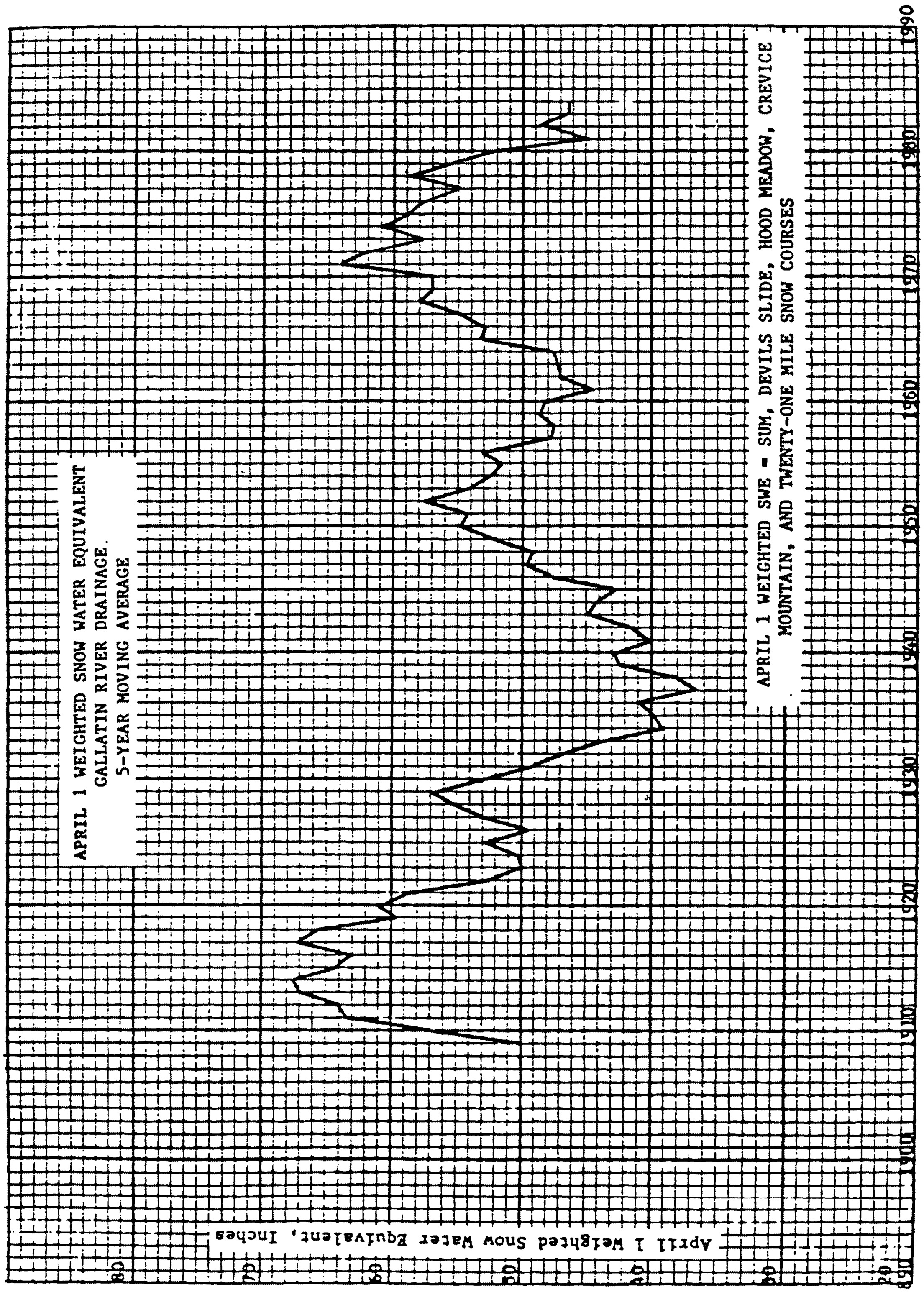
Snowfall and Runoff Analyses

Knowledge of the total amount of snow which falls in a winter is also of significant value. Snow removal costs become a factor in the routing of interstate highways, projection of highway maintenance costs, and planning of recreation areas. This hydrologic data can be presented in terms of averages, long term trends, frequency analyses, and maps. Figure 11.14 is an example of snowpack trends for the Gallatin River drainage in Montana. Such analyses help establish the climatology at elevations which sorely lacked reliable information. Too often, irreversible decisions are made by planners and managers from data gathered over a limited time span, not looking at the situation in terms of long term natural climatic fluctuations. This shortsightedness can be disastrous both for people involved and for the natural environment. Major disruptions in the environment can occur when too little heed is paid to data in its historical perspective.

To help alleviate some of the uncertainties in the planning process, the Snow Survey section in Montana developed and printed a report on the Hydrology of Mountain Watersheds. In it are simplified relationships for arriving at reliable numbers for estimating average annual runoff and peak flows from annual precipitation. Other publications prepared by this staff included hydrological reports on specific river basins detailing precipitation regimes, peak flows and yields from small ungaged sub-basins, average annual snowfall, snow loads, and potential winter sports areas.

At the request of the Oregon Department of Transportation, frequencies of snow depth and snow water contents have been issued in a publication, Snow Frequency Analysis for Oregon. This publication helps highway planners locate routes of transportation, plan highway maintenance and snow removal budgets. It is also used by NRCS River Basin and Watershed planners to identify areas of potential winter recreational use. In combination with soils information, it can also be used to identify areas of potential high soil erosion from rain or snowmelt events.

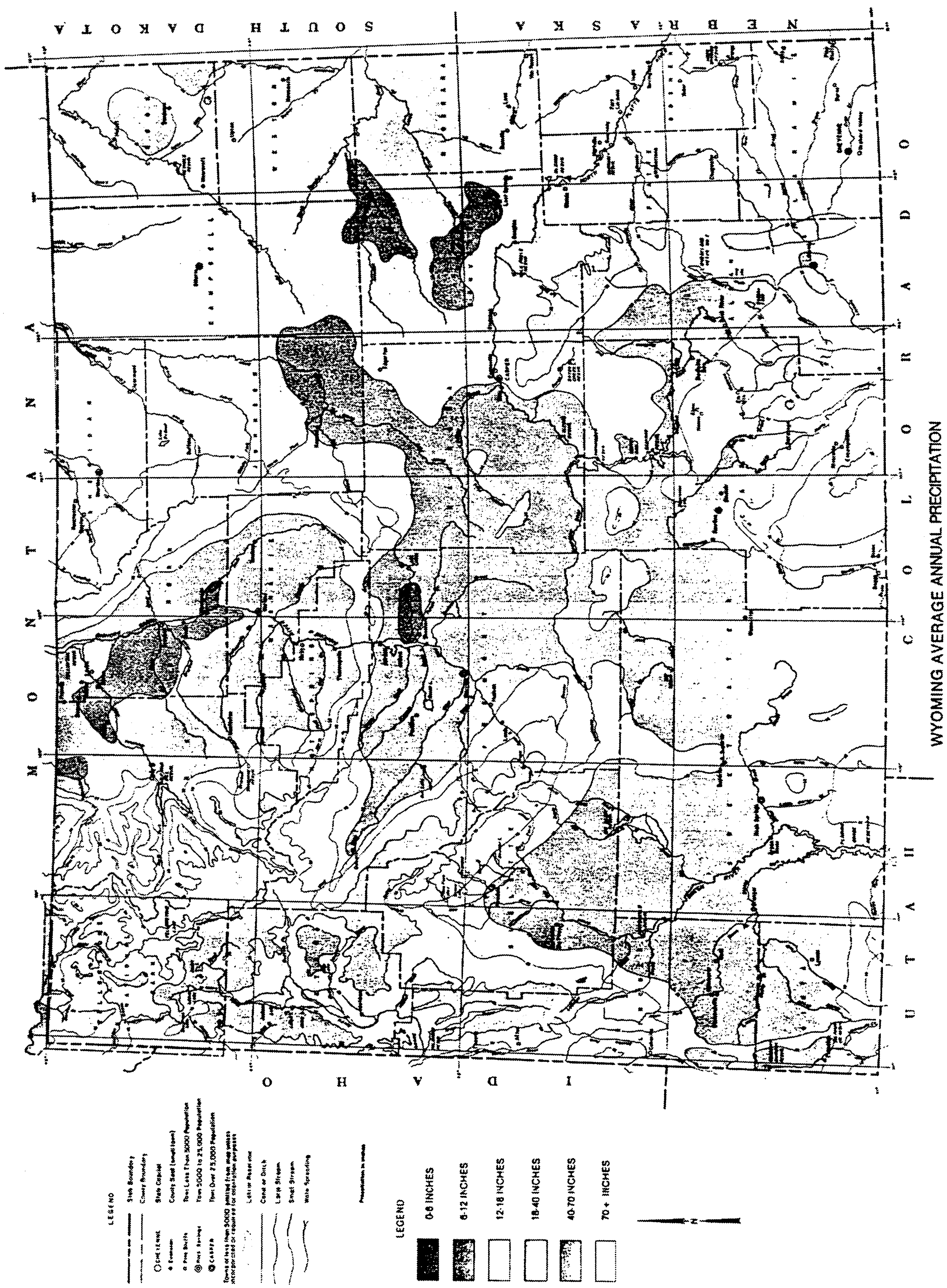
Figure 11.14 Long-term snowpack trends on the Gallatin River drainage in Montana based on snow course data.



Annual Precipitation Maps

Precipitation information is basic to any hydrologic evaluation of a drainage basin. Expressing precipitation as an average and looking at runoff in the same manner, deviations from the norm are more easily detected. Inspections of previously available maps in Montana and Wyoming and comparisons with annual runoff in certain mountainous regions revealed that average yield exceeded average precipitation. Since in most cases this is an impossibility, revisions in the mountain precipitation map seemed in order. This task has been accomplished for several states utilizing relationships developed between maximum snowpack accumulation, average annual precipitation, and elevation. Snow data sites in mountains provided the key to rectifying errors in prior maps. Statewide average annual precipitation maps generated by this process are now the officially recognized versions for nearly all planning or evaluation in both states. The average annual precipitation map for Wyoming is shown in figure 11.15.

Figure 11.15 Average annual precipitation map for Wyoming prepared using snow survey and other climatological data.



Remote Sensing

In the past decade remote sensing technology capable of monitoring snow areal extent and to a limited degree, snow depth, has been rapidly improving. This technology holds great promise for complementing manual and automated snow measurement networks. When perfected and incorporated with existing systems, it will afford hydrologists and engineers a truly three dimensional perspective of snowpack accumulation and melt.

Studies performed in the Rio Grande basin in Colorado by NRCS demonstrated that snow areal extent data derived from space borne platforms can significantly improve forecast accuracy if available in an operational time frame and used in conjunction with snow course data. Snow areal coverage information obtained using satellite imagery, along with elevational profiles of snow water equivalent from the SNOTEL network, were found to be the critical elements in describing and explaining the record 1983 runoff in the Colorado River basin.

NRCS is participating in multi-agency efforts to investigate and quantify the accuracy achievable utilizing visible, infrared, and microwave radiometers operated from space. Conventional snow course and SNOTEL data are being used in these studies to affirm what the remote sensing devices are recording. Results to date indicate that, while remote sensing is promising, operational forecasters will continue to rely heavily upon ground measurements as the mainstay of the functional data base for years to come. Ultimately, however, conventional and remotely sensed data will be integrated to maximize the amount of knowledge inherent in each measurement system.

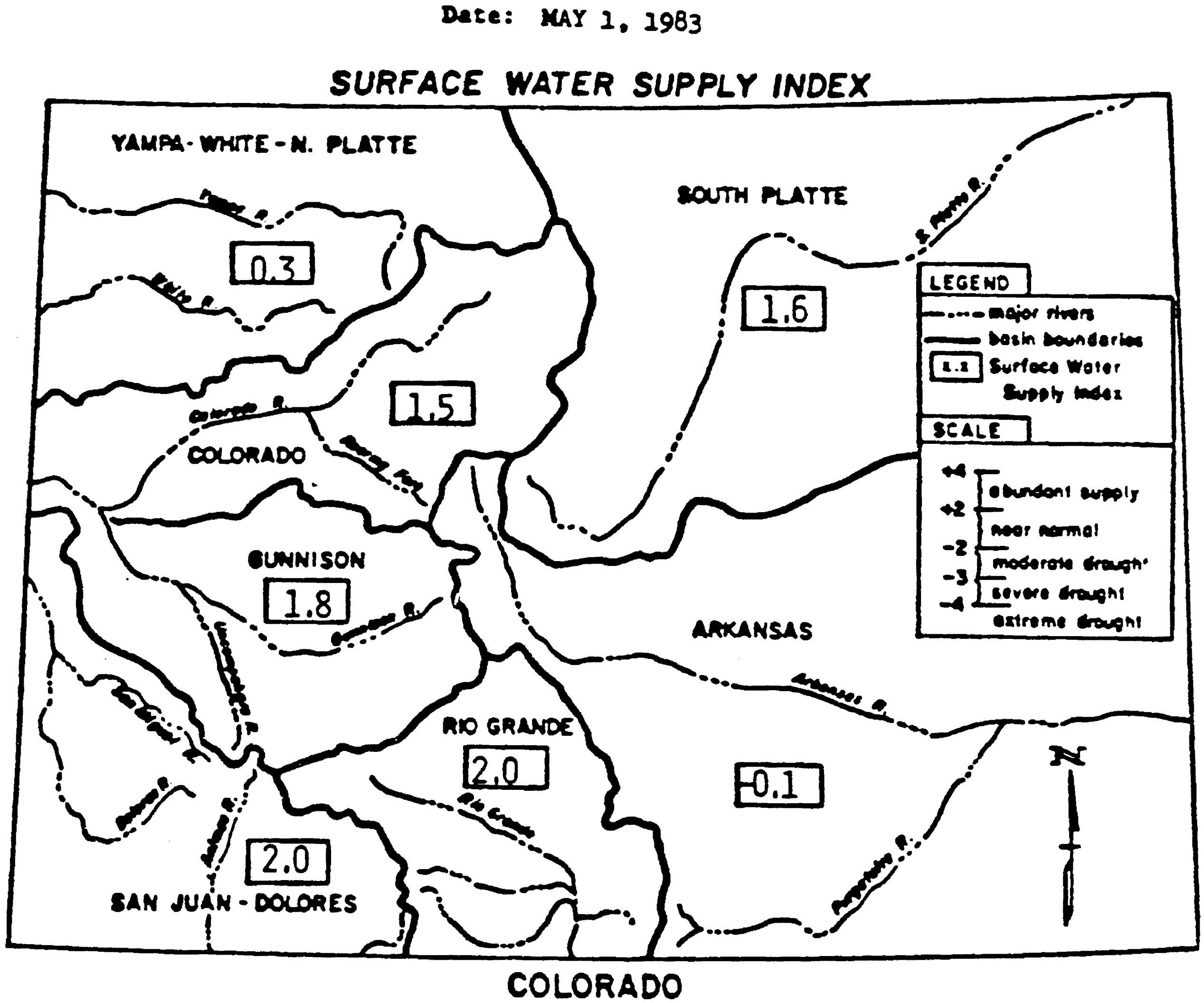
Drought Monitoring

Extremes in climatic conditions inevitably lead to hardship for some portion of the population. In the perennially water short West, the occurrence of dry or droughty conditions is particularly feared. Construction of storage reservoirs, extensive distribution facilities and ground water pumping have all served to reduce impacts of inevitable droughts. But, when a drought of serious proportions does occur, such as the one in 1976-77, all parts of the economy are affected. For this reason, several states have found it necessary to be able to monitor the onset, duration and end of drought conditions. The Palmer Drought Index, although useful, is recognized as having severe limitations in snowmelt runoff areas as a dependable indicator of overall water availability. An alternative method of drought monitoring was requested by the Governor of Colorado to remedy this deficiency.

In response to this identified need, the NRCS, in cooperation with the Colorado State Engineer's office, developed a Surface Water Supply Index (SWSI) akin to the Palmer Index for mountainous regions (figure 11.16). This index uses snow water equivalent, streamflow, reservoir storage, and cumulative precipitation to assess the status of moisture conditions in a specific area. In other states, drought monitoring programs also use soil moisture surveys and ground water levels. In all cases, however, snowpack data play a key role in determining the potential severity of drought and are used by action agencies to formulate responses that mitigate adverse effects.

Snowpack data, streamflow forecasts, and real-time weather data become increasingly important to federal, state, and private forestry officials in times of drought. These data have been found useful in predicting probable forest fire danger months in advance, allowing time to prepare for the season ahead. During the summer, SNOTEL data are made available to forestry management agencies to complement information being received by other fire weather observation networks.

Figure 11.16 Example of surface water supply index for Colorado.



The Surface Water Supply Index (SWSI) is a weighted value derived for each major basin which generally expresses the potential availability of the forthcoming season's water supply. The components used in computing the index are reservoir storage, snowpack water equivalent, and precipitation. The SWSI number for each basin ranges from a -4.00 (prospective water supplies extremely poor) to a +4.00 (prospective water supplies plentiful). The SWSI number is only a general indicator of surface water supply conditions. Further data analyses may be required in specific situations to more fully understand the impacts of abnormally dry or wet conditions suggested by the SWSI. Development of the SWSI has been a cooperative effort between the Colorado State Engineer's Office and the Soil Conservation Service.

Avalanche Prediction

Avalanches are a recognized hazard of winter travel in the mountains during winter. This fact has not deterred thousands of winter enthusiasts from snowmobiling, snowshoeing, and skiing into the back country or beyond ski area boundaries. Each traveler runs a risk of being caught and maybe killed in an avalanche whenever he ventures into snow-filled mountains. The degree of risk is related to terrain configuration, slope steepness, route selection, snowpack stratigraphy, and recent weather conditions.

In the past few years avalanche experts from the U.S. Forest Service have developed techniques to forecast the probability of avalanche activity over large areas to assist winter travelers in planning their trips. Their procedure is based on a knowledge of the current snowpack structure and strength obtained from observers. This information is then analyzed, together with recent snowfall amounts, wind speed, wind direction, and temperature, to produce avalanche warnings for the public. Daily SNOTEL data have been found to be extremely valuable in providing much of the information forecasters need to make their predictions. Avalanche warning activities using SNOTEL data are active in Alaska, Colorado, New Mexico and Utah.

Weather Modification

Winter orographic weather modification programs designed to enhance mountain snowpack and, thereby, increase water production, have been conducted in several western states. Some of these program were designed as research efforts while others were commercial ventures aimed at simply producing more snow for clients. Snowpack measurements have been heavily used in both types of programs

In research programs conducted in Montana, Colorado, New Mexico, and Utah, snowpack data from snow courses and snow pillows were used to help assess the effectiveness of seeding certain storm types. Historical snow course records have also been used to identify optimum locations for cloud seeding activities. In order to monitor and regulate research oriented and commercial cloud seeding operations, several states have established seed/no seed criteria based upon prevailing snowpack conditions determined from SNOTEL and snow course data. Although snow course, snow pillow and precipitation data collected in the Snow Survey program do not wholly satisfy all of the data requirements of a comprehensive weather modification monitoring effort, they do establish the long term historical perspective against which additional data can be compared.

Wildlife Management

Snowfall is known to be a significant environmental factor in the lives of nearly all animals inhabiting forests, streams, and skies of the West. Animal behavior, and in many cases animal survival, is dictated by the amount of snow, its duration, and melt pattern. A study in Montana has established a high correlation between the typical nesting habitat of eagles and the 200 - inch average annual snowfall line. This isoline also was found to be related closely to the habitat preferred by animals on which eagles preyed.

Snowpack data in Colorado were instrumental in documenting the extraordinarily brutal winter of 1978-79 and its adverse impact on big game animal survival. As a consequence, the state legislature appropriated funds to undertake an emergency supplemental feeding program for several major elk and deer herds. Although losses were still high, swift action by state officials is credited with preventing wholesale decimation of Colorado's elk population.

In other studies, snow survey data have been employed in environmental assessment reports of the impact of snowfall on the migratory habits of big game in Wyoming and Colorado. The spawning success of cut throat trout in Montana streams has been related to the magnitude of winter snowfall and the resultant spring runoff. Studies in Alaska have shown that certain characteristics of the shallow snowpack covering most of Alaska's reindeer winter habitat has a significant impact on population dynamics and survival chances. Snowpack hardness and depth are the primary factors limiting availability of forage for reindeer on their winter range.

User Applications Synopsis

In late 1979 and 1980, a series of public participation Workshops were held throughout the West as part of a USDA Snow Survey program review. The program's review was intended to determine the feasibility of moving the surveying and water supply forecasting functions to the non-federal sector. However, during the public participation process, strong sentiment was voiced for continued NRCS administration and oversight of the snow survey activity. The Department of Agriculture's final report on their review concluded the same thing and the program remains in NRCS.

