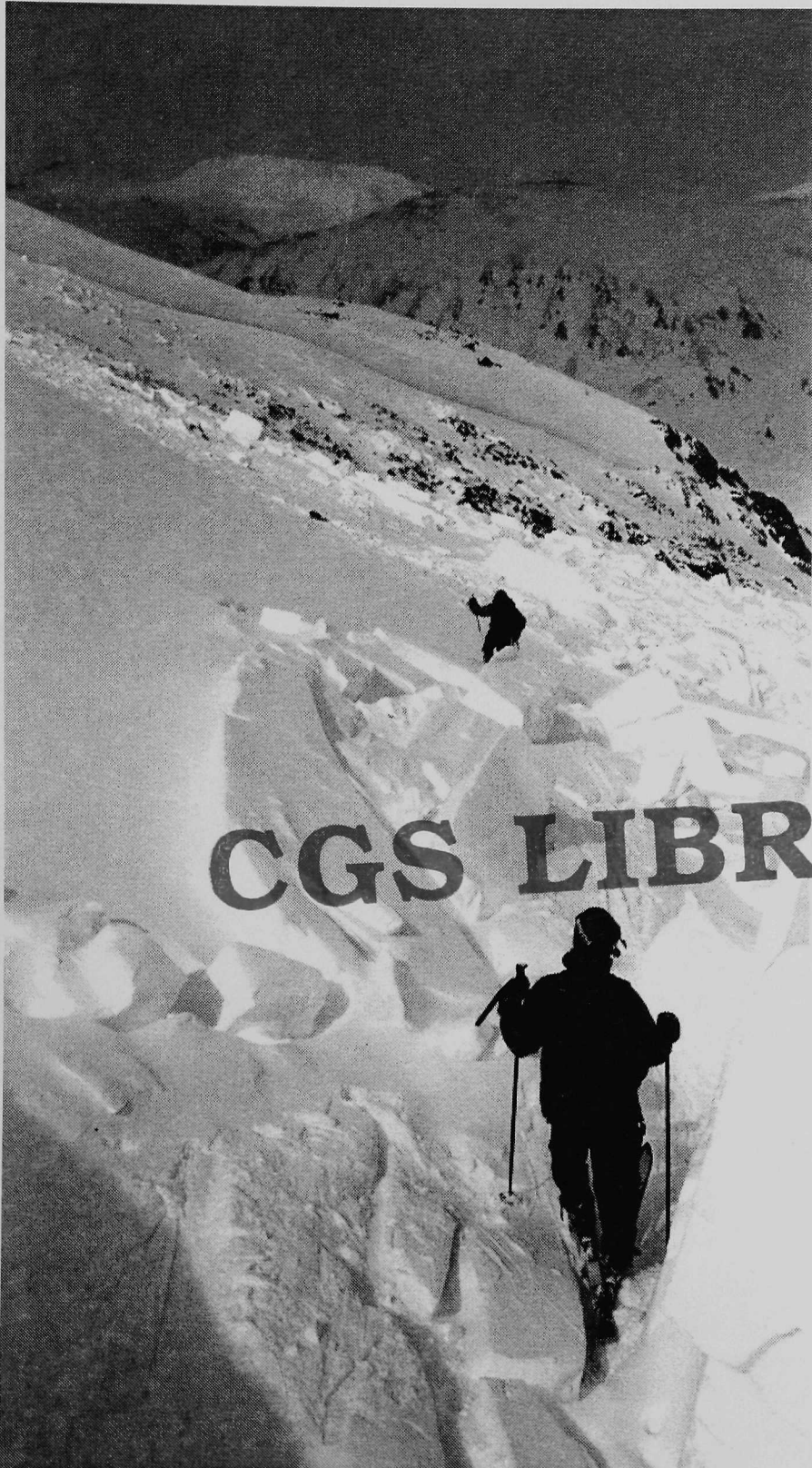


Snow & Avalanche



Annual
Report
1997-98

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Cover: CAIC forecasters Lee Metzger and Cathy Fraser on the debris of a hard-slab avalanche near Loveland Pass on February 22, 1998. Photo by Halsted Morris.