A valuable spin-off of the public participation process was a collection of responses to questionnaires sent to the public, soliciting their opinions about the snow survey program and how they used the information. Responses on how information was used were categorized by major applications area and classified by user type to obtain a profile of the user community's needs. Table 11.1 summarizes 800 responses from this survey. Table 11.2 is a further elaboration of the "Other Use" category of table 11.1. These tables offer all who are involved in collecting, managing, and archiving snow survey data an insight into the diverse nature of the clientele they serve.

Table 11.1 Uses of data by type and number of respondents in public participation study, December 1979–1980.

	Type and Number of Resondents													
Uses of Data	Academic	Agri-business	Business/ Industry Nonag.	Commodity Org.	Env. Conserv.	Farm Org.	Other Groups	Individuals	Local Gov.*	State Gov.		Other	Total	%
Irrigation water supply or equivalent	3	2	10	7	11	1	8	44	87	19	21	1	214	27
Reservoir operation	1		12	2	4		4	5	19	7	27		81	10
Flood control	1		5	1	6	1	3	7	23	13	30		90	11
Hydropower generation	1	1	10	3	4	1	1	5	7	10	8		51	6
Fish and game management	2		2		5		2	1	4	10	11	1	38	5
Snow related recreation (includes ski area operation, location, design, management; show machine locations, restrictions, etc.; cross-country skiing locations, restrictions, etc.)	1		2	1	5		6	5	11	4	14		49	6
Municipal water supply			1		5		1	1	21	4	2		35	4
Forestry and fire control	2	1	2				2	2		1	6		16	2
Range management							1	2	7	1	3		14	2
Snow loads								1		2	1		4	1
Construction (dams, bridges, buildings)	1		1				2	1		2	2		9	1
Pollution and dilution – air and/or water			1					2	1		1		5	<1
Weather modification and evaluation	2								1		2		5	<1
Ground water/soil moisture	1		1					1	3		1		7	1
Hydrologic and/or climatological analysis	2	2	9		1		1	2	1	3	8	1	30	4
Water management		1	9	1	5	1	4	5	45	17	20	1	109	14
Total exclusive of other special uses	17	7	65	15	46	4	35	84	230	93	157	4	757	
Other**	3	2	8	1			3	6	5	7	8		43	5
												Total	800	100

*Includes irrigation districts, soil/water conservation districts, drainage districts and other special purpose governments as well as general purpose local governments.

**See Table 11.2.

Table 11.2 Other uses of snow survey as stated by respondents.

- Academic
- — Research activities
- — Public school teaching, including farm management
- — University instruction
- Agribusiness
- — Drainage and/or pumping
- Business/Industry, Nonagriculture
- — Alert stockmen when to move livestock from river bottoms
- — Agricultural financing
- — Water availability for coal mining
- — Consultant studies
- — Coal-based synfuel development program
- — Demand for power
- Commodity Organizations
- — Planning grazing, stockwater, irrigation
- Other Groups
- — Streambank restoration program
- — News stories
- — Information
- — Data for congressional committee hearings
- Individuals (farmers)
- — General information
- — Fungi collection
- — Litigation over water rights
- — Water recreation
- — Highway design, location, snow removal
- Local Government Agencies
- — Avalanche
- — Civil defense
- — Flood warning
- — Identify potential emergency problems
- State Government
- — Rail/highway transport
- — Demand for power
- Federal Government
- — Highway design, location, snow removal
- — Ground truth data

Special Applications of Snow Technology

Managing snow to augment available water supplies in the semiarid to arid West is receiving renewed attention. Contour furrowing and vegetative (grass, brush, grain) barriers or strips trap snow that would otherwise blow and sublimate away. Soil moisture is also being augmented by tillage methods creating a "rough" or snow entrapping ground surface.

Research projects are underway in Wyoming to evaluate potential increase in water yield by creating more "open space" in forested mountain watersheds. Timbering and forest management practices that create more open space reduce sublimation and transpiration losses.

Costly mechanical snow fences used to trap blowing snow before it blocks roadways may be replaced in the future by living snow fences. Once established, the windbreak style snow fence will entrap snow to supplement its natural moisture supply, becoming self-sustaining in an otherwise water-short location.

Equipment used in monitoring mountain hydrometeorological conditions is also finding application in crop and rangeland locations, for measuring such important physical parameters as salinity, soil moisture, soil temperature, evaporation rates, soil erosion rates, wind speed and direction as well as snow, precipitation, and temperature.

Summary

A vast amount of data has been collected in the Snow Survey program for the expressed purpose of forecasting water supply. Additional interpretations of data collected in this program are now being made to aid planners, public officials, architects, engineers, managers, and developers in making rational land use and investment decisions. A substantial degree of uncertainty has been removed from the planning process as a direct result of such interpretations. Opportunities for future in-depth studies or analyses are by no means exhausted. Procedures and studies developed to this point represent a good start but more remains to be done. The cost of collecting the data is by far the highest when comparing it to the messaging and interpreting that is done once it is made available. To obtain more for our money in these days of rising costs, shrinking personnel forces, and public scrutiny, we need to continue to seek sound technical methods to derive more knowledge and meaning from data already collected.

USES OF NATURAL RESOURCES CONSERVATION SERVICE SNOW SURVEY DATA AND PRODUCTS

Ron Abramovich[1]

ABSTRACT

In the Western U.S., the annual accumulation of the mountain snowpack and the resulting predictability of streamflow have created a wide range and diverse use of Natural Resources Conservation Service (NRCS) Snow Survey data and products. The key factor in the West is how much snow falls and where it falls for water users to speculate what may happen and plan accordingly. Historically, the NRCS inventoried the mountain snowpack to predict spring and summer streamflow for irrigated agriculture. The installation of the SNOTEL (SNOw TELemetry) Network in the early 1980s and a daily climatic data set has increased the use of this high elevation data. Many customers use this data to assist in their day-to-day decisions, for winter or summer recreation, to hedge financial decisions, or for wise management of water as a natural resource.

This paper discusses the importance of snow in the West, how it accumulates, and melts to provide our water supply, and associated decisions made each season to manage and plan accordingly based on the winter snowfall. A seasonal timeline illustrates when customers need and use Snow Survey data and products. The obvious, but also unusual uses of snow survey data and water supply products are discussed. The many aspects of the work that NRCS Snow Survey and Water Supply Forecast staff does, affects everyone in the West, other parts of the nation, and even other countries.

INTRODUCTION

In the Western US, the annual accumulation of the mountainous snowpack and the resulting predictability of streamflow have created a wide range and diverse use of NRCS Snow Survey data and products. Many users use this data to assist in their day to day decisions, for personnel recreation information, to hedge their financial decisions, or for wise management of water as a natural resource. This paper attempts to summarize the different uses of snow survey data and products and when they are requested.

The key factor in the West is the amount of snow and its location for water users to speculate and plan accordingly. This is where NRCS comes into the picture by inventorying and monitoring the mountain snowpack throughout the West to predict the coming year's streamflow. If Mother Nature delivered the same amount of snow each and every winter, it would be nice and consistent and make it easy for water managers to manage and deliver constant supplies for irrigation, fish, and hydropower. Nature does not work this way and often goes through wet and dry cycles. In snow dominated streams in the West, 75 percent of the annual streamflow originates from the seasonal snowpack. First, lets discuss the importance of snow in the West, how it accumulates and melts to provide our water supply, and then discuss the decisions made each year to manage and plan accordingly based on the winter snowfall.

Paper presented Western Snow Conference 2007
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IMPORTANCE OF SNOW

Here in Idaho, we refer to the mountainous snowpack as Idaho's frozen liquid gold and when it melts, it becomes the lifeblood of the state. The snowpack is like a giant reservoir in the mountains storing and accumulating the moisture that falls in what we refer to as the mountainous snowpack. Each and every winter, storms roll in from the Pacific Ocean crossing the western US. In the spring, the snow gradually melts at an average rate of 1-2 inches a day. That would be the same as receiving 1-2 inches of precipitation for one to three months or until the snow was all gone. The spring thaw and melt produces predictable rise in streamflow across the western US. Over 75 percent of the annual streamflow originates from the melting mountain snowpack and could be over 95 percent if stream baseflows from snow were also included.

Figure 1. Idaho's frozen liquid gold, somewhere in eastern Idaho, March 31, 2006.

The West is different from the East and Midwest US, as 70-80 percent of our annual precipitation falls from November to March and less than 10 percent of the annual precipitation falls during the July to August growing season. Summer monthly precipitation amounts are 1-2 inches in the mountains and typically less than an inch in populated valleys and agricultural areas, thus creating the need for steady and constant irrigation supplies. Irrigation is critical to agriculture in the US as nearly half of the value of all crops sold comes from the 16 percent of harvested cropland that is irrigated. In the East and Midwest, nature delivers 3-4 inches a month, or an average of an inch a week, enough to sustain dryland farming.

Annual snowfall is variable and analysis of historic snow survey data shows that the West often goes through wet and dry cycles. In recent years, research has indicated that the weather is more volatile when compared to the 1950s and 1960s. Add to this, the increasing and competing demands for water as a limited resource is making it tough to be a water manager to manage a supply that is highly dependent upon the snowfall that falls, accumulates and melts each year in the West. Increased climatic variability has also increased use and need of snow survey data and products.

Let's start and look at how our internal and external users use our data and products in their numerous decisions whether for financial purposes or management of natural resources. The chart below illustrates the typical timeline when water users need and use Snow Survey products. The Preparation, Planning and Operations stages and associated uses will be discussed.

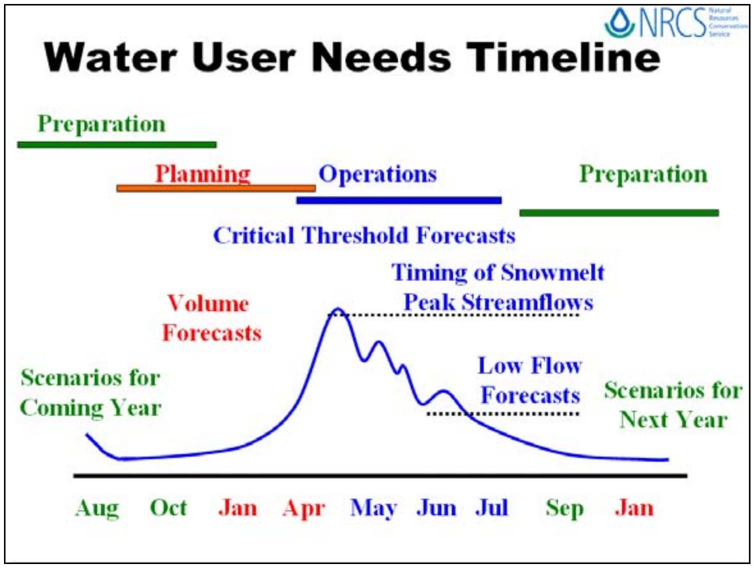


Figure 2. Water user needs timeline illustrating the Preparation, Planning and Operations stages when NRCS Snow Survey data and products are used.

Preparations – Scenarios for Next Year

Each summer and sometimes even before the previous season's snow melts, the news media, farmers and weather watchers call and ask "what's the outlook for next year?" Farmers harvesting their crops are ready to start thinking about the future, especially if it was a bad water year. We use El Nino/ La Nina also referenced as Southern Oscillation Index (SOI) to advise customers about what may happen next year. From July-November, SOI correlates with next winter's snowfall/streamflow in parts of the Pacific Northwest and Desert Southwest. This information allows us to provide scientific advice about next year's water supply. Other sources for next year's forecast are long-range weather forecasts along with the Farmers Almanac. Those interested and occasional phone calls include farmers, stock brokers, power producers and natural gas suppliers. If the Pacific Northwest has a good or bad snow year, a possible increase or decrease in coal and natural gas production could occur. Bonneville Power Administration provides 40 percent of their region's power with 90 percent coming from hydropower dams on the Columbia and Snake rivers. In an average runoff year, Idaho Power can produce 60 percent of its electricity needs from hydropower. Washington Water Power, now called Avista, generates 40 percent of its hydropower from the Clark Fork plant alone. Each spring, Idaho Power requests power cost adjustments for their consumers through the Public Utilities Commission based on April 1 water supply forecasts, contracts, and 'true up' which is based on our forecast accuracy for the previous year.

El Nino often makes the news in the fall, but don't put all your eggs in one basket, as we have learned in the past, past indicators do not always represent future conditions especially with the stock market and other events that may have human influence, such as climatic change. Other uses of El Nino and sea surface temperatures include an inquiry from a District Conservationist after learning about El Nino at a Snow Survey presentation. His interest was to help decide where to plan his next scuba diving vacation. He learned the ocean water where he went scuba diving was colder than normal and not as warm as they expected. However, more ocean life can usually be seen in cooler water. During another El Nino year, a soil conservationist called to see if there was any correlation between El Nino and spring precipitation in southern Idaho so he could accurately schedule the appropriate number of rain make-up games for the local softball league several months in advance. No such luck, there is very little correlation between El Nino and spring precipitation throughout the West. How can you use El

Nino/SOI in your Planning process? For more information see El Nino/SOI correlations verse western states water supplies: http://www.id.nrcs.usda.gov/snow/links/soiwsf3.html

As we move from summer to fall, the days are getting shorter, nights are getting colder, and we know our reservoir carryover storage for next year and have a feeling about how wet or dry the soils are. The fall rains help to get moisture back into the dry soils after the typical dry western summer. If the fall rains don't occur, soil moisture can be the "wild card" to accurately forecast streams next spring. Good antecedent moisture from fall rains means less snowmelt goes into the ground next spring and more drains into rivers and reservoirs for use above ground.

Summer maintenance at SNOTEL sites is done as we wait for the first snowfall of the season which could be September, October, November or even December in a bad year. Snow survey folks and our customers get excited when the first flakes arrive, it is the dawn of a new season, and the news media starts calling to find how much and where the snow is falling. If last year's water supply was bad for you, then it is time to stop worrying about last year and start speculating and worrying about next year. Each year the Idaho Snow Survey staff provides about 100 news media interviews, multiple this by 10 and you have a good ballpark figure for interviews throughout the west each year given by NRCS Snow Survey offices. We have learned the news media is interested in what we do, likes going snowshoeing with big, heavy cameras, sometimes get lost with snow experts, and most importantly, can get the 'word out' about our current and ever changing water supply conditions better than we can.

Figure 3. NRCS Snow Survey personnel provide approximately 1000 news media interviews each year.

Occasionally, in the fall some states compile a Fall Outlook summarizing accuracy of last year's streamflow forecasts, El Nino/SOI outlook for coming year, streamflow forecasts based on SOI, reservoir carryover for next year, and amount of snow needed to provide adequate irrigation supplies. Perhaps one of our greatest challenges is to provide a snow level threshold for irrigators to watch during the long, cold winter to help monitor if they will have an adequate water supply. Recently, we just started taking full advantage of having 20 plus years of daily SNOTEL data and are able to run daily volumetric streamflow forecasts starting on October 1 of each year. To learn more and their accuracy or skill level, see: http://www.id.nrcs.usda.gov/snow/watersupply/

Planning – Volume Forecasts

It is now January, the snow is falling and starting to accumulate, but we are only 40 percent of the way through winter. In January, NRCS starts providing monthly or bi-monthly volume forecasts for users to start Planning and thinking ahead about their financial decisions. Before 1990, we did not start forecasting until February because we were not even half-way through winter. Now, because of availability of daily SNOTEL data and more accurate statistical forecast procedures, we are able to meet these user requests and forecast streams with reasonable error bands in January. These volume forecasts allow users to start thinking ahead, Planning and making decisions based on the water supply forecasts for the coming season. If our volume forecasts are not available timely, customers (hydropower, irrigations districts, etc.) start calling and asking 'when they will be available' for their meetings, which are usually the first week of each month, or to verify their decisions and their forecasts. NRCS and NWS coordinate streamflow forecasts and provide the 'official public forecasts.' Other agencies may forecast for their internal operations. However, many users call NRCS for their forecast numbers and even request the 'uncoordinated value' to compare to their predictors so they can independently decide which forecasts to favor for their decision and Planning purpose. Most private irrigation districts and reservoir operators do not forecast and rely on NRCS forecasts. Volume forecasts are used by hydropower producers to help answer the critical question: how much hydropower can be produced, and if they need to start securing power from other sources at a reasonable price.

In mid-January and with half the winter still to come, which could change the water supply outlook for the better or for the worst, farmers start making decisions and signing contracts for growing crops and use our volume forecasts to guide their Planning decision. It may be too early for some producers to tell if they will have a full water supply or not, if they need to factor in additional costs for groundwater pumping or use a secondary irrigation source. From January-March, water managers use our forecasts for Planning and to shape their reservoir storage and releases by passing more or less water depending upon snow amounts at SNOTEL sites and associated volumetric streamflow forecasts. Some producers are lucky, and can put their decisions off until May to decide to plant higher money producing crops rather than grains in a low water year. In consecutive drought years, some farmers decided to (or had to) get a secondary job since they knew they would be out of irrigation water by mid-summer. State Department of Labor agencies use our water supply outlook reports to gauge migrant worker employment needs. You can bet that if a farmer is looking for a second job, then they won't need as many hired hands.

Let's change snow hats and discuss use of our snow data while it is still frozen in the mountains. Winter recreation use of SNOTEL data has grown over the years, especially with the invention of the automated snow depth sensor in the late 1990s. We are now able to collect snow depth along with new snowfall and monitor snow density on a daily basis to help determine when the snowpack is ripe to melt. To view reports that we have created for our customers and learn more of these uses, and even a new snowboard with a depth sensor, see: http://www.id.nrcs.usda.gov/snow/recreation/

Snow depth is as important to some as the amount of snow water in the snowpack is for hydrologists and engineers to manage water as a natural resource. Snow depth and snowfall is used for determining big animal migration, avalanche forecasting, snow loads, when Sandhill Cranes return, and more. Everyone likes to hear the optimistic snow reports about the big dumps, snowfall in the hundreds of inches. Some snow stories are like the 'big fish' that got away and we have learned that a good snowpack means more tourist and travel dollars for the local economy. Let's talk about some of these other uses in more detail.

Figure 4. Recreational use of NRCS Snow Survey data: resort or backcountry skiing, snowmobiling and digging out on a powder day.

Have you ever tried sampling snow on groomed ski trails? We did to help determine if there was enough snow on the race course to host a ski race or if the ski area had to move the race to another resort. Moving the race means loss of revenue for the ski club, ski area, and local economy. We have also assisted the Forest Service to determine if plowed snow would end up in a river and affect salmon habitat, and helped an elderly lady determine how much snow was at scenic Redfish Lake in Idaho in the middle of winter so she could spread her husband's ashes who had recently passed away. Our advice was to wait till spring. We have even loaned snow tubes to determine how much snow and water may have to be removed because of a high elevation petroleum leak, and assisted law enforcement officials about how much snow was at the scene of the crime and if the road was passable where a body was found. CSI (Crime Scene Investigation) would be impressed.

Building managers and city personnel use SNOTEL data to determine snow loads and to be proactive in sending crews to shovel roofs that maybe under-designed for mountain snowloads. Numerous calls about snow loads were received by the Idaho Snow Survey staff in the winter 2005-2006 because folks had not seen an above average snowpack in over six years. For more information on snow load calculations see: http://www.id.nrcs.usda.gov/snow/data/geninfo/snowload.html

Figure 5. Use of NRCS Snow Survey data to determine snow loads and what could happen: studying snow loads, properly designed roof and roof failures from snow.

Other users of NRCS snow data, Planning forecasts and Surface Water Supply Index (SWSI) products include: bank loan officers and USDA Risk Management Agency analysis of our forecasts to assist with loans and crop insurance needs. The Federal Reserve Board and Natural Gas Company use snow survey and water supply information to gauge the economy and population growth in southern Idaho and other areas of the West where water availability may influence or limit future residential growth. Anheuser-Busch headquarters in St. Louis uses our information to help determine their barley and hops outlook in many western states and Canada.

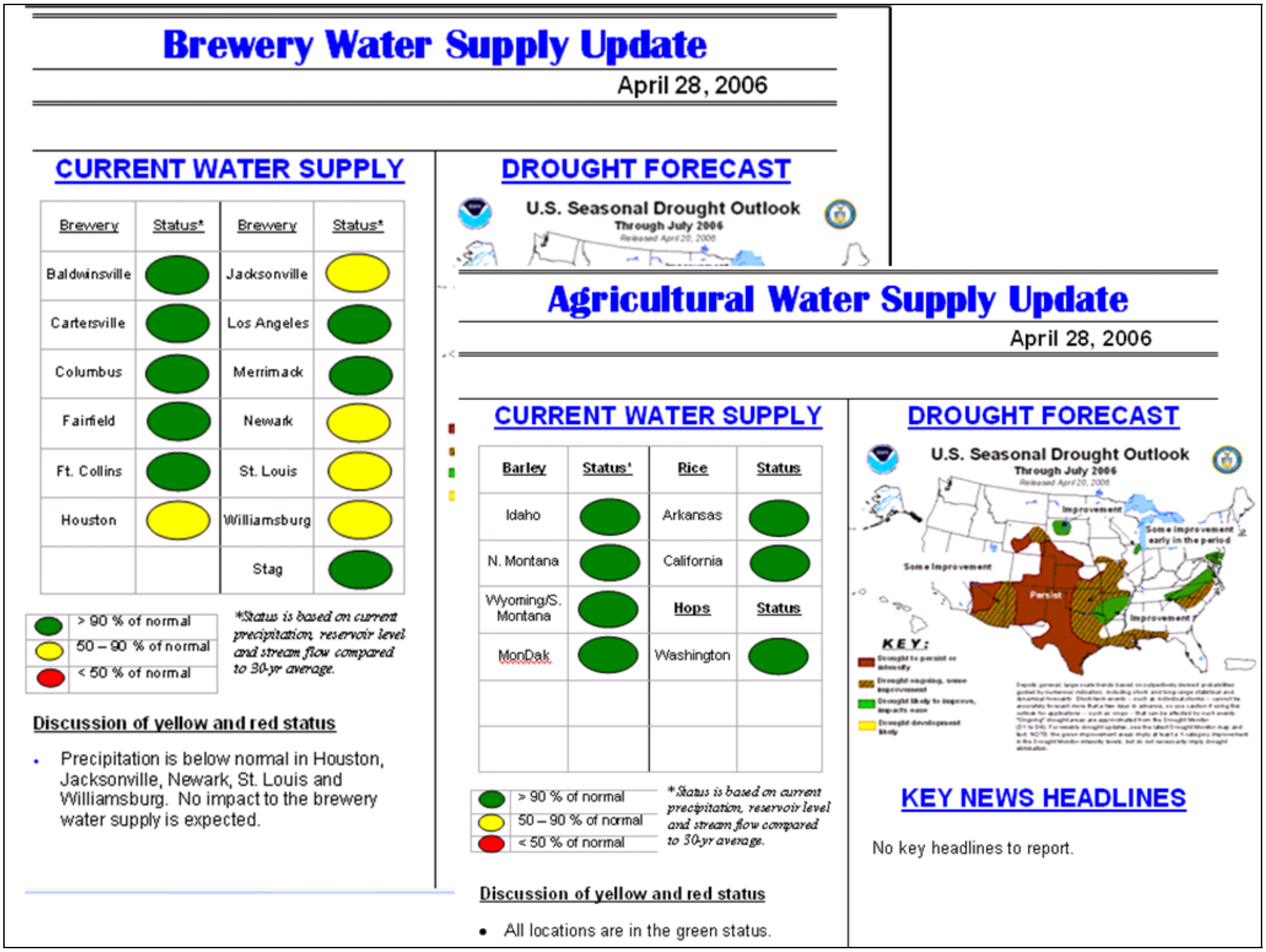


Figure 6. Stoplight diagram of Anheuser-Busch use of water supply information to help guide their operations.

SNOTEL data and water supplies are not just a western issue; SNOTEL data is available 24/7, updated hourly on the Internet and available to you no matter where you live. Program officials have provided advice or helped install automated snow measuring stations in Iraq, South Africa, China and Antarctica, and to develop SWSI in Iran. As long as our data and products are available on the Internet in a timely manner, we don’t usually hear from our customers. Nor do we know all the details on how they are using snow survey and water supply information in their Planning and Operation decisions, unless the data or products are not available. For numerous and different reasons, this is why the SNOTEL system is the only aspect of the USDA NRCS program that is listed as a ‘mission critical’ program for USDA.

In a low snow year, a mint contractor called to see who would be water-short and who would have water through August. He needed information to help determine where to sign contracts with farmers. Mint plants need water in late season to produce the valuable oil. In this case, the Idaho Surface Water Supply Index (SWSI) provided him the necessary information to determine where surface agricultural irrigation shortages may occur, and also illustrate where farmers may need crop insurance. This graph illustrates when shortages typically occur in the upper Snake River basin: http://www.id.nrcs.usda.gov/snow/watersupply/swsi/snake_heise/apr.html. More detailed information on the index can be found here: http://www.id.nrcs.usda.gov/snow/watersupply/swsi-main.html. Water managers also use the volume forecasts to set the price of rental water in water banks each year.

Operations – Critical Threshold Forecasts

It is now early April; the snowpack is reaching its peak water content for the season throughout the West, snow depth on the ground peaks in mid-March. The Planning volume forecasts have been useful, but now, let the fun begin as we shift gears and enter the Operations – Critical Threshold Forecasts period. This period is when the snow starts melting, streams start rising and we'll soon see how accurate our forecasts are and their usefulness for our customers. We'll hear them thank us or hear their complaints about under forecasting wet years and over forecasting dry years which is typical when using multiple regression forecasting. The extreme years are the critical years to get right; it is easy to forecast streams and be a water manager in normal runoff year when water management decisions are fairly standard. We have lots of excuses about what went wrong, and often say "spring precipitation can make or break our forecasts." In the 1960s and 1970s, weather was less volatile and the job as a water manager was easier with fewer demands placed on this limited resource. More recently, we have seen more volatile weather and are wondering how many curve balls Mother Nature can throw at us. Have we seen them all in the past 20 or 50 years of climatological data we base our projections on? As a result, greater climatic variability is encouraging our users to ask more specific questions about Timing of Snowmelt Peak Streamflows and Low Flow Forecasts. Now, we can accurately answer them because of 20 plus years of high elevation daily climatic data that Congress has invested in known as the SNOTEL Network. The annual Snow Survey and Water Supply Forecasting Program budget was $10.5 million dollars in 2006. What a bang for your tax dollar.

Let's get back on track and move on… Up until April everyone wants to know how much snow is 'up in them hills' and what the water supply outlook looks like. They'd like to hedge one way or another about their future decisions which is dependent on this year's snowpack and resulting water supply. Water users monitor the accumulation and melting of the pack at their favorite SNOTEL site, some even use SNOTEL graphs as screen savers on their home computers to remind them of their water source which provides them with the water to grow crops, to put food on their table (and ours) and provide their family income.

How an individual uses water or wants to use the water, determines how they want the snow to melt. There are strong feelings on how the snow should melt depending if you have a reservoir water right or surface water right, not to mention a groundwater right or a combination of them. Reservoir irrigation water right holders prefer a quick melt to flush the water out of the mountains to fill reservoirs and their water right. Natural streamflow irrigators and reservoir hydropower producers would rather see a gradual melt to maintain streamflow levels and their water supply through the dry summer months. In some small towns, neighbors gather at the local worship place and have their unofficial assigned seats. Groundwater users sit on the left and surface water users on the right because you know the other guy is stealing your water.

But after a series of drought years, it is amazing how a good snowpack can bring out smiles, change your attitude about life and bring joy to you and your neighbor. How do you put a dollar value on this? Even river runners have a preference on how the snow 'should' melt depending if they like big whitewater in the spring or want a gradual melt to maintain adequate flows for a family friendly whitewater rafting trip.

Now that May is here, things are heating up and snowmelt is in full swing. The rivers have peaked once, the questions that NRCS Water Supply Specialists get each spring are "is that all there is," "is there more runoff to come," "have the streams peaked," or "is there enough snow up there to produce one more peak," "will the next peak be higher than the last," "can we close the gates on the reservoir and do final fill," and "is it safe for whitewater river runners to put the boats on the river?" The same questions are asked each and every year in snow dominated streams; the answers assist water users in wise management and use of water as a natural resource.

Following is narrative and graphical illustration of recent streamflow variability for a stream in central Idaho which shows why users are asking these types of questions. Hot weather in 2006 melted snow quickly, increased the flow above flood stage and to new record high levels since measurements started in 1916. A year like 2003, resulted in a single peak but the locals that live by the river got lucky as the snow ran out just prior to reaching flood stage while irrigators downstream saw only one month of above average flows; April-September runoff volume was only 46 percent of average and a water short irrigation season materialized as predicted. Mild temperatures during the snowmelt season in 1998 produced multiple streamflow peaks for nearly two months. With the snowpack at only half of average in 2001, produced streamflows that were only 36 percent of average and resulted in change of crops planted and reduced acres plant as irrigation water ran out in July!

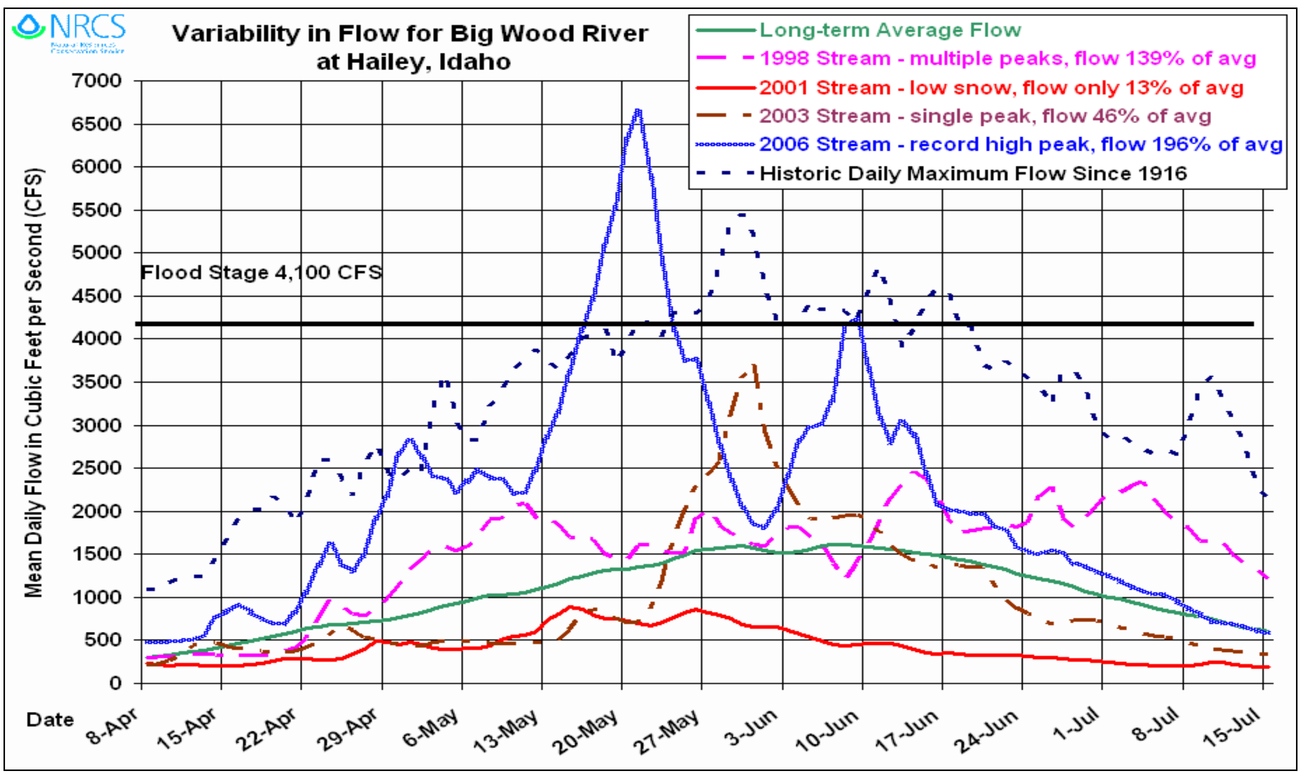


Figure 7. Graphical illustration of streamflow variability in recent years illustrating type of questions that NRCS receives each year in snowmelt dominated watersheds.

Who is interested in peak flow? Everyone from river runners, dam operators, hydro-power operators, fish management and more are interested in not only peak flows but also magnitude and duration of the high streamflows. Farmers and irrigators may not be as interested in the peak flows as they are in their total water supply to fill their water right for irrigation. Let's discuss some of those interested that have used our services in the past.

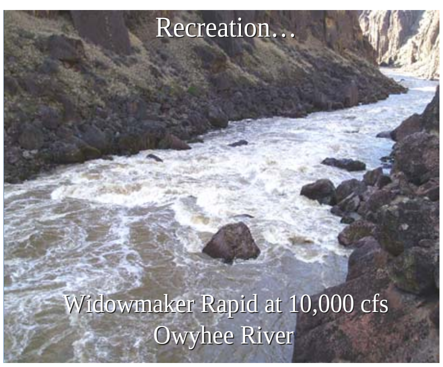
Hard-core whitewater river runners travel the West looking for big water each spring and want to know if the river has peaked or if there is potential for higher flows which may be more dangerous. Boy Scout Troop leaders want to know if flows will be above their level of confidence before taking troops on a raft trip. This was an excellent learning example in providing advice to the trip leader as he knew his 'comfort zone' for boating and only needed to know if the flow would exceed this level on a certain date. Everyone has their own 'comfort zone' on a river and it is difficult to explain the potential that rivers are capable of going 'big' if the optimum weather conditions occur in the spring.

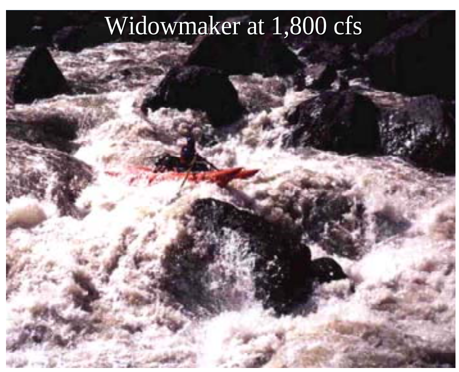
Figure 8. Filming whitewater rafting conditions in Idaho on Lochsa Falls Rapid on the Lochsa River for The Weather Channel June 8, 2006, and family boating on the Salmon River in the Frank Church River of No Return Wilderness Area, July 2005.

On the other hand, if you are into sunny skies and family whitewater raft tips in July, you would like a gradual melt to maintain adequate boating levels in the summer. This allows many to enjoy whitewater rafting without encountering high dangerous flows or low late summer flows that often occur in non-reservoir controlled western streams.

Figure 9. Boat launch at Heller Bar on lower Snake River, May 31, 2003 when the river rose quickly from hot temperatures producing rapid snowmelt in Idaho's Salmon River basin.

Be careful where you park your vehicle because streams can rise quickly even in years with a below normal snowpack, like in 2003. A delayed snowmelt in May gave way to record high temperatures melting two inches of snow water per day, increasing streams rapidly and to levels much higher than folks expected with a below average snowpack. River runners and land management agencies also monitor the melting snow at SNOTEL sites to determine when mountain forest roads will open and if you'll be able to drive to the river put-in. If roads are closed, river runners may have to cancel their ‘once in a life time trip’ or pay an additional expense to use over snow vehicles or fly gear to the river put-in. Likewise in the late summer, if rivers are too low to launch from the normal put-in. It pays to plan ahead and the SNOTEL Network provides key information for making these decisions.





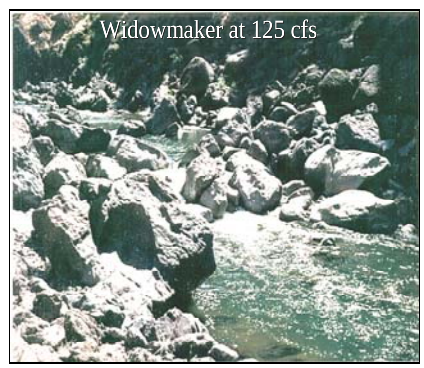


Figure 10. Widowmaker Rapid on Owyhee River at 10,000 cfs, 1,800 cfs, and 125 cfs (cubic feet per second).

Dam operators and hydropower producers are interested and aware of consequences of maintaining a full reservoir to produce power verse not planning properly and flooding if Mother Nature throws curveballs in the winter or spring producing inflows too big to manage.

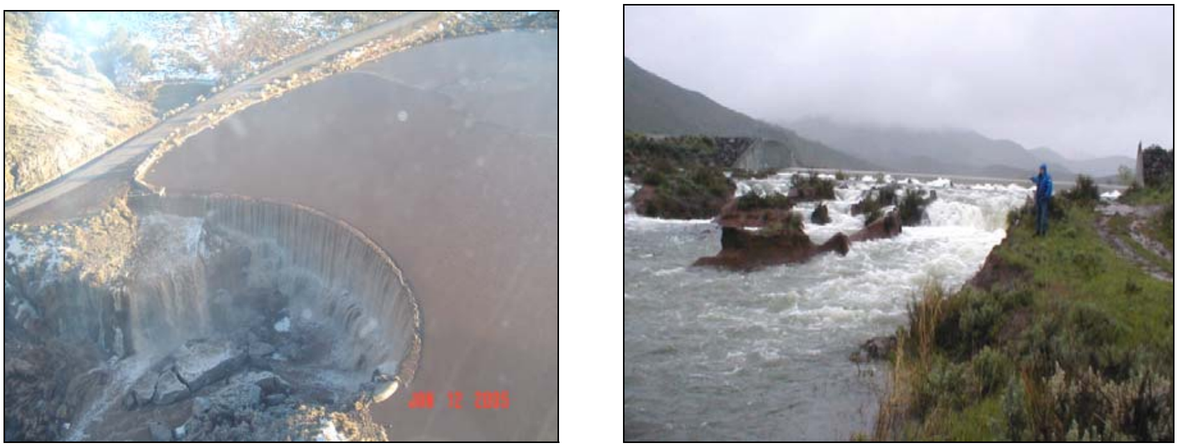


Figure 11. Lower Enterprise Dam (left) in southern Utah January 12, 2005 after heavy precipitation event and
Little Wood Reservoir spillway in central Idaho May 18, 2005 after two inches of rain fell in one day plus snowmelt.

It is now July**;** streams have receded from the snowmelt. Monthly precipitation amounts are less than an inch in the valleys and an inch or two in the mountains. This is enough for dryland farming to squeeze by in some western states, but not enough for growing irrigated crops. The lack of summer precipitation is the reason why our winter snowfall is so crucial for meeting summer water supply needs.

Fish managers use peak and low flow forecasts to determine if, and when or where they should plant hatchery fish in the spring or if the streams may dry-up and reduce fish habitat. Later in the summer months, low flow forecasts are used to determine if the fishing season should be curtailed due to low flows and warm water temperatures that stress the fish. Low volume and flow forecasts are also used to let the public know streams may open for salvage fishing as some streams dry-up in low snow years. Water supply information is also used as guidance for passing salmon flow water from the upstream reservoirs in Idaho and Wyoming through the Snake River dams to the Columbia River.

Figure 12. Fish managers use snow survey data for hatchery stocking and curtailing fishing season due to low streamflows.

It is now late summer and fall is coming, reservoir operators have learned it is financially better to rent excess water during the summer season then flush it in the fall or gradually release water to produce hydropower in the summer when the price of electricity is higher.

Who Did We Miss?

- Hunters – keep their eye on the sky watching snow data in the fall to see if weather and snow are driving big game down from the higher elevations.
- Tire sales – did you know that Mother Nature is the best sales ad for getting people to buy or put their winter tires on? A good old fashion snow storm in November or December increases sales, while a winter snow drought hurts tire sales. Likewise, windshield repair businesses are busy and hire more employees in good snow years.
- School bus drivers and highway departments – use SNOTEL data to monitor new snowfall before sending vehicles out and maybe even use it to call a "Snow Day"!
- Teachers and school children – access data for the Adopt–a-SNOTEL Program, for more information see: fttp://ftp.wcc.nrcs.usda.gov/downloads/centennial/article2120060522.pdf
- Ski rental stores thanked us – for providing encouraging information when El Nino conditions were threatening but had not happened yet in November and December 2006. They have learned once the public had the mind set of a bad snow year, their income decreases.
- Power boat sales – after hearing how local a ski area correlated their financial income to winter snowfall, a power boat dealer did the same thing and now advertises by mentioning snow and water supply in their ads.
- Enron spin-off company – to buy or sell hydropower based on the flashy side of the market, demands and streamflow peaks.
- Homeowners – use the snow and soil moisture data to help determine how long they need to run their sub-pumps to keep water away from their house foundation.
- Fire weather forecasters – use climatic and soil moisture data for monitoring, predicting and determining forest fire potential, crew deployment, and ideal time for controlled burns to reduce forest fuels.
- Range managers – use snow data and soil moisture data to determine range readiness and when to turn the cattle loose in the high county.
- Pizza sales - a take-n-bake pizza chain requested temperature data because they noticed a decease in pies sales as temperatures rose. Nobody wants to turn their stove on when temperatures are 90 or 100 degrees F. Our suggestion was 'if temperatures were above 85F, give 5 percent off; above 90F, give 10 percent off; above 95F, give 15 percent off; and if it sets a new record high, give the first 10 customers the next day free pies.' See this link for more information: http://www.id.nrcs.usda.gov/snow/watersupply/usdanews.htm

Who else – navigation on the Columbia and Missouri, global change research, glacier recession, lake water quality studies, leaky sewer lines, sizing evaporation ponds, weekly updates for the US Drought Monitor, and weekly reports summarizing snow water around Mount St. Helens (in case it blows). I'm sure there are more stories of how folks use NRCS Snow Survey data and products for their personnel or financial decisions. If you have a good use, let your local snow surveyor know.