Colorado Avalanche Information Center

Annual Report
1997-98

June 1998

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Colorado Geological Survey
Department of Natural Resources
1313 Sherman Street
Denver, Colorado 80203

STATE OF COLORADO



DEPARTMENT OF NATURAL RESOURCES
Colorado Avalanche Information Center
10230 Smith Road
Denver, CO 80239
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Director's Report

To our sponsors and patrons:

The year of El Nino! That was the hype last fall as dire predictions of monster winter storms made headlines. We in the Avalanche Center didn't get on that bandwagon. We were less concerned about heavy snows—for our data showed that El Nino winters typically produced snowfall a little lighter than normal—and more concerned about the weak and avalanche-prone snowpack that would result from less snowfall. Our seasonal prediction turned out to be on target as snowfall was slightly below normal (87-106%) and a weak snowpack caused six avalanche deaths. You can read all about it inside.

The year also brought several very positive happenings, none related to El Nino. First, more people got our daily forecasts than ever before. You wouldn't believe this by looking at our hotline counts alone, which actually decreased because of gremlins in the counters. But growth came in hits to our Internet web site and in e-mailings to Friends of the CAIC. When we totaled our hotline calls, web-site hits, and e-mailings, the number topped 160,000. This number is in addition to about 17,000 faxes and e-mails of our forecasts to observers, clients, and sponsors, and is a good measure of the public use—and success—of our forecast program.

Second, our revenues from grants, donations, and contracts-for-services grew and for the first time topped \$400,000 (see pages 2-3 inside). There are several reasons for this:

- We received an extraordinary donation from the family of Ethan Gell, a ski patroller at Beaver Creek who in 1995 died and will be forever young. We are working with Ethan's mother to use the donation to produce and distribute statewide an avalanche safety brochure to commemorate her son.
- The CAIC also received funding in memory of Jim Hamilton, an ex-patroller and long-time friend of the Center, who sadly succumbed to cancer; and in memory of Beth Barber, a part-time ski patroller at A-Basin and flight nurse who died in a tragic helicopter crash. This helicopter crash killed four people (as did a similar crash at Alta, Utah), and it is a glaring reminder of the dangers faced by flight nurses and doctors while working to save others. The CAIC is proud to be the recipient of these funds in memory of Jim Hamilton and Beth Barber.
- Our grassroots campaign "Friends of the CAIC" grew in its second year, especially because of a treeroots-sized donation from Rob and Samuel Gary. We hope to see more growth in this support group, eventually reaching 1,000 Friends who keep us going and get to read *The Beacon*.

Third, the CDOT avalanche reduction program took a giant step forward when they put six 105-mm howitzers into use. These weapons mean faster control missions and shorter road closures. The CAIC forecasters play a strategic role by providing CDOT with hazard forecasts and by aiding the control teams and observing the results of the missions. The synergy of the CAIC doing its forecasting and CDOT doing its avalanche reduction will pay long-term dividends in safety for both the public and highway maintenance crews.

The CAIC has completed its 15th year of operation, and we continue to grow (as needed) to meet our clients needs and to meet the demand for our services. As always I want to thank all our sponsors who make our mission of avalanche safety possible. And I want to thank my staff of forecasters for the professionalism they bring to the job everyday. Nick Logan, Dale Atkins, Scott Toepfer, Mark Mueller, Lee Metzger, Rob Hunker, Andy Gleason, Doug Lewis, and Cathy Fraser—thank you all. It's a pleasure to work with you.

A handwritten signature in black ink that reads "Knox Williams". The signature is written in a cursive style with a large initial "K".

Knox Williams
Director

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Executive Summary

Mission: The Colorado Avalanche Information Center promotes safety by reducing the impact of avalanches on recreation, industry, and transportation in the State through a program of forecasting and education.