Recipients of Idaho Water Supply Outlook Report

November 2002 breakdown of the recipients on the mailing list for the Idaho Water Supply Outlook Report:

Count	Customer Group
132	Federal Government
111	Private Total – Business / Industry / Consultant
43	Private – recreation
33	Private - industry
28	Private - hydropower
9	Private – bank
7	Private – consultant
94	Agriculture Group – irrigation district
86	Other – unknown, individual or landowner
61	State Government
34	News Media
28	Educator
21	Local Government
14	Agricultural Rural Group
9	Tribal Government
5	Congress Staff – federal
4	Community non-profit Organization
599	Total Count

Thirty-nine Idaho NRCS Field Offices also receive the report but are not included in above list. One hundredth twenty-three or 20 percent of recipients are from outside of Idaho. The list does not include users accessing the Idaho Water Supply Outlook Report from the Internet. In 2006, there were over 16 million web hits or accesses for data and information on the NRCS National Water and Climatic Center computer. This count does not include web hits at the NRCS state level, nor users that access SNOTEL data from other sources such as National Weather Service, Western Region Climatic Center, Mesonet Network or Weather Underground.

SUMMARY

The NRCS Snow Survey and Water Supply Forecasting Program provides a wealth of data and products for the public to access for their decision making process. High quality data is important and critical in our analysis and yours. How the snow falls, accumulates, melts and runoffs each year is different, but it is amazing how the weather or lack of weather affects all of us one way or another.

ACKNOWLEDGEMENTS

Thanks to Tom Perkins for his review and assigning this topic to me as part of the 100 Year Centennial for the Snow Survey Program. Thanks to Jeff Anderson, Dastina Johnson and Julie Koeberle for their review and feedback on this paper, and for the numerous users for sharing their stories and images with me.

REFERENCES

Schaible, G. 2004. Western Irrigated Agriculture. Internet Publication by United States Department of Agriculture, Economic Research Service, The Economics of Food, Farming, Natural Resources and Rural America.

Chapter 12—Policy

Objectives

Upon completion of this lesson, participants will be able to:

- Describe where to find policy concerning snow surveys and safety and health.
- Follow all safety and health policies closely when making snow surveys.

References

West-Wide Snow Survey Training School Workbook

General Manual 360-Personnel, Issue 15 (Part 420)

NRCS Property Management Regulations, Temporary Regulation E-5

Time

Classroom: Covered under other subjects

Self-paced at Headquarters: 2 hours

Safety and Occupational Health Management Program

Policy

In accordance with General Manual 360-Pers. Issue 15 (Part 420) dated March 1982. Subpart K (Requirements Applicable to Snow Survey Activities) only NRCS employees who are physically able and adequately trained to cope with the hazards involved are to be assigned to snow survey duties.

All employees assigned to hazardous snow courses in remote areas are required to have an annual physical examination at government expense before the snow season starts (30 days). If the examination reveals that the NRCS employee would be a hazard to himself/herself, to others, or to government property, he/she is not to be assigned to such duty.

Responsibilities

The Designated NRCS Safety and Health Official (Deputy Chief of Administration), is responsible for establishing goals and objectives for reducing and eliminating occupational accidents, injuries, and illnesses associated with snow survey operations. This official also establishes priorities with respect to the factors which cause accidents, injuries, and illnesses in the snow survey environment in order that appropriate corrective actions can be taken. Additionally, he is responsible for establishing plans and procedures for evaluating the safety and health snow survey program effectiveness at all operational levels.

Managers/Supervisors are responsible for the safety and occupational health of snow survey employees under their jurisdiction and are evaluated on their effectiveness in providing these employees safe and healthful working conditions.

They are also accountable for ensuring that employees are not subject to restraint, interference, coercion, discrimination, or reprisal by virtue of his/her participation in the snow survey activities involving safety and health related matters.

Employees should conduct their snow survey assignments in a safe and healthful manner and observe all NRCS safety and health management policies and regulations. They should report any suspected unsafe/unhealthful snow survey working conditions to their supervisor for corrective action. They are expected to use safety and health equipment, personal protective equipment, and other devices and procedures provided or directed by policy and necessary for snow survey operational protection.

Incident Reporting System

General

All job-related snow survey injuries, illnesses, and property damage incidents are to be thoroughly investigated to identify causes and initiate corrective action. Snow survey supervisors have primary responsibility for reporting all job-related snow survey injuries, illnesses and property damage incidents.

Investigation

Snow survey supervisors should identify the causes of all accidents and recommend actions to prevent any similar occurrences. Supervisors are to coordinate their efforts with the Administrative Officer (AO) for reporting procedures in the collection and summarization of information for injury, illness, and property damage incidents.

Training/Education

General

NWCC director and state conservationists are to ensure that supervisors at all snow survey levels identify the skills and knowledge required for each NRCS employee to conduct his or her snow survey function in a safe and healthful manner.

Managers/supervisors are to ensure that appropriate safety and health considerations are included in training and educational snow survey activities directed to new snow survey employees, employees given new snow survey responsibilities, and any specialized career development snow survey activities for managers/supervisors.

Specialized

Managers and supervisors are to ensure that specialized safety and health snow survey training activities are available to all snow survey employees in occupations or functions where there is potential for high incidence of injuries or illnesses.

Aircraft Services for Snow Survey

General

The use of contract aircraft in which NRCS snow survey personnel are passengers is to be limited to:

- Remote areas where oversnow travel is hazardous.
- Situations where important economics can be achieved.

- Emergency rescue work

  When employees are involved with snow survey work as passengers in contracted aircraft, the contract is to specify that:

  — A flight plan must be filed by the operator.

  — The aircraft is to be a color that can be distinguished against a snow background and shall be equipped with signal flares, smoke pots, radio equipment, etc.

Only NRCS personnel who have had survival training and are equipped with survival gear, including approved SPH-4 or SPH-4C helmet and a minimum 3-day emergency food supply, may be passengers on aircraft used on snow surveys or emergency rescues.

Note: Information communicated on “aircraft services for snow survey” is in accordance with General Manual (GM) 360-Pers Amendment 18 (Part 420) Subpart L, dated February 1983.

Injury Compensation for NRCS Snow Survey Employees

General

Snow survey managers/supervisors are to use the following Worker’s Compensation (OWCP) Forms when reporting on-the-job injury, illness, or fatality incident:

- USDA Modified CA-1 (Report of Injury)
- USDA Modified CA-2 (Report of Illness)
- USDA Modified CA-6 (Report of Fatality)

Employee Notice of Injury

The snow survey employee is required to give his/her official supervisor (injured party's supervisor) written notice of injury within 30 days after an injury sustained in the performance of duty. However, in order to avoid possible interruption of pay, the injured employee shall file USDA Modified CA-1 within two-(2) working days of an injury.

Snow Survey Supervisor's Report of Injury

The completed USDA Modified Form CA-1 or Form CA-2 is to be forwarded through appropriate NRCS administrative offices. The administrative officer will then submit the original CA-1 or CA-2 to the OWCP district office.

The snow survey supervisor has two (2) working days, after receipt of notice, to forward the injury report (CA-1 or CA-2) to the Administrative Officer if:

- The injury causes disability for the employee's usual work beyond the day of shift it occurred.
- It appears the injury will result in prolonged treatment, permanent disability or serious disfigurement of the head, face or neck.
- The injury has resulted, or appears it will result, in a charge for medical care or other related expense.

If none of these three items occur or appear likely, the form is to be retained as a permanent part of the NRCS snow survey employee's *personnel file*. This will protect the employee's rights if complications should develop later.

Safety Awards

All NRCS employees including snow survey personnel who regularly operate government automotive equipment without preventable accidents are eligible for safe driver awards. Employees who drive government vehicles less than 2,000 miles each year are not eligible.

Awards will be granted only to employees who have a full calendar year of service, with records beginning on the first workday of the year. All employees who do not have a full year's service, as a result of reporting after the first workday of the year or because of LWOP or furlough for any purpose, will be eliminated from current year consideration. This does not eliminate employees who take other types of leave.

State conservationists have the responsibility for keeping records on all employees under state jurisdiction and for making or requesting awards. NWCC is responsible for employees under its jurisdiction.

GENERAL MANUAL (GM) December 21, 1988
360-PER
AMENDMENT 46 (PART 420)

SUBJECT: PER — SAFETY AND HEALTH MANAGEMENT PROGRAM

Purpose. This transmits new policy and guidelines on the safety and health requirements applicable to snow survey activities, safety requirements for use of air transportation of official work, and safety requirements for incidental motor vehicle operators.

Effective Date. This Amendment is effective when received.

State Supplement. The State General Manual Supplement on snow survey activities required by 1420.103 is to be published by each snow survey state no later than March 30, 1989 and a copy of each published supplement shall be sent to the National Headquarters Safety Manager.

Filing Instructions. Remove Table of Contents page i, ii, and iii and replace with enclosed contents page. Remove old subpart K, L, and 0, and replace with enclosed new subparts K, L, and 0.

WILSON SCALING
Chief

Enclosure

DIST: GM

Contents

PART 420 - Safety and Health Management Program

SUBPART K - REQUIREMENTS APPLICABLE TO SNOW SURVEY ACTIVITIES

420.100 General.

(a) Only NRCS employees who are physically able and adequately trained to cope with the potential hazards involved are to be assigned to field snow survey duties.

(b) Snow surveyors shall be trained in first aid, survival in snow, search and rescue procedures, and avalanche avoidance, as prescribed by the program manager, the Data Collection Office supervisors, or water supply specialists. First-aid training for all snow surveyors will include the Red Cross multimedia standard first-aid course (8 hours) or equivalent and Cardiopulmonary Resuscitation (CPR) (8 hours). Full-time snow survey personnel with field duties should receive in addition the Red Cross advanced first-aid training (40 hours total) or equivalent and will be reimbursed for the cost of the training upon its successful completion. Snow surveyors who have to travel snow courses in remote areas shall be trained in snowshoeing and/or skiing and in operating oversnow equipment as appropriate; NRCS employees making snow surveys shall always work in parties of no fewer than two people.

(c) NRCS state conservationists and the National Water and Climate Center Director shall ensure that the safety and health program elements for all snow survey personnel are met.

420.101 Personal protective snow survey equipment.

(a) All equipment furnished to conduct snow surveys shall be uniform in function and quality for comparable conditions program-wide. This applies to oversnow vehicles, skis, snowshoes, radio communications equipment, where appropriate, avalanche rescue beacons (transceivers), and appurtenances.

(b) The personal protective equipment to be furnished snow surveyors shall be based on the most severe climatic conditions anticipated. It shall include but not be limited to such items as ski boots, snow pacs, parkas, pants, mittens or gloves, goggles or comparable protective clothing, and camping equipment. Special emergency field rations are to be determined for each snow course in advance.

(c) When operating or riding on oversnow vehicles without an enclosed cab, operators and passengers must wear an appropriately sized, proper-fitting helmet which bears either the Department of Transportation Label, the American Standards Institute Label (ANSI 290.1), or the Snell Memorial Foundation Label. This helmet may be either full or open face. NRCS will provide helmets. For enclosed cab operations, hearing protection will be worn.

Part 420 - Safety and Health Management Program

420.102 Physical examinations.

(a) *The snow survey employee's age, past medical history, and current medical conditions all must be considered.* Requirements of the job are physically stressful. Working in a cold environment at high elevations and involving vigorous physical exertion make it most difficult to assure that no problems will occur. The following medical tests are recommended for NRCS snow surveyors. The examining physician can determine the *frequency* of a particular test for the employee being examined.

(b) *Current or past medical conditions.* NRCS employees who have had evidence of atherosclerotic cardiovascular disease, transient ischemic attacks, gastrointestinal bleeding, significant urinary obstruction, chronic obstructive pulmonary disease, coronary artery disease symptoms, significant arthritis or other musculoskeletal difficulties, diabetes, or seizure problems are clearly at higher risk during exertion at altitude in cold climates in isolated areas. Extra caution clearly needs to be taken for these employees. To be safe one would have to assume that any existing medical condition would only worsen given the strenuous situation in which these employees will be working.

(c) *Back problems.* The occupational medicine literature suggests that the best office screening to rule out current or potential back problems is the Kraus-Weber tests for minimum muscular fitness. They are easily done in the office and include a physician's examining the patient during sit-ups, flexed knee sit-ups, straight leg raising, trunk and back extension, and flexing to the floor while standing. All employees who are going to be engaged in the vigorous snow survey activities should take these tests or a similar procedure.

(d) *Cardiovascular fitness.* Screening Electrocardiograms (EKG) is recommended for all snow survey employees over the age of 30 years. All over 40 years of age should have a stress (treadmill) cardiac test.

(e) *Respiratory system.* All snow survey employees undergoing the stresses of snow survey field work should have an office spirometry performed. Those employees over 40 years of age should have full pulmonary function tests performed.

(360-GM, Amend. 46, Jan. 1989)

Subpart K - Requirements Applicable to Snow Survey Activities

(f) *Well adult care.* NRCS strongly encourages active participation in some type of regular mild physical exercise; for example, vigorous walking three to four times a week for half an hour each session. There is growing medical opinion that High-Density Lipoprotein (HDL) cholesterol and cholesterol levels should be drawn on all employees as a screening procedure. A general screening urinalysis and hematocrit should be performed. Their immunization status must be complete and they should have a tetanus shot within the last 10 years.

(g) *Employees who have specific medical histories or who are currently taking any type of prescription medications should be treated on an individualized basis by their physician.* The Office of Personnel Management (OPM) exam form which NRCS is using can be adequate as long as the physician performing the exam includes the above mentioned tests. The form is referred to as "Certificate of Medical Examination" (SF-78).

420.103 Emergency preparedness procedures.

(a) Each state conducting snow survey operations shall develop a General Manual Supplement that establishes state policy for monitoring activities in remote areas and initiating and conducting rescue operations when necessary.

(b) When snow surveyors are called upon by responsible local officials for emergency rescue assistance in saving a life, they should respond and notify the appropriate NRCS line officer as soon as practical. Such activity should be considered part of their assigned duty. It is suggested that an advisory meeting with local responsible officials emphasizing that NRCS will only become involved in life-threatening situations and where snow survey expertise and equipment are specifically required to *augment* normal rescue arrangements. NRCS equipment will be operated only by NRCS employees.

420.104 West-wide snow survey training school.

(a) The program manager in cooperation with the Employee Development Branch shall conduct an annual snow survey training school to teach snow surveying techniques and appropriate survival skills. Participating states will provide equipment and instructors required to conduct the school.

(b) An educational program using video instruction and other media should be established to supplement the training school. These videos shall be used as annual refresher training for snow surveyors. Videos should be used for at least the following elements: First Aid, hypothermia, shelter construction, winter vehicle operations, oversnow machinery, CPR, shelter construction, helicopter operations, snow sampling, summer survival (insect bites, heat strokes), proper use and handling of pack animals, and four-wheel all-terrain vehicle (ATV) operations.

(360-GM, Amend. 46, Jan. 1989)

SUBPART L - USE OF AIR TRANSPORTATION ON OFFICIAL WORK

420.110 General.

(a) This subpart sets forth NRCS policy relative to the approval required and control necessary to ensure that authorized personnel using chartered, contract, or privately owned aircraft are properly licensed and responsible.

(b) NRCS employees shall be authorized to pilot privately owned or rented aircraft for official business after obtaining approval of those officials having delegated authority.

420.111 Responsibilities.

(a) State conservationists, National Center and Institute Directors, the Caribbean Area Director, and the Director of the Pacific Basin Area shall be responsible for approving all charter, contract, or privately owned aircraft requests within their administrative areas.

(b) State conservationists, National Center and Institute Directors, the Caribbean Area and the Director of the Pacific Basin Area are responsible for their own requests to use charter, contract, and privately owned aircraft.

(c) National Headquarters (NEO) employees will submit aircraft requests to the NHQ Administrative Officer for approval.

420.112 Scope.

(a) Immediately upon receipt of this subpart, state conservationists, National Center and Institute Directors, the Caribbean Area Director, and the Director of the Pacific Basin Area shall discontinue submitting aircraft requests to NHQ.

(b) Responsible officials will issue a supplement to this subpart which will provide additional guidance to managers and supervisors in carrying out the requirements contained herein.

420.113 Approval requirements.

(a) The pilot-in-command shall have a valid class II (two) medical certificate.

(b) The aircraft shall have an air worthiness certificate displayed and be inspected in accordance with Federal Aviation Regulations (FAR).

(c) At least $75,000 liability insurance coverage shall be in effect for each passenger.

(360-CM. Amend. 46, Jan. 1989)

Part 420 - Safety and Health Management Program

(d) The pilot-in-command shall have a valid, current, FAA unrestricted Commercial Pilot Certificate or Airline Transport Pilot Certificate and appropriate aircraft ratings. The minimum flight requirements are:

FIXED WING AIRCRAFT

Category	Minimum Hours
(1) Total time	1500
(2) Pilot-in-command total	1200
(3) Pilot-in-command, as follows:	
Category and class to be flown	200
Cross country	300
Operations in typical terrain	200
Night	100
Instrument actual/simulated	100
Make and model to be flown	25
Preceding 12 months	100
Preceding 60 days	10

HELICOPTERS

Category	
(1) Helicopter	1500
(2) Weight class*	100
(3) Turbine	100
(4) Make, model, and subsequent series	50
(5) Make and model in previous 60 days	10
(6) Make and model in previous 30 days	5
(7) Typical terrain**	200
(8) Typical terrain in make and model	10

* Weight Class: Light (up to 6000 lbs. normal gross), medium (6001 to 12,500 lbs. normal gross), heavy (12,501 lbs. and over, normal gross)

** Typical terrain experience requirement is defined as: Pilot experience in mountainous terrain with varying elevations of over 5000 foot pressure altitude at temperature ranges above 75 degrees F., rugged slopes, mountain top helispots, mountainside landing spots surrounded by trees, brush or rocks, persistent wind, and weather that includes strong winds In the mountains with sudden up-and-down drafts and direction changes.

(e) The provisions of 420.113(d) do not apply when the pilot-in-command is an NRCS employee on official travel and is the sole traveler. In such a situation, all applicable federal laws and regulations shall be followed.

420.114 Approval policies to contract aircraft services for snow survey operations.

(a) Flying in mountainous areas requires special equipment and procedures. The use of aircraft in which NRCS personnel are passengers is usually in remote areas where oversnow travel is especially hazardous, in situations where important economies can be achieved, or for emergency rescue work.

(b) If an aircraft is used under the conditions outlined in 420.114(a), it is to be either for taking aerial readings for snow survey markers or for making landings in remote areas to conduct snow surveys or site Installation/maintenance activities. Landings by conventional airplanes on other than authorizes airports or airstrips are prohibited except as specifically approved on a case-by-case basis. Landings on open water may be made by properly equipped aircraft. Landings on snow may be made by a helicopter or ski-equipped airplane if the pilot and the NRCS representative agree on the need and feasibility and if the normal safety requirements of the operations can be maintained. This determination shall be made by aerial reconnaissance and/or advance ground reconnaissance prior to the snow survey season. The pilot always has the final decision on whether a landing will be made.

(c) The pilot-in-command shall have the same qualifications as shown in 420.113(a). Pilots certified by another federal agency for operating in mountainous areas in snow conditions are considered to be particularly well qualified for snow survey operations.

(d) The aircraft shall meet specifications of 420.113(c) with special consideration for the last inspection. Aircraft certified by another federal agency are considered to be particularly well qualified for snow survey operations.

(360-CM, Amend. 46, Jan. 1989)

PART 420 - Safety and Health Management Program

(e) If NRCS personnel are Involved with snow survey work as passengers in contact aircraft, the contract is to specify that:

(1) A flight plan shall be filed by the operator with the Federal Aviation Administration (FAA) when required as a minimum. An itinerary which includes estimated departure and arrival times will be filed with the appropriate responsible organization prior to departure. Where radio communication facilities exist, position-reporting procedures established by the agency owning or responsible for the aircraft will be followed for helicopter operations. If NRCS is responsible for the contract, the minimum requirement will consist of a report prior to descent to a site that includes the estimated time on the ground and a report after lift-off with the destination and estimated time of arrival.

(2) The aircraft shall be of a color that can be distinguished against a snow background and shall be equipped with signal flares, first-aid kit, approved fire extinguisher, radio equipment, emergency locator transmitter (ELT), and survival equipment for the pilot. All seats will be equipped with FAA approved lap belts. Front seats in helicopters will also be equipped with FAA approved double-strap shoulder harness, with automatic-locking inertia reels.

(f) Only NRCS personnel who have had survival training and are equipped with survival gear (including a Gentex SPH-4C with communications or equivalent flying helmet), Nomex or equivalent fire-retardant flight suit and gloves, above-the-ankle boots, and a minimum 3-day emergency food supply may be passengers on aircraft used in snow survey activities.

(g) Sling load/hover hookup operations should only be undertaken by personnel who have received formal training such as that which is offered by the United States Forest Service and the Department of the Interior-Office of Aircraft Services.

(h) Prior to any fueling operation, all aircraft engines must be shut down, all passengers off-loaded, and proper grounding assured.

(360-GM, Amend. 46, Jan. 1989)

Subpart L - Use of Air Transportation on Official Work

420.115 Corrective actions.

(a) Operation or use of charter, contract, or privately owned aircraft for official business in relation to any of the following conditions will constitute sufficient cause for disciplinary action:

(1) An employee is convicted of being under the influence of alcohol, narcotics, or pathogenic drugs while piloting or riding—in charter, contract, or privately owned aircraft.

(2) An employee is found not qualified to operate charter, contract, or privately owned aircraft safely because of a physical or medical condition as determined by appropriate medical authority.

(3) The employee's valid Class II (two) medical certificate is revoked.

(4) The employee's privately owned aircraft fails to meet inspection and maintenance requirements established by the FAA.

(5) The employee's valid commercial pilot's license is revoked.

(6) State conservationists or Center and Institute directors fail to properly authorize an employee to use charter, contract, or privately owned aircraft.

(7) The employee pilots charter, contract, or privately owned aircraft when the weather is not appropriate for flying.

(8) An employee is found to be at fault in on aircraft accident while piloting a charter, contract, or privately owned aircraft.

(b) (Reserved).

(360-GM, Amend. 46, Jan. 1989)

SUBPART 0 - SAFETY REQUIREMENTS FOR INCIDENTAL MOTOR VEHICLE OPERATORS

420.140 General.

(a) This subpart sets forth National Resrouces Conservation Service (NRCS) policy relative to the approval required and control necessary to ensure that incidental motor-vehicle operators are properly licensed and responsible.

(b) All NRCS employees and all employees working under a cooperative arrangement with NRCS who are required to operate a government-owned or leased motor vehicle to carry out the duties of their position are covered by the requirements of this subpart.

420.141 Other pertinent regulations.

Policy contained in this subpart and any supplements thereto must comply with the provisions contained in Subchapter 1, Chapter 930, of the Federal Personnel Manual (FPM), and Subpart 104-38.50 of Agriculture Property Management Regulations.

420.142 Responsibilities.

(a) State conservationists, Caribbean Area Director, Pacific Basin Area Director, and Center and Institute are responsible for carrying out the provisions of this subpart within their administrative areas.

(b) The National Headquarters Administrative Officer is responsible for carrying out the provisions of this subpart for employees working out of National Headquarters.

420.143 Scope.

(a) Immediately upon receipt of this subpart, all offices of the Soil Conservation Service will discontinue the use of Standard Forms 46 and 47 as well as Form AD-184.

(b) Responsible officials will issue a supplement to this subpart which will delegate responsibilities and provide additional guidance to supervisors and property-management officials in carrying out the requirements contained herein.

(360-CM, Amend. 46, Jan. 1989)

PART 420 - SAFETY AND HEALTH MANAGEMENT PROGRAM

420.144 Licensing requirement.

(a) All incidental operators are required to have a valid state driver's license.

(b) In addition, all incidental operators, while operating a government-owned or leased vehicle, must have in their possession an identification card or other document which identifies the driver as an employee of the Natural Resources Conservation Service or as an employee working under a cooperative arrangement with NRCS.

420.145 Application requirements for new employees.

(a) New employees who are to be incidental operators must request authorization to drive a government-owned or leased vehicle from their immediate supervisor. This request must be in the form of a *memorandum* and must contain the following:

(1) Number of current valid license and state issued.

(2) List of arrests or summonses for violation of motor vehicle laws (excluding non-moving violations) and convictions, if any.

(3) Any suspensions or revocations of his/her state license or agency driver authorization within the past 5 years.

(4) Any motor vehicle accidents within the past 5 years.

(b) Employing offices will provide instruction on filing of information obtained from new employees.

420.146 Road test requirements.

The Natural Resources Conservation Service waives the road-test requirements for incidental operators as provided in paragraph 1-8(b) of Subchapter I of Federal Personnel Manual (FPM) Chapter 930 when operating standard sedans and pickup trucks. Operators of trucks other than pickups and operators of any vehicle towing a trailer shall demonstrate to their supervisor the ability to drive under conditions they are expected to encounter.

(360-CM, Amend. 46, Jan. 1989)

Subpart 0 - Safety Requirements for Incidental Motor Vehicle Operators

420.147 Physical requirements.

(a) The Natural Resources Conservation Service waives the physical fitness inquiry for Incidental operators as provided in paragraph A-5(b) of Appendix A to FPM Chapter 930.

(b) State or other employing offices will be responsible for establishing a procedure for ensuring that only authorized individuals operate government-owned or leased motor vehicles. Additionally, those offices must establish a procedure ensuring that any employee authorized to drive is physically able to operate the assigned vehicle without danger to himself/herself or others and that each authorized employee is in possession of a valid state driver's license. Established procedures must be communicated to supervisors and accountable property officers.

(c) If a health problem is identified which would tend to impair an employee's capability to safely operate a motor vehicle, the supervisor or other responsible official should obtain a professional medical evaluation of the problem and submit the evaluation through channels to the Employee Relations Branch at National Headquarters. It will then be referred to the Department's medical officer for an opinion on whether or not authorization to drive should be continued.

420.148 Driving record review.

(a) The Natural Resources Conservation Service will discontinue periodic reviews of driving records of incidental operators.

(b) In lieu of periodic reviews, all incidental operators are required to notify their immediate supervisor of any citation for moving-traffic violation as soon as practical after receiving the citation.

(c) Incidental operators also are required to notify their supervisor as soon as practical of the disposition to the citation, including suspension or revocation of the state driving license. Failure to make a timely report will result in disciplinary action against the offending employee.

(360-CM, Amend. 46, Jan. 1989)

PART 420 - Safety and Health Management Program

420.149 Corrective actions.

(a) The following events will constitute sufficient cause for adverse or disciplinary action:

(1) An employee is convicted of operating under the influence of alcohol, narcotics, or pathogenic drugs.

(2) An employee is convicted of leaving the scene of an accident without making herself/himself known.

420.149 (a) (3)

(3) An employee is found not qualified to operate safely because of a physical or medical condition as determined by appropriate medical authority.

(4) An employee's state license is revoked.

(5) An employee's state license is suspended. Employees whose position description contains a requirement to operate a motor vehicle on public highways will be accommodated in their position for no longer than 30 days from the date of suspension. If the period of suspension exceeds 30 days, responsible officials will evaluate the work situation to see if the employee can be reassigned to a position which does not require operation of a motor vehicle on public highways. If no position is found, then appropriate action will be initiated to remove or suspend the employee. Loss of driving privileges for 6 months or longer will normally result in a proposal to remove.

(6) An employee receives a ticket for careless/reckless and/or unlawful speed while driving a government-owned or leased vehicle.

(7) A supervisor or property-management officer fails to take appropriate action to determine the qualifications of an incidental operator or fails to properly authorize an employee to operate a government-owned or leased motor vehicle.

(360-CM, Amend. 46, Jan. 1989)

(b) The following events will constitute sufficient cause to relieve employees, for such period of time as may be necessary, from duties requiring the operations of a motor vehicle:

(1) An employee who after investigation is found to, be at fault in a motor vehicle accident while operating a government-owned or leased vehicle.

(2) An employee is convicted of a moving violation while operating a government-owned or leased vehicle.

(3) An employee improperly operates a motor vehicle assigned to her/him.

(4) An employee fails to comply with federal administration orders relating to motor vehicle operations.

(5) An employee is found upon medical examination to fail to meet the appropriate physical standards, but the diagnosed defects are considered by the Departmental medical officer to be of a temporary or remedial nature.

(6) An employee is convicted of operating under the influence of intoxicating liquor.

(360-CM, Amend. 46, Jan. 1989)

United States Department of Agriculture

Soil Conservation Service

P.O Box 2890
Washington, D.C.
20013

November 16, 1987

SOIL CONSERVATION SERVICE PROPERTY MANAGEMENT REGULATIONS (SCSPMR) TEMPORARY REGULATION E-5

SUBJECT: Safety Equipment Requirements for Three and-Four Wheel All-Terrain Vehicles (ATV's)

Purpose: This temporary regulation of the Soil Conservation Service Property Management Regulations (SCSPMR) transmits SCSPMR Temporary Regulation E-5, Safety Equipment Requirements for Three- and Four-Wheel All-Terrain Vehicles.

Effective Date: This regulation is effective upon receipt.

Directives Canceled: The following regulation is hereby canceled and should be destroyed.

a. SCS Property Management Regulations E-4 Safety Equipment Requirements for Three- and Four-Wheel All-Terrain Vehicles, October 2, 1986.

Filing Instructions: File temporary regulation E-5 in the front part of Subchapter E.

WILSON SCALING
Chief

Enclosure

DIST: SCSPMR

United States Department of Agriculture
Soil Conservation Service
P.O Box 2890
Washington, D.C.
20013

November 16, 1987

SOIL CONSERVATION SERVICE PROPERTY MANAGEMENT REGULATIONS TEMPORARY REGULATION E-5

TO: Holders of Federal Property Management Regulations

SUBJECT: Safety Equipment Requirements for Three- and Four-Wheel All-Terrain Vehicles (ATV's)

Purpose. This temporary regulation supplements and changes Soil Conservation Service Property Management Regulation Temporary Regulation E-4, dated October 2, 1986, concerning the safe use of three- and four-wheel all-terrain vehicles.

Effective Date. This amendment is effective upon receipt and will remain in effect until superseded or canceled by an amendment.

Procedures. SCSPMR 104.26.7005 et seq. required that rollover protection and seatbelts be added to all all-terrain vehicles. Since the regulation was written, other three- and four-wheel all-terrain vehicles have been brought to the market which require the operator to participate in the operation by shifting his/her weight when riding the vehicle (sometimes called a rider-activated vehicle). This negates the use of rollover protection and seatbelts because the operator must move forward, backward, and sideways to control the vehicle; therefore, SCSPMR 104-26.7005 et seq. is no longer an appropriate policy for these types of all-terrain vehicles. The following are new requirements for all operators of these vehicles:

(a) Participation in a training course recognized by the Specialty Vehicle Institute of America (SVIA). The course is mandatory for new operators and must be taken before using the vehicle. Personnel who are now using an all-terrain vehicle must take the course no later than October 31, 1988. Each state that uses ATV's will designate an individual operator(s) who will participate in an instructors training course that is recognized by SVIA. All Soil Conservation Service users in the state will be trained by the ATV state instructor or instructors recognized by SVIA prior to operating ATV's after October 31, 1988. Operators will adhere to the safety precautions outlined in the operator's manual and the rules taught in this class while operating ATV's.

(b) While riding these vehicles, operators must:

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(1) Wear a proper-fitting helmet which bears either the Department of Transportation Label, the American National Standards Institute Label (ANSI 290.1), or the Snell Memorial Foundation Label. This is to reduce the possibility of head injuries. This helmet may be either full or open-faced. SCS will provide helmets.

(2) Wear goggles or a full-faced shield for eye protection, which must bear the standard markings VESC8 or V-8 or 287.1 or be constructed of a hard-coated polycarbonate. SCS will provide eye-protective wear.

(3) Wear substantial shoes of material such as leather which cover at least the ankle and have heels to reduce the possibility of injury to feet and ankles. Cloth or canvas shoes are not acceptable. SCS operators will provide their own shoes.

(4) Wear long pants for total leg support. SCS operator will provide long pants since they can reasonably be expected to be a part of everyday attire.

(c) SCS recommends the operator wear the following items of equipment for his/her personal protection, which the SCS operator should provide:

(1) Off-road style gloves for personal protection, particularly when operating in brushy, forested, or rocky terrain.

(2) Long-sleeved shirt or long-sleeved jacket.

These are the minimum requirements to insure full workers-compensation financial protection for SCS employees while on official duty.

Filing Instructions

File this temporary instruction in the front part of subchapter E.

13. Water Supply Forecasting

Chapter 13—Water Supply Forecasting

Objectives

Upon completion of this lesson, participants will be able to:

- Explain how snow survey and water supply forecast information is used.
- Provide an overview of the operational data base.

References

West-Wide Snow Survey Training School Workbook

Time

Classroom: 30 minutes

Introduction

The Natural Resources Conservation Service (NRCS) has responsibility for conducting the cooperative Snow Survey and Water Supply Forecasting program in the western United States. This program is administered by NRCS in ten western states and provides prediction of seasonal water supplies based on current mountain snowpack and other hydrometeorological conditions. This information is primarily provided to the agricultural community for use in managing farming operations in a manner consistent with projected water supplies. In excess of 600 individual streamflow gaging points are now being forecast operationally; drainage areas range in size from under 100 square miles (25,900 hectare) to over 100,000 square miles (25,900,445 hectare).

Streamflow predictions are currently made monthly, January through June, and disseminated via state water supply outlook reports and through dial-up computer access to an audience of over 15,000 organizations and individuals. Major interest groups benefiting from these forecasts include irrigators who derive their water supply from direct diversions or from reservoir, watershed associations, water conservancy districts, reservoir managers, ditch companies, units of government, water distribution administrators, and hydropower generation facilities. Runoff predictions are generated and issued in cooperation with five National Weather Service (NWS) River Forecast Centers (RFC's).

Water Supply from a National Perspective

Water quality and water (erosion) conservation including water supply are a major priority in NRCS operations targeted under the Food Security Act (FSA) of 1985. Accurate predictions of seasonal runoff originating from snowmelt is an important component of the overall national effort. NRCS has taken several steps recently in an attempt to strengthen and improve its delivery of water supply information to water managers in snowmelt runoff areas. These are (1) reorganization of the snow survey program to place more emphasis on the use of hydrologic process models in a real-time operating environment; and (2) increasing the effort to integrate snow survey technology into other ongoing conservation operations programs and focus more attention on applying forecast predictions on an agricultural operating unit.

Snow Survey Reorganization

Realignment of responsibilities and redistribution of personnel accomplished as part of the snow survey reorganization has provided a number of positive benefits to overall water supply forecasting efforts. These include:

- Improved NRCS hydrologic modeling capabilities.
- Centralizing data analysis and interpretation functions to capitalize on the expert effects of a multi-disciplinary staff in one location.
- Enhanced data base management capabilities.
- Facilitated regional and national interagency cooperation.
- Standardization of forecast products and improved service to users of forecast information.
- Provided for a focal point for technology transfer activities.
- Expedited forecast products to the lowest operational level through the use of automated data processing and telecommunications facilities.
- Created water supply specialist positions to serve a liaison function between forecasters and users.

Since the implementation of the program reorganization in 1983, the benefits of these efforts are ever expanding. Today the Centralized Forecasting System (CFS) (Shafer, 1989), a computer facility designed to address water user needs, is fully operational. CFS utilization is providing a crossover service to users by providing access to data, analyses and interpretation of water supply factors. Mated with the NRCS automated data acquisition SNOTEL (SNOW TELemetry) (Barton, 1977), CPS has become a model 'one-stop' source of water resource information.

NRCS Forecast Procedures

NRCS produces a number of streamflow forecast products for public consumption including seasonal volume, seasonal snowmelt peak flows, hydrograph recession, lake level, and seasonal low flow predictions. A combination of statistical and empirical techniques have traditionally been employed to generate these products. However, within the last few years a new era has dawned with the rapid evolution in forecast technology occasioned by the following:

- Development of automated remote data acquisition networks.
- Tremendous advances in computational power housed in personal and mini computers.
- Availability of data base management systems to facilitate access, exchange, storage, and retrieval of large volumes of data.
- Development of physically based process simulation models which effectively utilize available conventional and remotely sensed data in user selected time steps.

These advancements dictated a reassessment of how forecasts had been produced in the past and a careful evaluation of what implications these changes in technology held for the future.

Current Methods

The most common technique used by NRCS to predict water supplies and hydrograph characteristics is one based on statistical regression concepts. Various types of regression including simple linear, multiple linear, curvilinear, and principle components have been employed to develop forecast equations. Regression procedures have been attractive because they are relatively easy to generate and apply, require a minimum amount of input data compared to simulation models, are easily understood, and have proven relatively reliable for most types of forecasts issued. However, hydrologists have long recognized that statistical models suffer from a number of limitations which restrict or prohibit their applicability in many situations.

Regression models are unreliable in extreme years which are outside the bounds of the historical time series used in developing the original forecast equation. They are not easily adaptable to run in short time steps on the order of days. They often do not reliably predict the consequences of infrequently observed hydrometeorological conditions because the streamflow that occurred from these conditions are treated as outliers and omitted in equation development. The most serious limitation of regression procedures, however, is their inability to provide any insight into the physical processes and interactions at play. With water management becoming more complex and the level of competition rising for available water, it was readily apparent that other forecast tools were needed to complement existing procedures.

Hydrologic Process Models

An obvious solution to the need for more flexibility and greater insight into hydrological processes was to employ continuous simulation models in a forecast mode. Selection of which model(s) to use was not a simple matter. The leading candidates for NRCS applications were:

- National Weather Service Forecasting System (NWSRFS).
- U.S. Geological Survey Precipitation Runoff Modeling System (PRMS).
- Agriculture Research Service Snowmelt Runoff Model (SRM).
- U.S. Army Corps of Engineers Streamflow Synthesis and Reservoir Regulation model (SSARR).

Other models have been studied but were not judged suitable for a variety of reasons.

Models evaluated by NRCS suffered from some or all of the following characteristics which detracted from their acceptability for agency forecast purposes:

- Minimal or no use of actual measured snow water equivalent available on a daily basis through the NRCS SNOTEL network.
- Calibration required a lengthy period of record.
- Complexity of model and associated preprocessor routines required a continuing high commitment of personnel and computer resources.
- Documentation and/or accessibility was inadequate.
- Transportability between computer systems was questionable.
- Data to drive the model were lacking for operational application.

- Minimal or no use was made of soils or vegetation information.

- Natural resource impact analysis from management systems was not supported.

Before adopting any of the leading models for operational forecasting, NRCS investigated them further using the expertise of the Agricultural Research Service (ARS) (Huber, 1983), Colorado State University, and US Geological Survey scientists (Leavesley and Saindon, 1985). Cooperative efforts with these agencies and institutions has centered around the models' use of data from the SNOTEL system. In addition, tests were conducted on operationally forecasted basins (Cooley, 1986), to determine each model's suitability to run in a forecast mode.

The U.S. Army Corps of Engineers SSARR model has been selected as the primary hydrologic process model for forecasting (Jones, 1986 and Perkins, 1988). Other natural resource impact assessment models with hydrologic components, used for such things as rangeland production planning, erosion prediction, and agricultural chemical management will also be supported in CFS (Shafer, 1989). Much of the work in the last year has concentrated on developing the software to operationally run the SSARR model for a moderate number of basins. For the 1989 water supply season, 3 basins have been monitored using SSARR, while in the 1990 forecast season, up to 6 basins will be operationally evaluated using the SSARR model.

Future Operations

Hydrologic modeling activities will require developing supporting software to run continuous simulation models for water supply forecasting and environmental impact assessment. Access to real-time data systems like SNOTEL, require exchange protocols and formats like the Standard Hydrologic Exchange Format (SHEF), developed by the NWS NWRFC, for true operational use of models. SHEF and other data manipulation software necessary, is being incorporated into CFS.

Although the SSARR model is the primary water supply forecast model, other models will be evaluated and employed where they are needed. Models that can be adapted to use remotely sensed snow covered area and soil moisture are likely to be investigated closely for their potential in all aspects of water management. A hierarchy of models is envisioned ranging from simple empirical relationships to very sophisticated natural resource assessment models that also have forecast capabilities imbedded in them. Greater reliance will be placed on multicomponent hydrologic process simulation models that incorporate watershed characteristics and effectively use SNOTEL data obtained on a daily basis.

In the process of reviewing water supply forecast requirements for the future, NRCS has identified the following needs that will need to be addressed in order to achieve potential benefits acquired from accurate and timely forecasts delivered to the agricultural community:

- Development of a methodology for applying streamflow forecast information at the farm operator level to maximize productivity and economic returns (Krzysztofowicz, 1988).
- Development of a hydrologically sound automated means of incorporating real-time data from short-term record stations into physically based conceptual forecast models (Day, 1988).
- Development of an operationally viable procedure to use remote sensing techniques to monitor snow covered area, snow depth, soil moisture, and surface temperature for application in streamflow forecast models (Cooley, et al., 1988).

- Development of an extended streamflow prediction (ESP) capability with the CFS modeling framework, with focus on SNOTEL site characteristic responses (Marron, 1987).

Summary

NRCS has been involved in snow survey and water supply forecast activities since the mid 1930's. This program serves a large sector of the economy in the western United States dependent upon snowmelt runoff for its water supply. A reorganization of the snow survey program has been completed to increase capabilities in the area of hydrologic modeling and to provide better and more timely forecasts to water managers. Forecast procedures, although primarily based on regression techniques, are being supplemented by hydrologic models which take advantage of real-time data collected by the SNOTEL system. NRCS has developed a forecasting environment in CFS which employs data collection, data analysis and hydrologic product generation in response to user desires, agency priorities, and improvements in information resources management capabilities. NRCS, through the Water Supply Forecasting Staff is providing dynamic leadership in the evolving of physical process simulation models for water supply forecasting operations.