Administration: The Center is a program of the Colorado Geological Survey of the Department of Natural Resources.

Funding: The Center is totally funded by grants and donations. In FY 97-98, total revenues were \$403,011, compared to \$356,588 last year.

Housing: The main office of the Avalanche Center is at the National Weather Service in Denver. Offices for CDOT operations are located in Silverton, Pagosa Springs, Carbondale, and the Eisenhower Tunnel.

Staff: Total staff was 10. Four forecasters shared the duties of a 7-day work week during the winter season at the main office in Denver. Two forecasters were the Silverton office, two at the Eisenhower Tunnel, one at Pagosa Springs, and one at Carbondale. Personnel at the four mountain offices provide specific training and forecasting for CDOT.

Avalanche events of 1997-98: This was an El Niño winter. It produced snowfall that was slightly below normal (87% to 106%) with many days of very light snow and few large storms. The mountain snowpack was shallower and weaker than normal in the first 4 months of winter. A total of 2,958 avalanches was reported to the Center (40% above the average of 2,110). Though there were more avalanches, the average size was smaller and there were very few large, destructive avalanches. Avalanche Warnings were posted on 21 days (12 below normal). There were six avalanche deaths (one above normal). Property damage was \$150,000 (near normal).

Dissemination of forecasts via hotlines, Internet, e-mail, and radio broadcasts: The public made 76,724 calls to the CAIC hotlines this winter, but the counters malfunctioned on three of our hotlines so that actual usage was much higher. In addition, 30,000 forecasts were sent to Friends via e-mail, and there were 53,371 hits on our web site forecast page. That is a total of 160,095 sendings of our daily forecasts. Additionally, 11 mountain radio stations broadcast our hotline messages daily.

Media contacts: As Colorado's spokes-agency for avalanche matters, we received or initiated 215 contacts with broadcast and print media.

Public education: We presented 79 avalanche seminars to 3,505 people.

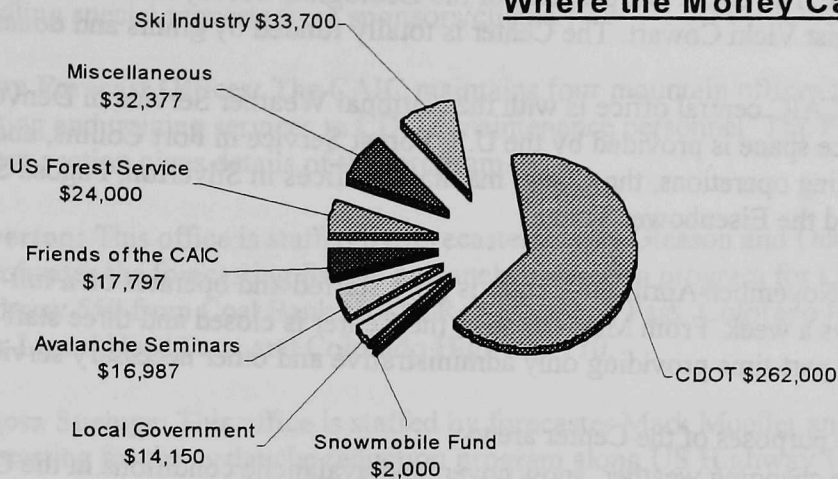
Funding and Budget

For FY 1997-98, funding from donations, grants, and contracts came from the sponsors and clients listed below, plus estimated in-kind support is listed.

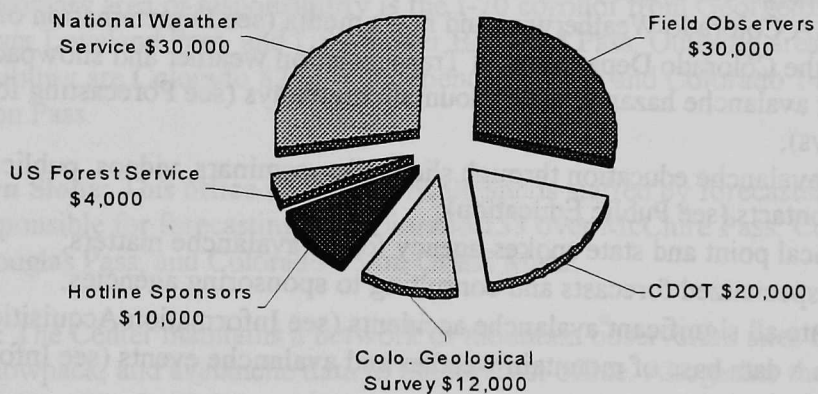
State	\$264,000	Tenth Mountain Huts	525
CDOT contract for services	240,000	Pikes Peak Alpine School	510
CDOT grant	22,000	Mountain Rescue - Aspen	500
Parks, Snowmobile Fund	2,000	Summit County Pro Course	500
		Colorado School of Mines	450
Federal	\$24,000	Silverton Avalanche School	450
US Forest Service	24,000	Ft. Collins Mountain Shop	400
		Bent Gate	250
Local Government	\$14,150	Colorado Outward Bound School	250
Summit County District Court	8,950	Summit Huts	225
Summit County Government	1,500	Keystone Weather Course	200
Town of Breckenridge	1,200	Snow Operations Center	200
Eagle County	1,000	Pueblo Snowmobile Club	155
Town of Frisco	1,000	Keystone Science School	150
Town of Dillon	500	Pikes Peak Hi Riders	125
		Buena Vista Snowmobile Club	100
Ski Resorts	\$33,700		
Colorado Ski Country USA	20,000	Miscellaneous	\$32,377
Aspen Skiing Company	4,000	Ethan Gell Memorial Fund	25,150
Vail Associates	2,000	People Productions	1,718
Breckenridge	1,500	Ascent Entertainment	1,000
Winter Park	1,500	Mountain Chalet	1,000
Arapahoe Basin	1,000	Antler Foundation	500
Copper Mountain	1,000	Braun Huts	500
Steamboat	1,000	Tenth Mountain Huts	500
Telluride	1,000	Anderson Hunter Law Firm	450
Crested Butte	300	Summit Huts	400
Monarch	250	Great Pacific/Patagonia	349
Eldora	150	Fort Lewis Outdoor Pursuits	300
		Jim Hamilton Memorial Fund	260
Friends of the CAIC	\$17,797	International Alpine School	200
516 Friends	15,272	Beth Barber Memorial Fund	50
Rob & Samuel Gary	2,525	Total	\$403,011
Avalanche Seminars	\$16,987	Estimated In-kind Support	\$106,000
National Avalanche Foundation	4,258	National Weather Service	30,000
Colorado Mountain Club	3,200	Field observations	30,000
Summit County Rescue	1,000	CDOT	20,000
Hidden Treasure Yurt	900	Colorado Geological Survey	12,000
Newt Wheatley Foundation	800	Hotline sponsors	10,000
Steamboat Ski Haus	669	US Forest Service	4,000
REI	620		
Vail Associates	550	Grand Total	\$509,011

Funding and Budget

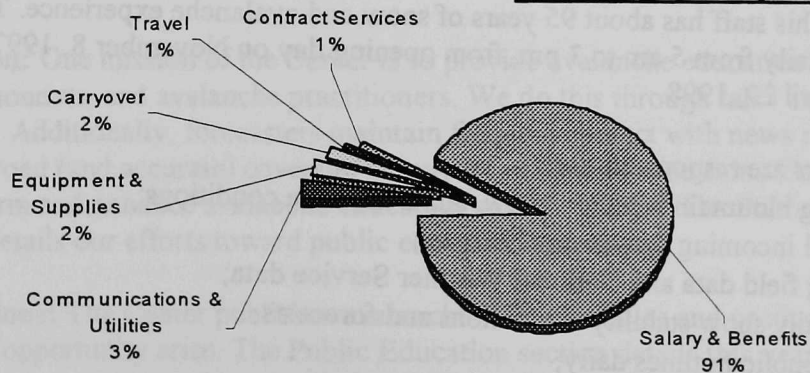
Where the Money Came From



Estimated In-kind Support



How the Money Was Spent



Operations

Administration: The CAIC is a program of the Geological Survey under the directorship of State Geologist Vicki Cowart. The Center is totally funded by grants and donations.