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The Operational Data Base

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Introduction

Background

On April 27, 1935, the 49th statute of public law 74-46 established within the Department of Agriculture a "Soil Conservation Service" (SCS) for the development and prosecution of a continuing program of soil and water conservation. On July 1, 1939, the Division of Irrigation of the former Bureau of Agricultural Engineering, including its snow survey responsibilities, was transferred to SCS. In 1940, the Weather Bureau activities were transferred to the Department of Commerce, provided that the Department of Agriculture would continue to make snow surveys and conduct research concerning relationships between weather and soil erosion. Secretary's Memorandum 870, dated July 1, 1940, made SCS responsible for these activities within the Department of Agriculture.

In July, 1982, Department approval was given for the reorganization of the snow survey program. A number of functions including streamflow forecasting, data base management, report generation, applications development, and hydrologic modeling were assigned to a Water Supply Forecasting Staff (SWFS) at the SCS West National Technical Center (WNTC) in Portland, Oregon. The WSFS members were assembled in 1983 to fulfill these responsibilities and develop the necessary hardware and software systems to support program activities in the western states.

Data General Minicomputer

The requirements for the procurement of a minicomputer were completed in June, 1983. In April 1984, a Data General MV-8000 II was installed with AOS/VS, 2 megabytes (MB) memory, one Zebra 277 MB removable hard disk, one argus 354 MB hard disk, one IAC-16 and one IAC-8 asynchronous communication board, two ISC asynchronous communication boards, a floating point processor, 16 Tektronix 4105 terminals, one dasher 211 terminal, a 600 line per minute printer, a 55 character per second letter quality printer, and an 800/1600 bpi tape drive.

In 1985, the Data General system was modified to increase disk space, memory, and access. The 277 MB removable drive was replaced by three 592 MB hard disk drives and 6 MB of memory were added to the original 2 MB of main memory. Additional asynchronous boards, one IAC-16, and three IAC-8 boards were added to the system to boost the number of user ports to 64 (32 dial-up, 32 hardwired).

An additional tape drive, 1600/6250, was added to the system to perform backups and unload data. 16 dasher 460 terminals were added to the system as was another letter quality printer and an HP7475 flat bed plotter. Data General's MV/UX, compatible with UNIX System III, was added to run concurrently with AOS/VS.

Minicomputer Pilot Project

The WNTC Data General computer would become one of four Data General computers purchased in what was then a minicomputer pilot study to determine the benefit to the SCS of using automated data processing technology. The WNTC minicomputer pilot project goals were to implement a centralized data processing concept that would meet data processing needs; develop a strategy for implementing existing ADP technology in operations to accomplish the SCS mission; and increase the productivity of program staffs through automation. A software system designed to meet these goals was formulated and called the centralized forecasting system (CFS). The CFS, as envisioned in 1983, was to be the primary focal point for snow survey data collection, streamflow forecasting, data exchange, and product dissemination. It became an integration mechanism and delivery system to make planning information available at local SCS offices.

A menu system was developed using CLI macros to provide an interface to simplify user access to programs and data within CFS. The description of this CLI menu system was presented at the 1987 NADGUG conference in "Intelligent Processing With CLI". As CFS users became more adept at the menu system, the users suggested analyses and products of their own needs and design. CFS now has become a synergistic balance between users and developers and it is still growing.

The Operational Data Base

In 1984, a project was begun to evaluate the various alternative commercial data bases and the corresponding report generation facilities. With the knowledge that the data set would not change frequently and with the need of higher mathematical functions to produce statistical and probability analyses, a custom designed data base was proposed. The proposed operational data base (ODB) would unify and restructure all the existing flat files into one related data base. The principle features of the ODB include a data loading function, data access for the report and analysis routines, and a data update process.

A contract was initiated and in 1985 work started on the design of the ODB. MV/UX was and is an essential element in the development of the ODB. The designer used the C shell with its aliases and other features as the platform for all the C development. The load and update commands would be executable from either the CLI or the MV/UX environment as one line commands with arguments. The data access system, on the other hand, would include a complete parser query language for finding the stations that had been loaded and then executing specific preprogrammed functions to output the data and/or analyses for the selected stations.

In 1986, the WSFS members worked together for reorganizing CFS and the directory structure for ODB. The original design had put all data files into one directory, /CFS/CFS/DATA, which is the development section of CFS. ODB's directory structure was changed to partition the data by state and to place it onto its own disk system called ODB. The general format for the MV/UX path to the data file is /ODB/ST/data YY where "ST" refers to the two character state abbreviation, "data" refers to the 4 character datatype code (see Exhibit #1), and "YY" refers to the two character state FIPS (Federal Information Processing Standard) code. As originally established, there would be 14 directories, (12 western states, Alaska, and Hawaii) with 18 files per directory. This design made the load and retrieval processes more logical. It allowed for expansion of both the number of states (directories) and datatypes (2 files per datatype) without degrading performance. It also allowed the ODB system administrator to assign unique group access permissions to the directory and the data files.

Operational Data Base Design

ODB Data

The ODB presently manages hydrometeorological data for 2270 snow courses, 849 stream gauges, 280 reservoirs, and 1740 precipitation stations as well as data from 560 SNOTEL (SNOw TELemetry) sites, 2266 climatological stations, 12 daily stream gauges and 2 daily reservoirs. All data are stored in a water year format, October 1st through September 30th of the following year. It is conceptually comprised of two major sections that are integrated through a common data base architecture. These sections are defined by the time steps of their data: daily and monthly.

The monthly data section of the ODB hold data for five data types; these include snow (date of measurement, snow depth, and snow water equivalent) precipitation depth, streamflow volume, reservoir storage, and miscellaneous (reserved). Of the monthly data types, only "snow" is stored in an ASCII format. All other monthly data has the same structure (see Exhibit #2). The first 12 bytes are used to identify the basin, the station id, and the count of the number of years of data to follow.

The SCS SNOTEL meteorburst technology system uses the reflection of VHF signals by ionized meteor trails to enable communications between remote sites and a master station. As many as 64 channels (sensors) of data can be stored in the remote site transceiver. At a minimum, battery, snow water equivalent, total precipitation, minimum daily temperature, maximum daily temperature, and the ambient air temperature are recorded. Some locations also record wind run, soil moisture, soil temperature, solar radiation and humidity. At present, there are 6 SNOTEL data sensors that are capable of being stored in the ODB. These are snow water equivalent, precipitation, maximum temperature, minimum temperature, average temperature, and radiation. (See Exhibit #3.)

The National Climatic Data Center (NCDC) in Asheville, NC is the repository for the National Weather Service (NWS) climatological data. A total of 36 reels of 2400' variable block variable record data were initially ordered from NCDC covering the 12 western states, Alaska, and Hawaii. These tapes, know as a TD-3200 format, contain all the daily weather observations for the period of record through calendar year 1983 for individual states. After these tapes were loaded, annual tapes for 1984 to the present available year have been acquired for appending the CLIMATE data to the ODB files. While the pre-1984 CLIMATE data tapes had to be ordered for individual states, annual TD-

3200 contain CLIMATE data for stations in all the states. Similar to the SNOTEL data, not all CLIMATE sensors have been loaded into the ODB. While many data types are available, only daily maximum and minimum temperatures and precipitation are stored for the selected climatological stations. (See Exhibit #4.) State and federal water resource agencies monitor and archive streamflow and reservoir data. While many stations exist, only those required for hydrologic modeling or conservation applications assessment have been loaded.

ODB XREF Information

All of the data loaded into the ODB existed in other data bases, both SCS and non-SCS. The design intent of the ODB was to put portions of the various data bases into a single data base for central accessing and then provide procedures to allow a user to select stations based on key attributes. These key attributes are defined as cross reference ids and geographic location information for the stations to be loaded. An editor was built to allow the WSFS members to create, append, edit, or delete records containing this location information. This editor and the set of state ASCII data files is know as the XREF system.

Each station found in the XREF system is described by 12 key attributes or characteristics that are used to locate data. (See Exhibit #5) Various SORT/MERGE and CLI macros have been created to facilitate the transformation of other agencies' location information into the XREF format. There were so many types of tapes from varied computers that a CLI macro (TAPE2DSK.CLI) was designed to create SORT/MERGE commands to read these tapes. (See Exhibit #6) It is designed to allow the user to enter in the drive name, the blocksize, the record length, the output record length, and if the output records will be data sensitive (with delimiters) or not. All this information is captured and written to a file as SORT/MERGE commands. These commands are used by invoking the FILTER.CLI macro. Once the data reformatting has been completed, the SORT/MERGE command file is deleted.

To initially create the NCDC XREF records, TD-9767 biographical information tapes were purchased from NCDC. The TD-9767 data is distributed by NCDC on a 9 track 6250 bpi tape with a blocksize of 8000 and a record length of 80. The TAPE2DSK.CLI macro is used to copy the records to disk as data sensitive records. A "C program" is used to reformat the records into the XREF record format. (See Exhibit #7) Similarly, the USGS offered information in their Prime Header Files that can be reformatted for direct inclusion in the XREF files. (See Exhibit #8a-b) With these utilities to create the records, all that remained was the editing to fill in any missing attributes.

Once the process of creating and editing the XREF records has been completed, the XREF ASCII file is read by a "C program" which appends each record to an ODB attributes file called "MAINSITE" in a compressed C structure format. (See Exhibit #9) After the addition process to the MAINSITE file concludes, a set of primary and secondary indices to the structure records must be recreated. The primary indices are 60 byte C structure records containing selected XREF information (See Exhibit #10) The secondary indices are binary indices used by a hashing sequence for quick station retrieval. The "C program" which creates these indices is shown in Exhibit #11. Both of these indices, relating the retrieval keys to the stations, must be sorted. The operation takes several hours but when complete allows for an extremely fast retrieval process.

ODB Data Load Facility

In order for data to be loaded into the ODB, the station id must exist in the ODB MAINSITE attributes file. The procedure checks for the existence of a station id using the MAINSITE indices. If the station is not found, the data is dumped, and the next station's data is retrieved. If the station is found in MAINSITE, the next step is to check another ODB attribute file called "NEWSITE". If the attribute record is found in NEWSITE, then the data has already been loaded and the load procedure skips to the next station. If the attribute record is not in NEWSITE, then the attribute record is added to NEWSITE and the data is loaded into the appropriate data file.

The data load procedure is a manually intensive procedure that has been automated with the use of CLI macros and UNIX shell scripts. First, there is a separate load program for each datatype. Second, when the data load program has completely read all the data, another program must be run against the ODB data file to create an ASCII file containing the starting byte position for each station in the data file. These ASCII files can be described as sparse data location index files. They contain the station id (or the station name in the case of SNOTEL data only), a tab character, and the byte location number to the beginning of the station's data. All of these files end with the three characters CNT. For example, the precipitation file for Montana is located by the MV/UX path/ODB/MT/PREC30 and the corresponding index file path is /ODB/MT/PRBC30CNT.

ODB Query Facility

Most users are primarily interested in data retrieval and report generation to address a specific problem. This task is accomplished by invoking the ODB query language that locates and retrieves stations matching key attributes and outputs data corresponding to the selected station in predefined formats. The first command must begin with the work "find". The second word in the find command must be one of the retrieval keys as defined in exhibit. For example, the command "find station 1093 and state mt" will retrieve a station with the id 1093 in Montana. The phrase "and state mt" ensures that the station will only come from Montana.

Depending upon the retrieval key selected, a location process is started that used the various sets of location indices based on station names, station ids, hydrologic unit code, or county FIPS number. For instance, when finding a station, the first two characters will determine the starting location in the primary index file with the algorithm k= 37*i+j where i and j are the positions of the first and second characters within a list of number and letters. Once positioned, there may be numerous stations beginning with these two characters. The primary index file is read until there is a match with the user's station id. If there is no match, then the next primary index record is retrieved. If there is a match then a closed hashing function computes the binary representation of the characters in the search key. An extract of the query source code demonstrates these processes. (See Exhibit #12)

The hashing function was chosen at the time of the design of the ODB. It results in extremely fast identification of keys for the user. This process coupled with the sparse data location indices for the data files provides the mechanism for fast data retrieval.

ODB Update Facility

A custom data base update mechanism written in C is designed to manage insertion, updating, and appending of the data described. Data base editing is performed by using the query system to dump a data table to disk, using an editor to update the table, and using the update facility to reload the data.

The first lines in all the data tables identify the path to the ODB data. If the user elects to delete data records from the ODB a minus sign is placed in the first column. The user would then only include those lines to be deleted. If there is a plus sign in the first column, then the data records that follow will be appended to the ODB. If there is neither a minus nor plus sign, then the records that follow are assumed to be edited records to update the ODB. The only exception to this is the use of an asterisk to identify an older format, or 80 column card format, of the data in the table. If an asterisk is used to append or delete records, it must follow the plus or minus sign.

In an edit process, there will be no change in the byte count of the file and the sparse data location indices will not have to be computed. The data is first assigned into the appropriate data structure, the position location in the ODB file is determined, and the C "write" function is used to overlay the edited data over the old data.

If the append or deletion process is used, a new film will be created for the data. First the data up to the station to be modified is written to the file. The modified stations's data is written to the file. The remaining data from the original file is added to the new file. The new file replaces the original file with a system call using the MV/UX "mv" command. A byte count must be computed for each station's position in the file to create new sparse data location indices.

Future Issues

Reformation of the Existing Water Year SNOTEL System

At the present time, CFS is able to receive, process, and store data from over 560 hydrometeorological stations in the SNOTEL network. The data is stored in flat files external to the ODB that contain the current year SNOTEL data. The combination of these flat files, CLI macros, and BASIC programs is known as the water year SNOTEL (WYSNO) system.

Since ODB presently contains only historical SNOTEL data, one objective is to add the current year data to the ODB. In this way, SNOTEL data can be processed once thus eliminating duplicate data bases. Another objective is to increase the number of SNOTEL sensors that the ODB can store. There are only 6 sensor types presently stored within the ODB. There is a capacity of 16 sensors available in the master SNOTEL computer and as mentioned above, the remote SNOTEL sites can store up to 64 sensors. As the snow survey program progresses towards integration with other SCS activities, sensors in the areas of water quality, air quality, and soil moisture and temperature measurement will be come more abundant.

The present file system does not have to be changed in order to add additional datatypes to the SNOTEL files within ODB. The C data structure allows a one byte field for the identification of the datatype. All the data are stored as integers so there is a multiplication factor associated with each datatype. The load and query systems will have to be modified to check for all possible datatypes. This modification will not be hardwired into the C source code but rather will bind to the sensor types upon program execution.

Expansion of the CLIMATE data

In 1987 analysis of the SCS CLIMATE data needs identified an increased number of data types not presently available within the ODB. While this information is available from other agencies, the data is not readily available for use by the SCS offices using AT&T 3B2 and 8386 minicomputers. A plan was formulated to provide this data to all the SCS offices in a format that could be assimilated into the data base that they presently operate. The data would be provided by a national climatic data access facility.

If the ODB is to be converted to contain additional datatypes, it will have to be modified to accommodate the increased data. There are 3 datatypes types presently stored within ODB and the NCDC tapes contain more than 11 major classifications of datatypes with more than 20 types of soil information depending upon the ground cover and soil depth. Even if the ODB system had not been selected to be the national CLIMATE system, the snow survey program is progressing towards integration with other SCS activities. Datatypes that can be useful in conservation application, resource evaluation, watershed planning, and other SCS activities will be more in demand.

The present file system does not have to be changed in order to add additional datatypes to the CLIMATE files. The C data structure allows a one byte field for the identification of the datatype. All the data are stored as integers so there is a multiplication factor associated with each datatype. Since none of the data exceeds the value of 9999, the data field will be modified to be stored as a short (16 bits) which will reduce the storage requirements by nearly 50%. Similar to the WYSNO system enhancement, the ODB CLIMATE load, update, and query processes will bind to the sensor types upon startup.

The Water Year Hydrology System

SNOTEL data is not presently available to conceptual computer models in an automated mode. Automated procedures will be designed to access this data directly out of ODB for the current and historical years and reformat it for mode usage.

The modeling effort is presently restricted by its lack of capability to automatically receive data from other agencies' computers and post it into the ODB or to flat files. Communication software batch command files will be designed to routinely access remote computers and capture the data for subsequent processing. The retrieved data will be reformatted into a form that will be used by the model or used to load into the ODB. The initial sources of remote data will be from state and federal water resource agencies. Many offices in these agencies are using the Standard Hydrometeorological Exchange Format (SHEF) to disseminate their data. SHEF is designed to be used as a universal, operational exchange medium between the different federal agencies. There is presently no automated capability within CFS to translate the interagency data that will be remotely accessed. Needed data is presently manipulated by hand to make it usable to any forecast procedure.

14. Publicity

Chapter 14—Publicity

Objectives

Upon completion of this lesson, participants will be able to:

- Write local snow survey related news articles that are timely and accurate.
- Prepare news releases for radio delivery.

References

West-Wide Snow Survey Training School Workbook

Time

Self-Study at Headquarters: 4 hours

Introduction

Usually the best way to write a news story is by not writing it yourself. If you build a good rapport with your local news people, they will write the story for you. They do need some guidance and accurate facts. Once they have this, the story will be easy for them to write. The guidance you give them goes hand-in-hand with the rapport which you have developed. The news people must be familiar with you and your program. They should know what a snow surveys is, what it does, how it is done, why it is done, who does it, when and where it is done. Once you have built this base of knowledge all they need in the future is the accurate data.

If you feel more comfortable developing the story or if your local news people aren't getting the facts straight (which sometimes happens), you should write the story yourself. If you do that, the following will assist you in writing a good news story.

Make clear immediately to an editor that this is news—not a memorandum, letter, fact sheet or other written material. Tell whether it can be used right away or should be held up until a certain date and time. Release time and dates are used when you want to give all or certain media an even break or when details are not complete or confirmed. An editor needs to know where the release came from and whom he can contact for further information if need be.

Ordinarily, average snowfall, snowpack, and water supply would not be "hot news." But what if it is the first time in two or three years that things appear to be building up toward a normal supply? That is news worth incorporating in your story.

Certain basic information is developed from snow survey data: Expected water supply, snowpack levels, recent precipitation, reservoir levels, conditions needed to improve or maintain the outlook.

But people are interested also in how deep the snow is—even if NRCS is interested only so far as it affects water content. Why not give a few sample depths for an area?

And people are interested in comparisons: More water or less water? More snow or less snow on the ground? More precipitation or less precipitation?

The reader wants to know: "Who says so?" "Who makes surveys?" "Why are surveys made and when are they made?" "Will streams be high, average, or low?"

Then there are history and circumstances: Has there been a drought? Was last winter "a bad one" followed by floods from sudden snowmelt and runoff? Is there a controversy over a watershed project to control runoff?

You, as the head technician and spokesperson locally, are in touch with situations and conditions and you can make a story about snow surveys more meaningful to local readers. Snow, water, weather, and other conditions are part of the local scene readers are interested in. For a successful information program at the district level, get acquainted first of all with local news media representatives: Newspapers, news wire services, radio and television stations. Find out who does what—to whom you should take your story; who you should telephone a query or facts for a story.

Learn the deadlines for each news medium. It does no good to call or take a story in after the paper has "gone to bed" or the broadcast has started. Time your efforts to give news media the best service possible. A word of caution here. If you provide transportation for the reporter, check with your Administrative office regarding liability, disclaimers, etc.

Make a List of Contacts, Phone Numbers, Addresses, and Deadlines

Media people know when you are going out on surveys; when you will have reports back to the State Office. Explain what you and other snow surveyors do and what your data is used for. Invite a member of the press to go along on one of the surveys. This is a great way to get the media people involved in snow surveys. Usually they jump at the chance and the result will be a terrific story. Find out what kind and what length of story, what aspect of snow surveys media people are interested in. Put this information with your media list. Find out what kinds of photos, slides, film, and other visuals each media is interested in—if any. Get deadlines for submitting these also—media need more time to prepare visual material.

Do not overlook opportunities to provide news and tips that may not be a part of snow survey information. This will aid you in press relations. Radio relies solely on sound to entertain, inform, attract and keep audiences. Telephone reports can be recorded for broadcast. Tape interviews in the field. Sounds that go along with snow survey work can give a change of pace for radio. "Sound out" your local station(s) on these ideas.

This aid is written in the format of a newspaper news release, except that we have single spaced this paper. You will need to double space the release. It can be used for wire service releases also. Radio and television each has its own special format, although broadcasters many times will accept material written in the newspaper release style. Remember though, radio and TV measure material in seconds usually—now and then, in minutes. News must be brief and easy to read aloud. The style must be natural for the voice and understandable for the ear. It is not hard to develop once you squelch any tendency towards technical words and phrases, government "gobbledygook," etc. Samples blurbs of radio and television news releases are attached. Also attached is an aid on news writing, a subject in itself. The secret of interesting news writing—once you master the five W's and H and simple style—is alertness and flexibility. Do not get locked into a stiff, stereotyped format. It is not enough to say who did what or what happened. You need to put these in the context of time, place and current conditions of your community; tell these in a way that is newsy and significant for the reader.