Housing: The CAIC central office is with the National Weather Service in Denver. Secondary office space is provided by the U.S. Forest Service in Fort Collins, and for CDOT forecasting operations, the Center maintains offices in Silverton, Pagosa Springs, Carbondale, and the Eisenhower Tunnel.

Season: From November-April, the Center is fully staffed and operates on a full-time basis seven days a week. From May-October, the Center is closed and three staff members work part-time providing only administrative and other necessary services.

Purposes: The purposes of the Center are to:

- monitor the changing weather, snow cover, and avalanche conditions in the Colorado mountains (see Data Sites below);
- provide twice-daily mountain weather and avalanche risk information to the public, via recorded hotline messages, the Internet and e-mail (see Dissemination of Forecasts);
- warn of dangerous avalanche conditions by issuing Avalanche Warning Bulletins via the NOAA Colorado Weatherwire and news media (see Dissemination of Forecasts);
- provide the Colorado Department of Transportation weather and snowpack data for reducing avalanche hazards along mountain highways (see Forecasting for Highways);
- provide avalanche education through slide talks, seminars, videos, publications, and media contacts (see Public Education);
- be the focal point and state spokes-agency for all avalanche matters;
- provide specialized forecasts and consulting to sponsoring agencies;
- investigate all significant avalanche accidents (see Information Acquisition);
- maintain a data base of mountain weather and avalanche events (see Information Acquisition).

Staffing and Duties at the Main Office: Personnel for the 1997-98 season were Knox Williams (Director), Nick Logan (Associate Director), Dale Atkins, and Scott Toepfer. Collectively, this staff has about 95 years of snow and avalanche experience. The Center was manned daily from 5 am to 3 pm, from opening day on November 8, 1997 until closing on April 29, 1998.

The forecasters are responsible for:

- monitoring mountain weather, snow, and avalanche conditions;
- logging all incoming data from observers;
- evaluating field data and National Weather Service data;
- making daily snow stability evaluations and forecasts;
- updating public hotlines daily;
- issuing forecasts for five highway areas daily;
- issuing and terminating Avalanche Warnings when warranted;

- initiating or responding to calls from the news media,
- handling special requests from sponsors/clients.

Highway Forecast Offices: The CAIC maintains four mountain offices to provide forecasting and training services to CDOT maintenance personnel. The Forecasting for Highways section gives details of this program.

- **Silverton:** This office is staffed by forecasters Andy Gleason and Doug Lewis, and coordinates the forecasting for the avalanche reduction program for CDOT along US Highway 550 from Coal Bank Hill to Red Mountain Pass, Colorado Highway 145 over Lizard Head Pass, and Colorado Highway 110.
- **Pagosa Springs:** This office is staffed by forecaster Mark Mueller and provides forecasting for the avalanche reduction program along US Highway 160 over Wolf Creek Pass, US 50 over Monarch Pass, and Colorado 17 over Cumbres and La Manga Passes.
- **Eisenhower Tunnel:** This office is staffed by forecasters Lee Metzger and Cathy Fraser and is the forecast center for CDOT's avalanche reduction program in District 1. The primary area of responsibility is the I-70 corridor from Georgetown to Vail, US 6 over Loveland Pass, and US 40 over Berthoud Pass. Outlying areas of responsibility are Colorado 82 over Independence Pass and Colorado 14 over Cameron Pass.
- **Western Slope:** This office is in Carbondale and is staffed by forecaster Rob Hunker. It is responsible for forecasting for Colorado 133 over McClure Pass, Colorado 139 over Douglas Pass, and Colorado 65 on Grand Mesa.

Data Sites: The Center maintains a network of mountain observation sites for providing weather, snowpack, and avalanche data to the forecast office. Altogether there are about 33 manned sites, 20 of which are ski areas and the remainder are highway and backcountry sites. The Center supports a contract observer at Gothic. The Highway Forecast Offices maintain and access data from remote weather stations, and also use the NRCS Snotel sites.

Education: One mission of the Center is to provide avalanche education opportunities to citizens, tourists, and avalanche practitioners. We do this through talks and field seminars. Additionally, forecasters maintain frequent contact with news media personnel to give broad (and accurate) coverage of current avalanche conditions. Such news stories both inform and enhance avalanche education with the public. The Public Education Section details our efforts toward public education and safety.

Publications: The Center publishes avalanche-related articles and produces videos as need and opportunity arise. The Public Education section details this year's publications.

Weather and Avalanche Synopsis

Long before the winter of 1997-98 arrived a new term had swept up America's imagination with weather: El Niño. The spreading of warmer tropical water into the Eastern Pacific Ocean was not new, but for the first time ever technology allowed climate researchers to detect the El Niño in November, 1996, and predict its magnitude by June, 1997. Researchers originally felt it would be the biggest El Niño this century. Long before the arrival of autumn everybody from United States Congress to the individual backcountry traveler was interested in El Niño and what connection this global event would have on local weather. The last El Niño of similar magnitude occurred in 1982-83. It caused 8 billion dollars in damages worldwide, pummeled the western US and smothered the Colorado Mountains with snow.

Expectations for abundant snows for the 1997-98 winter in Colorado ran high, but the Avalanche Center was not as optimistic. Review of snowfall records showed great variability during previous El Niño winters. Some El Niño's brought wetter winters while others brought drought winters. There was no strong correlation between El Niño and winter weather, though there was a bias toward a drier winter. One strong trend that appeared from the dry winters was the early and middle winter (November through February) was very dry, but the spring months of March and April were snowy. This would mean a thin, unstable snowcover with lots of depth hoar for most of the winter to be followed by springtime deep snows and a few big avalanches. That is exactly what happened!

Seasonal snowfall in the Northern, Central and Southern Mountains¹ ranged from slightly below normal to about normal and temperatures were above normal. The number of reported avalanches was well above normal, but the number of days with avalanche warnings was well below normal. The number of people caught by avalanches was well above normal, but fortunately the number killed was up only slightly. Property damage and losses were minor.

Snowfall

Table 1 shows monthly and seasonal snowfalls for all sites that regularly reported data to the Avalanche Center this year.

Colorado's mild and dry fall ended suddenly in late October when a massive storm clobbered the entire state. In November abundant snows continued to fall in the Southern Mountains as subtropical moisture streamed eastward from California; however, other mountain areas were not as fortunate. Monthly snowfall was 53-147% of normal. In December a typical El Niño pattern—the infamous split flow—set up over Colorado.

¹ The geographical regions called Northern, Central, and Southern Mountains of Colorado are used extensively in this report. The Northern Mountains extend from the Wyoming border to a line from Denver to Hoosier Pass (just south of Breckenridge) to Glenwood Springs, as the southern boundary. This boundary roughly follows the I-70 corridor but dips south in the area of Breckenridge to include the Ten Mile Range. The Central Mountains extend south from the Denver-Hoosier Pass-Glenwood Springs line to a southern boundary line from Pueblo to Montrose. The Southern Mountains lie between this Pueblo-Montrose line and the New Mexico border.

Weather and Avalanche Synopsis

Snowfall with few exceptions was well below normal, 34-72%. Telluride and Monarch somehow managed above normal snowfalls.