Write Snow Survey Stories

In these busy, always-in-a-hurry times, people do not often spend much time reading newspapers. They want to glance over their newspaper and pick out items that look interesting.

Luckily, newspapers are put together with just such readers in mind. If you want your news item read, better get with it and write the way people (and editors) demand: short, sweet, lively, and interesting. The two principle attention-getting devices used by newspapers are headlines and photographs. The reader glances first at these to find out what is going on and what the reader wants to know more about. One way to get attention from editor and reader is to supply a striking photograph along with your news item. Lucky for you, snow is one of the most photogenic settings for photographs. Whether the photo comes out photogenic and striking depends entirely on the photographer. That is another subject.

You will not be writing headlines for your news stories. But you can set them up so it is easy for a headline writer to work up sharp, attention-getting heads. If you will look at the samples attached, you will see a line about midway between the news source block (upper right) and the beginning of the story. This is the "slug" line. A "slug" line is simply a few key words—the fewer the better—telling what the story is about. If you are telling about snow, the slug line could simply be "SNOW." If it is about snow surveys, then logically the slug line could be "SNOW SURVEYS." If you are writing about the water that will come from snow, the single word "WATER" will do the job.

This slug line should appear at the top of each page of the story for reasons we do not need to go into here. The slug line actually goes on a story before the headline. If you have chosen well, the most important word in the slug will appear also in the head—but that is the only connection.

The first thing you write in the news story itself is called the "lead" (pronounced "leed"). Here is where you keep or lose your reader. The basic form of lead is a summary of "what happened." It is called the 'summary lead' and should tell immediately the most important facts. If you have trouble writing this summary lead, you probably do not have a clear idea of what it is you are trying to tell. Writing the lead is half the job of writing the story. What do you put into a lead? You may have read about the five W's and H: *who, what, where, why, when,* and *how*. Just about anything you might write could fit under one of these. You do not have to answer all six—you seldom do—in the lead. Pick out the most important and bring up the others later. Start with these questions: What happened? Who did what? What is going on?

Your answers and subsequent questions probably will run like this (in your mind, of course): "I just came back from a snow survey." "When?" "Yesterday." "Where?" "On Able Pass." "What did you find out?" "The snow is 50 percent deeper than usual for this time of year." "Who went with you?"

"Jack Jones of the Forest Service." "Why make snow surveys?" "To find out how much water there will be next summer." "What else did you find out?" "Well, the ground is pretty well saturated—about 80 percent." "What does that mean?" "Most of the snowmelt water will run off instead of soaking into the soil."

This should give you the picture. You are interviewing yourself. The answer to the first "What" brings up another question about where or when. The next answer brings up another question. Out of all this, what's the most significant, interesting, startling or "newsy" for local readers? The deeper-than-usual snow? The prospects for good water supply? One editor may be interested in the first; another, the second information.

Now we come to an important feature of news writing. Remember, the most important information comes first. The second most important, then, comes second; the next most important, third. And so on. This describes development of the straight news story, starting from the summary lead.

If all the stories in a newspaper were written in this same style, it would make for dull reading. And readers would quit reading. Editors, therefore, vary this format and use other devices—even "fictionalizing" or building up to a climax instead of the other way around.

The information gleaned above would be written as a summary lead, something like this:

The snowpack on Able Pass is 50 percent greater than usual for this time of year, snow surveyors reported today. "That should mean a good supply of water next year." John Jones of the USDA Natural Resources Conservation Service said.

But suppose there has been a two- or three-year drought. People looking at the snow buildup on the mountains THINK that perhaps the drought will be broken. But will it? You can satisfy this question that goes beyond the depth of snow:

Three years of drought could be ended — if snow continues to build up in the mountains.

That is the encouraging, but cautious report of snow surveyors who measured the snow on Able Pass yesterday. John Jones, District Conservationist for the USDA Natural Resources Conservation Service said...

The above is called a "punch lead." It does not summarize the facts but makes an attention-getting statement of interest to the readers. Here is another approach:

Hoping this winter's heavy snow will mean more water next summer? Your hopes should be bolstered by snow survey reports from Able Pass: The snowpack is 50 percent deeper than usual for this time of year. "If this keeps up, our drought should be ended and there will be plenty of water next summer," Jack Jones of the USDA Natural Resources Conservation Service said.

That is called a 'question' lead. It sparks an idea for another type of lead—the "quotation" lead:

If the snowpack keeps building up, our drought should be ended. That is the optimistic report from Jack Jones of the USDA Natural Resources Conservation Service who just returned from a snow survey at Able Pass.

Still another approach suggests itself—an alternative, if you have used the above recently. It is called the contrast lead:

Last year, Jack Jones and Pete Smith went up to Able Pass to measure snow. That was on January 3. Yesterday, January 3 a year later, they went to the same spot and found plenty of it—50 percent more than the year before.

Then there is something called the "picture" lead:

Yesterday, when most people were settling down after a holiday in the big city, the desert, or the mountains, Jack Jones and Pete Smith loaded a snowmobile on a truck and headed for Able Pass. It was strictly business—the business of snow surveys.

And that brings us to the "freak" lead:

WANTED: Able-bodied person to drive truck and snowmobile, ski, and snowshoe. Needed for making snow surveys. Jack Jones, district conservationist for the USDA Natural Resources Conservation Service wishes be could run such an ad in the paper. He needs a new snow survey partner.

In case you think some of these are for feature stories but not news stories, imagine the circumstances and how the latter might be written up as straight news:

The USDA Natural Resources Conservation Service and Forest Service are looking for a new member for the cooperative snow survey team. It should be clear by now that news writing does not have to be dull and stereotyped. It is a challenge to the writer's wits to find the little or big kernel of information that will make a good headline, a good lead, and a good story. It takes practice to hone the "sense" that ferrets out this thing that "makes" a story.

Here are some final tips on news story writing:

- Use simple words, short sentences and paragraphs for the most part. What is the proper length for sentences? Three typewritten lines is one yardstick. Another: 25 words. These are maximums. Vary your sentence lengths within this range.
- Keep paragraphs down to six to eight lines. Vary the length from one line to the maximum.
- Use quotations to break up the pattern—but make them interesting or significant, not asinine.
- One hundred words makes about two and a half column inches of type. How much is your story worth—to the reader? Moral: Keep it short. Shoot for less than a page, first. Then a page. After that, be urgent about ending your

story. Two pages is an awful lot of copy for a news story—about 400 words or 10 inches, in fact. Forget the usual rules for paragraph development learned in English composition classes. Newspapers have their own rules which consider the visual impact on the reader as well as the impact of the words.

- Long paragraphs make for dull reading. Who wants to read anything dull? A series of these kills readability as quickly as anything. And they are unnecessary and confusing. When they start popping up, look for other ways of saying it—or leave it out. Use complex or compound sentences sparingly. Sandwich them along good old straight declarative sentences.

Using Radio in Snow Survey Information

Radio reaches everywhere: Wakes people up, lulls things during the lunch hour. When they cannot park in front of TV or read a paper, a tiny transistor radio can feed them information they want. As they commute to work in an automobile, radio keeps them posted on traffic, weather or other developments.

Radio tells the farmer and businessman about market conditions. Even at a football or baseball game, people listen to radio to find out what is going on.

All these are in addition to music, commercials, and talk shows that seem to dominate radio. Far from dead, radio is bigger, healthier, more useful than ever. It moves an awful lot of information. Better get with it in your work. How? Recognize how useful radio is and determine to use it. Then get acquainted with the people who operate it and with some of the techniques needed to use it.

Radio relies solely on sound—pretty much of the time, the human voice. Your voice could be among those heard telling people the latest news on snowpack and water supply.

Radio thrives on local names, local events, local conditions. It gives you regular contact with the public—and the public regular contact with you.

Radio is now. That may sound wrong grammatically, but it expresses simply and clearly the major impact of radio. In a fraction of a second, your voice reaches out in all directions to thousands of listeners with information you think they should know.

Because radio depends so much on the sounds of human voices and the same voice is on the air for about a four-hour stretch, radio needs a break—many breaks—to relieve the monotony. The solution: Bring in other voices—not necessarily polished voices that sound silky sure like that of a professional announcer. 'People voices' are what is wanted. You hear them all the time. Kids, youths, housewives, laborers, business men and women—some stumbling and halting; some crisp; some formal; some giggly; some sounding like kids reading aloud in the classroom.

A good, clear, pleasant voice is fine—but it should not sound like the voice of another announcer. That would not provide this change of pace radio needs. How are these voices put on the air? What are they used for? Mostly they are taped: In the studio, over the telephone, or in the field. They give reports; they plug (promote or advertise) community events; they explain; they advise; they tell about themselves and work; they help bring news to people.

To find out where and how you can fit into the broadcasting time of a local radio station, you need, first of all, to get acquainted with people who staff the station. Their titles and duties vary from station to station, but look for and get acquainted with these people: the station manager who runs the whole shebang; the program director who sets the schedule of what is going on the air; and the news director who is in charge of gathering news and reporting it on the air.

Any one of these may put you in touch with a fourth station staffer for special programs or material: the public service or public affairs director. On small stations, one of the other three may wear this "hat."

Ask these people:

- When are your newscasts?
- What are the deadlines?
- Do you use:
  - Copies of regular news releases?
  - Special radio news releases?
  - Taped news reports?
  - Phoned-in reports?
- For public service announcements (spots) do you use:
  - Scripts for announcers to read?
  - Taped spots?
  - Discs (long-playing records)?
  - What lengths (words and seconds) do you prefer for public service material?

It would be well for you to go there with a regular news release about your latest snow survey. Or perhaps, in advance of the new season, take one from last season. Show it to one of the three people mentioned and ask if this would be acceptable. You can then ask the other questions above and firm up arrangements for future coverage.

Many alternatives can be discussed. Your best guidance will come from the station. Here are some ideas you can talk over, however:

- Arrange to tape a report in the studio after you come back from a snow survey trip.
- Arrange to phone in a report for taping. Send in a news release as quickly as possible and offer to tape the information, using your voice to read it for broadcast. Follow a snow survey trip report with an interview explaining what the information means to local residents.
- Cut tapes of public service announcements advising people what to do about water use in view of the forecast water supply situation. Here are some things to keep in mind about using radio:
- Competition for attention is keen—just a flick of the dial away. Unless listeners are "hooked" in the first 20 seconds, they may get away. Even if they do not turn the dial their minds can "tune you out."
- Three words describe what you can do to get and keep attention:
  - Vary
  - Localize
  - Personalize
- Vary order, style and material. Get in locally known places, conditions and events. Use people's names—local people, well known or not. Lean heavily on the five W's and H in

deciding what to tell about: What did you do? Where did you go? When? What did you find? How does this affect the community? Use one of these as the main thing you are going to tell about and tie the other things to it. Get other experts or lay people into the act: Public officials, irrigation and water district managers, soil and water conservation district people, farmers, etc. Record their comments.

- Practice, practice, practice talking into a microphone or telephone; practice timing; practice boiling your material down; practice enunciation and voice control.

- Get constant evaluation from the professionals for improvement. Talk over ideas.

Working with Television

If available local media includes a television station, try to use whatever time and facilities are available. See program, news, and public service directors. Let them know about snow surveys. Remember, for television, think about what viewers will see as well as what they will hear: Film, video tape, slides, photos, tools, maps, and other materials that can be shown on TV as visuals. Remember, too, competition for television time is keen. There are relatively few stations. Most are committed extensively to rigid network and local program schedules. Even local newscasts hit only the "top" of the news. Ninety seconds is a long segment on TV news. You are lucky to get 30 seconds. TV welcomes interesting people and subjects that make for good visual impact; but, time and competition drastically limit what can be used. Do not get discouraged—keep trying and trying and trying.

Here are some suggestions on what you can do for TV:

- Submit to the news director copies of your important releases. Better yet, boil these to about 30 seconds and write in TV format.

- Offer station slides or photos with simple captions, illustrating and telling about snow surveys or the latest snowpack or water supply information.

- Query about sending TV cameraman and reporter out to shoot news film and report on snow survey activity. Arrange for interview—in the field or in the studio—on the status of snow and water supply conditions.

- Inquire about local programs that feature interviews with local people or visitors. How about an interview with a "snow surveyor." Take the tools of the trade along—they are good visuals and interesting to laymen.

- Discuss with news, program or public service director a special documentary on water, snow or related subject.

- When there is need for public cooperation in saving water, etc., TV and radio probably will give free public service time for spot announcements. Your best bet for visuals here are 35mm color transparencies. A public service director will explain procedure.

- Get acquainted with TV people. Learn schedules, news deadlines, visual requirements. Relate what you have to offer to their needs. Opportunities limited—but rewards enormous.

- Invite TV people to go along on the first survey of the season. If average year that is probably all they will want.

Newswriting—Summary

News gathering precedes news writing. In hunting for news story material, rely on these basic questions:

- Who?
- What?
- When?
- Where?
- Why?
- How?

When you begin writing, evaluate the importance of these elements. Rarely can you use all.

Remember, a headline has brought the reader to your story. In your first paragraph of lead (pronounced "leed") you must hold the reader.

Which element will interest the reader most and keep that person reading: Who? What? What happened?

A longtime snow surveyor reported today that snowpack in Able Pass is "about as deep as I have ever seen it this time of year." The snowpack in Able Pass is 50 percent deeper than the average of the past 10 years.

Deep, fluffy white and plentiful—that is the picture snow surveyors brought back yesterday from Able Pass.

News stories also include facts, quotes, anecdotes, and descriptions as the above examples illustrate. These qualify as answers to who, what, when, where, why, and how?

A straight news story—the kind used most—starts with the climax or most important information and adds other information in diminishing order of interest. Picture it as an upside down pyramid with the broad base at the top representing the climax. A fiction story is just the reverse. It works from a point and builds down toward the base or climax—like a regular pyramid.

Because of how it is designed, the straight news story can be shortened by cutting paragraphs off the bottom without leaving out the most important details.

Keep these criteria in mind as you write:

- Sentences—25 to 30 words or three typewritten lines.
- Paragraphs—six to eight lines.
- Vary sentence and paragraph lengths WITHIN these limits.
- Use active voice most of the time ("car struck boy"—not "boy was struck by car").
- Use simple words mostly—save up for those big words you may have to use.
- Stay under a page to page and a half on length. Avoid technical or bureaucratic jargon.

Working with Radio—Summary

Radio is limited to communication by sound—mostly the human voice. But it reaches people more broadly and intimately than any other mass medium. Through homes, in automobiles, boats and airplanes, at work and at play. Radio can be there—educating, entertaining and informative.

Best of all, radio wants voices of people like you, since you have something to tell that will interest people. People ARE interested in snow and water supply. You can tell them via radio what the snowpack is and probably what the outlook is for water during the summer.

Get acquainted with station staff members. Contact one of these three people: Station manager; Program director; or News director. (You will probably be working with both program and news directors.) Arrange an appointment and take with you a current news release about some phase of snow survey activities. Find out about:

- News releases: Regular release provided newspapers? Or is special, brief radio news release needed?
- When are station newscasts? When do releases have to be in to meet deadlines for these newscasts?
- Are phone-in reports accepted for taping and later broadcast? What about tapes made on portable recorders in the field? (Get details on requirements—some inexpensive recorders do not have quality or proper speed.)
- Interviews in the studio for news or special programs? Do reporters go out to offices or in the field for taping? Public service announcements (spots): Does station use scripts for announcer to read? Prerecorded tapes? LP records (discs)? How long (words and seconds)?

Make certain you understand what the station wants or has to have in order to put snow survey and water supply news on the air. Do not be afraid you will ask "dumb questions.' You will go there knowing more than the average person making an inquiry.

Remember these things about radio:

- Competition is keen. Another program is a flick of the dial away. Hook your listeners in the first 20 seconds or you will lose them. If they do not change stations, they will tune you, out mentally.
- Vary, localize, and personalize. Vary style and material. Use locally known places, conditions and events. Use names of local people. Talk to your listener in a personal way.
- Lean heavily on the who, what, when, where, why, and how? of news writing: What did you do? Where did you go? When? What did you find? How does this affect community?

Information Items to be Included in Water Supply Outlook News Releases

- Water supply forecasts
- Streamflow forecasts
- Snow cover
- Precipitation
- Reservoir storage
- Unusual local conditions
- Soil moisture—valley and mountain
- Comparison to other years—extremes and recent
- Comments on local conditions by local residents

- Water conservation practices for:
  - Good year to provide adequate carry over water
  - Poor year to save water
- Drought effect
- Flooding effect

Several of the last items might be used only as called for, considering the type of water year.

An example of a news release is on the next page (figure 14.1).

Figure 14.1 Example news release.

FOR IMMEDIATE RELEASE

Writing Snow Survey Articles:

- Make your news releases easy for newspapers to use. This aid shows a format which should be acceptable.
- Certain basic information is developed from snow survey data: Expected water supply, snowpack levels, recent precipitation, reservoir levels, conditions needed to improve or maintain the water supply outlook.
- People are interested in comparisons: More or less water? More or less snow on the ground? More precipitation or less?
- The reader wants to know: Who says so? Who makes surveys? Why are surveys made? When are they made? Will streams be high, average or low?
- Then there are history and circumstances: Has there been a drought? Was last winter "a bad one" followed by floods from sudden, snowmelt and runoff? Is there controversy over a watershed project to control runoff?
- Snow, water, weather, and other conditions are all part of the local scene that readers are interested in.

(more) <——— WRITE THIS WHEN THERE IS ANOTHER PAGE

<————WRITE THIS AT THE END

[Break story at end of paragraph—Not in middle of word, sentence or paragraph)

Chapter 15—Photography

Objectives

Upon completion of this lesson, participants will be able to:

- Select and use the proper film for snow photography.
- Explain the basic principles of composition and, using these principles, take high quality photographs.

References

West-Wide Snow Survey Training School Workbook

Photography Manuals and Books

Time

Classroom: 1 hour

Field: Optional

Snow Photography

The Snow Survey program is a unique and popular program in our Service. The data is effectively used by urban and city people interested in recreation, as well as rural areas with their agricultural water needs. Therefore, one of the main objectives is to document the program—show the methods and materials used in obtaining the information in a setting with the greatest viewer impact. Word stories only, are fine, but pictures of snow under various conditions—falling, blowing, melting, drifting, frost or undisturbed—will gain impact to articles or displays. Snow and snow survey photography is not as simple as shooting documentary photographs of general practices. Many additional problems are encountered. Example: extreme brightness, high elevations, fast action, fast film, emulsions.

Films and Exposures

Black and White

- PLUS-X film, moderately slow, ASA-125 (preferred). Basic exposure for snow—f22 @ 1/100 sec. Exceptionally bright at high altitudes—1/200 sec.

- TRI-X film, fast, ASA-320 or 400. Can be slowed down by using a K2 yellow filter which will drop the ASA to 160. The yellow filter will also darken the blues, such as the sky and shadows. Basic exposure without filter over snow—f22 @. 1/400 sec. Basic exposure with filter (K2) over snow—f22 @ 1/200 sec.

- To insure a correct exposure, bracket the basic exposure with one f-stop greater and one f-stop less.

- Exposure meter is the most accurate method of determining proper exposure. **Do not point meter towards the snow for it is excessively bright and will give an underexposed reading.** Take reading by holding meter close (8' or less) to main subject matter such an hand, face, jackets, or equipment. Bracket exposure for insurance.

- Backlighting (sun coming towards but not into camera lens) is very dramatic lighting but will require a one f-stop increase if details are desired in the final prints.

- Cross lighting or side lighting (sun coming from the sides) will not require additional exposure compensation. This is very good lighting because long shadows will be cast from trees, depressions in the snow and surrounding terrain. Cross lighting will break up the overall monotony of the white snow.

Color Film

- KODACHROME 25, 35mm, Daylight Type, slow, ASA-25. Basic exposure over snow—fll @ 1/100 sec. Note: Color contrast filters are not used with color film.

- KODACHROME 64, 35mm, Medium Speed, (preferred) ASA 64. Basic exposure over snow—f22 @ 1/100.

- EKTACHROME 64. Basic exposure over snow—fl6 to f22 @ 1/100 see. 4x5 comes in single sheets and needs cut film holders.

- Color film has very little latitude (range in which an acceptable color shot can be made).

  — 1 1/2 f-stops over normal-overexposed clear or burned out slide.

  — 1 1/2 f-stops under normal-underexposed black or very dark image.

- A one-half (1/2) f-stop underexposed results in a slide with heavy color saturation and very vivid. This is better than overexposed.

- Most 35mm cameras have built in light meters and read the light on the mirror. This is quite accurate. Recommended method is to read the reflected light value off the hands or face or jackets. To insure a proper exposure, bracket exposure as in black and white.