In January the West Coast storms finally reached Colorado bringing above normal snows to the Northern and Central Mountains. In the Southern Mountains drier conditions prevailed.

February's weather was unsettled but mild. The northern branch of the split-flow pattern blocked all invasions of cold polar air masses, while the southern branch carried storms well south of Colorado. Though the storms tracked southward just enough moisture would reach Colorado to fuel frequent but light snowfalls. Snowfall ranged from 71-138% of normal.

The split-flow pattern continued into March. Spring-like conditions arrived in earnest in the middle of the month, but the warmth was short lived. By the end of the month the storm track roared back over the mountains bringing heavy snows especially to the Southern Mountains. Like the month before, March's monthly snowfall was a mixture of both above and below normal snows.

The El Niño pattern for a snowy spring continued in April with most mountain sites reporting above normal snowfalls.

Spring finally returned in May, but avalanches in earlier months had removed most of the weak layers and generally yielded minor wet-avalanche cycles as the snow slowly melted.

For the seasonal trend, note in Table 1 the percent-of-normal totals for December-March. Most sites received near-normal snows ranging from 83-104%. Only Breckenridge was well below normal at 79%; only Telluride was well above normal at 122%. Also note that only a few sites have long-term snowfall records for the 6 months of November-April. Abundant snows in November and especially April helped boost seasonal totals for five of the seven sites.

Avalanches

This winter a total of 2,958 avalanches was reported to the Avalanche Center from November through April. This number is 40% above normal. Table 2 shows the monthly distribution of these events.

November and December were active avalanche months (270 and 283 respectively, as shown in Table 2). Significant faceted-snow development, and later in December, depth-hoar development resulted in numerous direct-action avalanches.

The trend of numerous direct-action avalanches continued in January. With a significant base layer of depth hoar it generally took little additional load to trigger avalanches. Above normal snowfall caused a near record number of avalanches to be reported, but in the absence of major storms the slides tended to be small to medium sized rather than

Weather and Avalanche Synopsis

large and destructive. By later in the month deep instability problems started to develop as new snows buried weak layers.

Avalanche workers anticipated a punishing February, but it never came. Historically February is a big avalanche month; however, this February left avalanche workers a bit disappointed. Warm temperatures and consistent light snows stabilized the upper portion of the snowpack, but allowed deep instabilities to persist.

A mid-March warm spell released a flurry of wet releases in the Central and Southern Mountains, but it was not until late March when a significant storm finally punched into Colorado and smothered the mountains. The Southern Mountains caught the brunt of the storm with a thick, heavy layer of new snow resulting in the season's only true cycle of large destructive avalanches. In the west San Juans some of the biggest avalanches in memory fell. In the rest of the mountain areas avalanches released into deep-buried, old layers, but it was the Southern Mountains that were hit the hardest. Though avalanches released in many areas not all paths slid and some deep instabilities remained.

In April cool temperatures, light snows and winds meant not enough load or potential for thaw to cause much concern about avalanches. Few avalanches were reported (134); however, the occasional deep release would occur reminding us the snowpack was not entirely safe.

At higher elevations the snowpack struggled to melt and at some sites it grew deeper. It was May before the snowpack started to melt away, and in the absence of weak layers there was no significant wet-avalanche cycle.

Avalanche Danger and Warnings

Table 2 shows the danger ratings (low, moderate, considerable, high, extreme) for the Northern, Central, and Southern Mountains on a days-per-month basis. The table also shows avalanche counts, accidents, and warning periods by month.

The 21 Avalanche Warnings days were well under the long-term average of 33 days. (A warning day is one on which the danger was rated high or extreme and an Avalanche Warning was issued.)

Table 5 shows the impact of avalanches this season on Colorado Mountain highways. It lists the number of natural and explosive-triggered avalanches reaching roadways.