- A "Skylight filter" (appears clear but pale pink in color) is used with color film to reduce the excessive bluish color in shadows and snow which is reflected from the sky. This filter helps reduce the blue haze effect to some degree.

- In color photography, "yellow" becomes more brilliant in the early morning light while "reds" register the brightest in the afternoon light.

General Tips on Shooting and Posing the Scene

- Camera equipment used at low temperatures should be free of moisture to prevent the slowing down or the freezing of the shutters. Most "between the lens shutters" are affected by cold. Most new 35mm single lens reflex cameras have focal plane shutters which are not affected.

- Most snow courses are not in a good location for pictorial photography. Create a "snow course" with a set of portable markers and poles in a semi-open area for good lighting and dramatic backgrounds.

- Locate desired area for photographs but do not track the area before the "shot is setup and made." Keep the undisturbed look as much as possible.

- "Pose" surveyors, skiers, snow machines and equipment in a position so they "stand out" from the background. Trees and brush, unless heavily covered with snow do not give the illusion of the High Country. Look for sky, cloud effects, ridges, and adjacent mountains for backgrounds.

- Subject matter, men or equipment should be relatively close to the camera. Subject matter too far from the camera will appear smaller due to the effect created by the great amount of white area.

- Side lighting or backlighting will create many shadows and is very dramatic. This light will increase the detail in the foreground snow and highlight snow or frost on trees. The shadows created by the uneven snow surface will add to the photo and break the monotony of the white expanse.

- Avoid gray and overcast days for photography unless a shot for "the record." In black and white photography, the loss of contrast gives a "dirty" appearance to the scene and is not eye appealing. Color photography without good sunlight will result in a bluish-gray slide. Sunlight is needed for the reds and yellows.

- When shooting color, subjects should wear colorful clothes if possible. Reds, yellows, pinks, flame, light blue and yellow-greens are good. Blue and green are ever present in outdoor photography. The addition of bright foreground colors will increase overall color contrast.

- Never "mug" a camera. Pose the action if need be but have the subjects interested in what they are looking at or doing. No pointing.

- Close-ups and fine detail shots are also needed to add to a slide talk for continuity or to explain a technique or action in an article or exhibit.

- Good recreational photos of snow activities are needed such as skiing, snowmobiling, sledding, tobogganing, skating, tube sliding, snow-shoeing, hiking, snowballing, etc. Also, show the hazards and recommended safety practices.

- Red filters create extreme dramatic effects on landscapes but with a loss of detail. People's faces become a chalky white with loss of lip details.

- Snow surveyors or people in snow scenes should be wearing either skis or snowshoes regardless of depth or snow condition. This helps create the illusion of "deep snow."

- Try to emphasize the NRCS or snow survey "patch" on personnel when setting up the shot.

- Early morning sun (up to 2 hours after sunrise) and late afternoon sun (2 hours before sunset) will require a one f-stop increase in exposure to compensate for the low angle of the sun. This pertains to both color and black and white photography.

- Aluminum foil on cardboard makes an excellent 'fill-in' reflector.

- Action shots of skiers, snow mobiles and general snow activities may require a "rehearsal area." The photographer will get only one chance in an "undisturbed area."

- Skiing-type action shots will require shutter speeds of 1/200 to 1/500 sec. for "head-on shots." Action passing close in front of camera at 90 degree angle will require shutter speeds of 1/500 to 1/1000 of a second. Speed is relative to the angle of action from the camera and also the distance from the camera.

- Use foreground framing to improve a general documentary type photo. Example: tree limbs of snow covered branches, skis and poles, equipment, snowmobiles or snocats, door frames, snow banks and shadows, etc.

- In snow photography, the general rule for exposure is to shoot for the shadow detail and let the highlights take care of themselves. Most good snow survey photographs are the result of advanced planning and devoting the day specifically to "photography."

Basic Principles of Composition

Composition is really no more than arranging the parts of a picture in a pleasing manner. Knowing that, you need not be worried by your highbrowed friends. Another approach to composition is to remember, whenever you take a picture, that you must present it in the strongest way. To do that, you must think and thinking paves the road to success. In other words, composition is chiefly common sense. To make your pictures more pleasing, you may follow certain principles to gain certain effects. But these principles must not become rigid laws. They are only guides. After you have acquired some background, you will know how far you may deviate from the rules and still have good pictures.

Division of Picture Space

Your first problem is, where to put things in a picture. A helpful rule—never divide a picture in halves or quarters, as shown in figure 1, but rather, arrange it by thirds, as in figure 2.

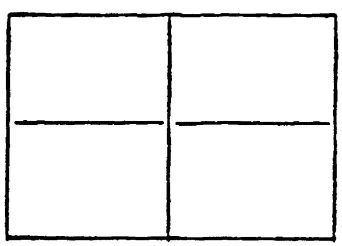


Figure 1—Wrong

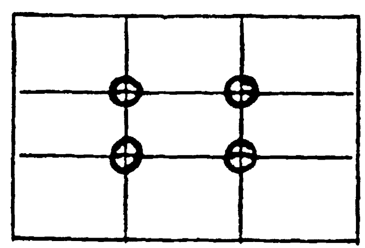


Figure 2—Correct

Place important objects where lines cross.

The reason for the rule is simple. One feature should dominate, since we can consider only one thing at a time. If you divide your space in halves favoring neither one or the other, our mind jumps from one half to the other. We are like the fellow on the fence, not sure which way he will jump. But if you divide the space into thirds, it is easy to let one part of the picture predominate. For instance, in a scene we usually have earth and sky. If the skyline dividing the two is placed in the center, neither earth nor sky will predominate. So we must decide which is more important. Is it the heavens, with a graceful arrangement of clouds? Or is it a winding roadway leading up to the hills? Whichever you wish to emphasize, give that part the largest amount of space in the picture.

Thus you see that we do not strive for perfect symmetry, but for variation of spacing. Unequal spacing, unequal masses, not only give emphasis, but add interest. And this division of space into third applies whether the picture is horizontal or vertical. Therefore, the next time you make a picture, imagine lines drawn on your film as in figure 2. Then place the most important objects either *directly on the lines* or near the *intersections* of these lines, as shown by the circles. These four circles are the four strongest parts in the picture space. However, since you want only one thing to dominate in a picture, use only one strong spot at a time, or at the most, two. If you actually place objects on each of the four spots, you create confusion and defeat the principle of "Dominance" (figures 3, 4, and 5).

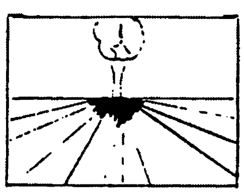


Figure 3 WRONG
Divided in halves-Sky and earth of equal importance.

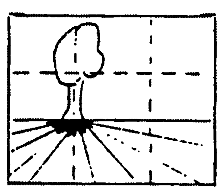


Figure 4 GOOD
Divided in thirds
Sky area dominant.

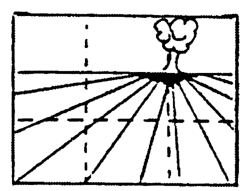


Figure 5 GOOD
Divided in thirds
Foreground dominant.

Balance in Photographs

After spacing your picture, the next step is balancing it. The quickest way to understand pictorial balance is to assume that each part of a picture has a certain weight, which could be placed on a pair of scales. The easiest scale to call to mind is the old steelyard type, shown in figures 6 and 7.

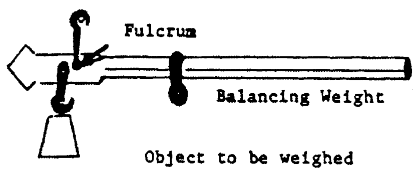


Figure 6

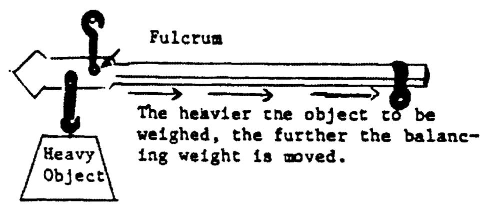


Figure 7

On a steelyard, a heavy object can balance a lighter one, provided the lighter one is moved further away from the child having the shorter piece of the plank, see figures 8 and 9.

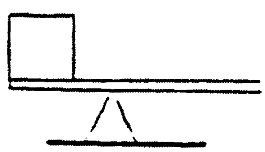


Figure 8 PLANE

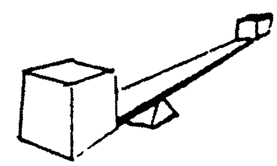


Figure 9 IN PERSPECTIVE

In the same way, in a picture a large object—or one nearer the camera and hence seeming to be larger—can be balanced by a small one, depending on where they are placed. The nearer a small object is placed to the edge of the picture, the more pictorial "weight" it has. A massive, heavy tree in the foreground may be properly balanced by another appearing smaller, since it stands in the distance. A short cut to applying this principle is to place the most important object on one of the "thirds" as shown in figures 10 and 11.

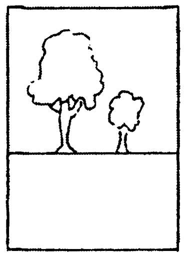


Figure 10 PLANE
Small tree balances

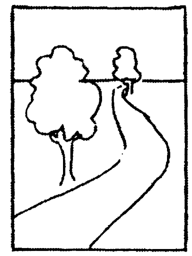


Figure 11 IN PERSPECTIVE
Balanced again

Meaning of Lines

A great aid in the creation of mood or idea in a picture is an understanding of the meaning of various lines. There are four main forms: the Horizontal, the Vertical, the Diagonal, and the Curved Line (figure 12).

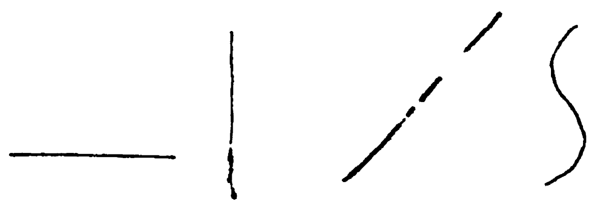


Figure 12

The *horizontal* line renders a feeling of *peace* and quiet, such as we feel when gazing at the horizon at the seashore (figure 13).

The *vertical* line suggests height, serenity, *strength*, power. You may find it in architecture, landscape, portraits (figure 14).

The *diagonal* line implies motion, force, *action*. You often see it when gazing at the horizon at the seashore (figure 15).

The *curved* line implies *grace* and charm. A curve, more or less like the letter S, is found in winding brooks. When properly drawn, it is the shape of a woman's back, pointed out centuries ago by Michael Angelo, but commonly known today as "Hogarth's Line of Beauty" (figure 16).

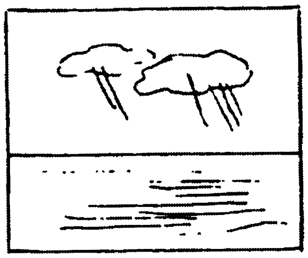


Figure 13 HORIZONTAL

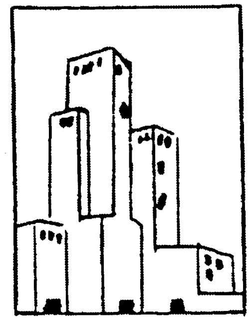


Figure 14 VERTICAL

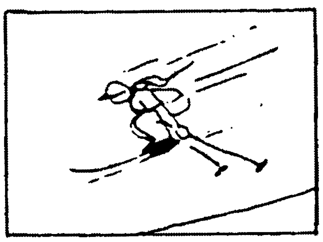


Figure 15 DIAGONAL

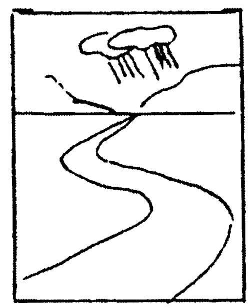


Figure 16 CURVED

Keeping in mind the moods associated with the lines, you can deliberately use them to create such moods in your pictures. For instance, think of these lines in connection with human behavior. Associate the vertical line with the proud, stiff soldier standing at attention; the diagonal line with the soldier rushing forward to attack, his body at an oblique angle; the horizontal line with the weary soldier at the end of the day, stretched out for a rest. Or you may think of these lines in connection with an object such as a tree. For the vertical line, imagine the tree rising up majestically against the sky (figure 17), then suppose a gale sweeps it, bending it over in the diagonal line. There you have force and action (figure 18), if the storm is strong enough, the tree bole snaps, down it goes, to lie in the horizontal line of peace (figure 19).

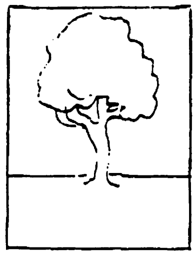


Figure 17 VERTICAL

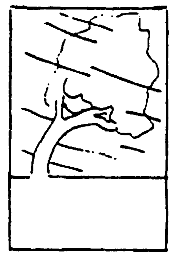


Figure 18 DIAGONAL

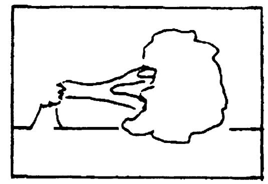


Figure 19 HORIZONTAL

Geometrical Forms

Some experts, in analyzing masterpieces to learn the secret of their effectiveness, have found that the parts of the picture are grouped according to some geometrical form. Some of these forms are illustrated below, as you may use them or recognize them, in pictures. However, do not apply them too mechanically. If you use these forms without modification, the pictures will be stilted and dull. The real trick is to use the forms so that you partially hide them. The most important BASIC FORMS are: the Pyramid (sometimes called the Triangle), the Circle, the Cross, the L, the Radii, the S form which we have previously considered as a line (figure 20).

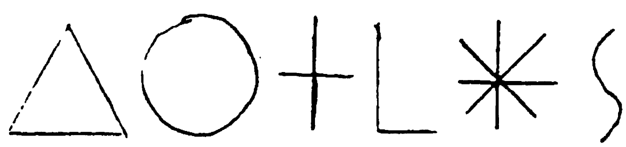


Figure 20-A PLANE

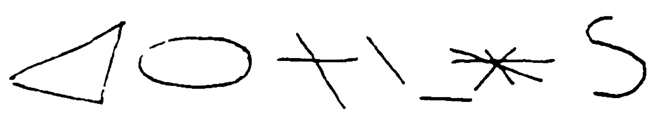


Figure 20-B IN PERSPECTIVE

All of these forms may be used in composition of material in a vertical plane, or in a picture involving perspective. Combinations of these forms, such as a circle and a cross, may appear in one picture.

The *pyramid* form suggests symmetry, solidity, aspiration, *dignity*. We see it in religious pictures, in church spires, in portraits, with the head as the apex of the triangle (figure 21).

The *circle* lends itself to flower studies, still life, graceful groups, or landscapes framed in trees (figure 22).

The *cross* composition is found in a sailboat with its reflection in water forming one line, the horizon the other (figure 23).

The *L* composition may occur when a tree at one side of the picture forms an L with the horizon line (figure 24).

The *RADII* composition has lines leading into a center, or out from it, as spokes lead to the hub of a wheel (figure 25).

The *S* composition is undoubtedly the one most used by photographers, and the one most popular with viewers (figure 16).

Figure 21

Figure 22

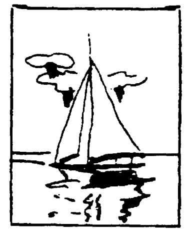


Figure 23

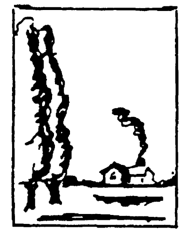


Figure 24

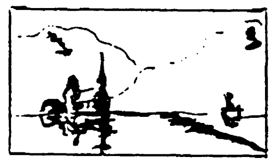


Figure 25

Rhythm or Pattern

One word you often hear in connection with pictures is rhythm. It means merely repetition of some form. This may be a shape or a line. An illustration in nature is that of a clump of grasses blown by the wind. The single blades are repeated, producing rhythm, with changing patterns (figure 26).

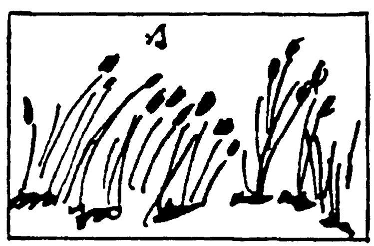


Figure 26 RHYTHM

Exposure

Exposure settings of the camera depends on two factors:

- The Film Speed (ASA)

- The amount of light available in the scene. The correct exposure is obtained by adjusting two camera controls:
  - — The Shutter speed
  - — The F-Stop of the lens

The following is an explanation of the relationship of shutter speeds and F-Stops that are used as a combination in setting the camera for a correct exposure.

F-Stops

Fact—Each F-Stop will differ from its adjacent neighbors in that it will allow either twice as much or half as such light to enter the camera.

Example—Here is a progression of F-Numbers:

1.4-----2.8-----4-----5.6-----8-----11-----16-----22-----32-----45

- F-5.6 which is a wider opening than 8 allows twice as much light to enter the camera.
- F-11 which is a smaller opening than 8 allows only one half as much light to enter the camera.

Shutter Speeds

Fact—Each shutter speed will allow light to strike the film either twice as long or half as long as the next.

Example—Here is a progression of shutter speeds in terms fractions of a second:

1/2, 1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000

- Notice that each is half as long as the one below it and twice as long as the one above it.
- Notice that 1/1000th of a second is a shorter period of time than 1/2 second.

Now, by putting the above two examples together, you can see that the same exposure is given by many different combinations of F-Stop/shutter speed combinations:

1.4	2	2.8	4	5.6	8	11	16	32
1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4

These exposure combinations are the same—but remember that your depth of field changes.

Bracketed Exposures

The purpose of this message is to give you an idea of the range and limitations of the film you are shooting in your camera, as well as to demonstrate the effects that aperture size and shutter speed have upon exposure.

Steps in making bracketed exposures:

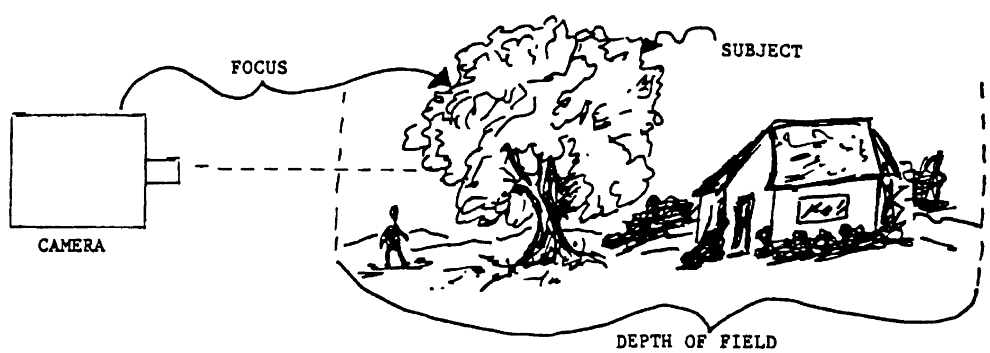
- Determine what the correct exposure should be for the particular scene that you are shooting, either by using your light meter or by consulting the exposure guide which comes with each roll of film.
- Make your first exposure according to the settings dictated by the chart or your light meter. Write down all your camera settings.
- Make your second shot of the same subject and the same point of view as the first shot, but this time set the aperture one stop smaller than the setting for the first shot. The shutter speed should remain the same.

- Make your third shot of the same subject with the same point of view as the first and second shots, but this time set the aperture one stop larger than the setting for the first shot. Again, the shutter speed should remain the same. Be sure to write down ALL of your camera settings for all three shots.

Example:

1st exposure:	f 8, 1/125 second (normal exposure)
2nd exposure:	f 11, 1/125 second (under exposure)
3rd exposure:	f 5.6, 1/125 second (over exposure)

Remember that the above figures are only given as an example. They will vary according to the light conditions that you are shooting in. You can bracket exposures by varying shutter speed instead of aperture (f-stops). Once you have practiced bracketing, you will be able to determine the best combination of shutter speeds and f-stops to obtain desired results with the equipment you are using.



Depth of Field

Depth of field refers to the following situation. You have focused on a certain subject. You notice that certain other objects both in front of and behind the subject are also in acceptable focus. This area in front and behind the subject is referred to as depth of field.

Depth of field is controlled by three factors:

- *Focal length of the lens*—Long focal length lenses (Telephoto) tend to have short depth. Short focal length lenses (wide angle) tend to have long depth.

- *F-Stop*—Small lens openings (Large F-No.) have large depth of field. Large lens openings (Small F-No.) have small depth of field.

- *Camera to subject distance*—When the camera to subject distance is great, then the depth of field is great. When the camera to subject is short, then the depth of field is small. As you can see by manipulating these three factors, it is possible to cause the background or foreground in a photo to be sharp and thus relevant to the picture, or out of focus and more or less irrelevant to the photograph. When the foreground and background are out of focus, the subject of the photo becomes the main and only part of the picture that draws the eye of the observer. When the foreground and background are in focus they become important elements of the photo and compete with the subject for the attention of the observer. This is a very important concept in the composition of photograph.