Avalanche Accidents

The last part of Table 2 lists a monthly breakdown of avalanches involving people and property in 1997-98. The property damage occurred when a home outside of Silverton was destroyed in a large March avalanche. Table 3 lists all the avalanche accidents reported to the Center during the winter. Table 4 compares this season's accident statistics with long-term averages.

Weather and Avalanche Synopsis

The total of 101 people reported caught to the Center is the most ever for a single season. Some of this increase, but not all, can be attributed to improved reporting. Unlike the past several years where abundant snows created an uncharacteristically strong snowpack, this past January saw a more typical shallow, weak and unstable Colorado snowpack. Add to the weak snowpack an ever-increasing number of backcountry enthusiasts and that is a recipe for avalanche accidents.

This January 43 people were caught in avalanches. That is the same total that is caught in an average winter! Good luck can be the only reason to explain why more people did not die in January avalanches.

Figure 1 represents a 15-year look at avalanche accidents. Shown here are the number of people caught in avalanches and killed each winter.

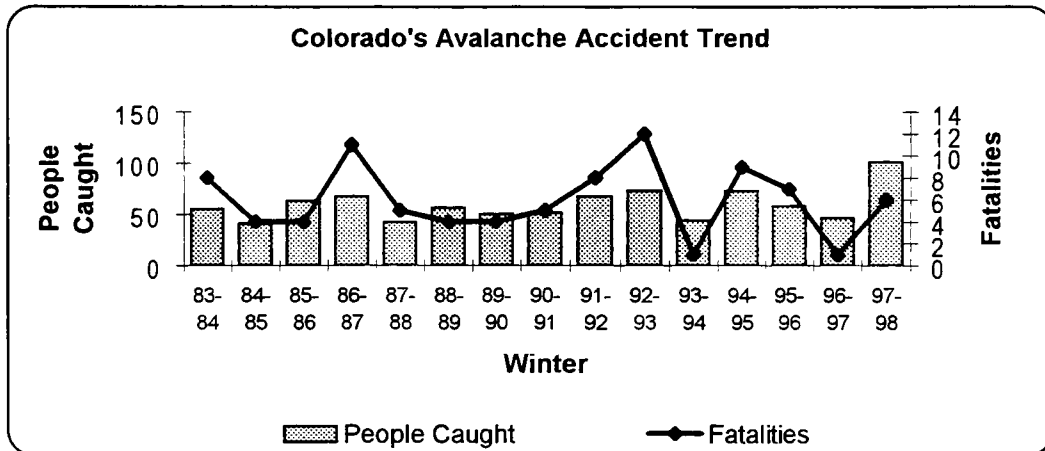


Figure 1. Colorado Avalanche Victims by Winter

Weather and Avalanche Synopsis

Table 1. 1997-98 Snowfall (inches)

	Nov	Dec	Jan	Feb	Mar	Apr	Total Dec-	% of Norma	Total Nov-Apr	% of Normal
Northern Mountains										
Arapahoe Basin	27	21	58	60	50	54	189	100%	270	90%
Bear Lake (RMNP)	30	19	44	29	44	46	126	83%	212	87%
Beaver Creek	58	37	60	64	67	44	228	101%	330	
Breckenridge	48	23	56	38	41	44	158	79%	250	
Copper Mountain	37	24	61	47	52	57	184	100%	278	100%
Eldora	34	26	49	26	40	56	141		231	
Keystone	42	36	48	34	33		151			
Loveland Basin	61	33	75	60	53	72	221	97%	354	106%
Steamboat	34	40	78	65	60		243	99%		
Vail	52	41	62	64	72	56	239	92%	347	
Winter Park	69	39	80	58	54	62	231	90%	362	98%
Central Mountains										
Aspen Highlands	47	16	38	48	51	46	153	89%	246	
Aspen Mountain		28	44	51	55		178	104%		
Crested Butte		18	56	35	46		155	92%		
Gothic	76	30	82	58	56	62	226	92%	364	106%
Irwin Lodge	68	45	102	76	77	62	300		430	
McClure Pass	44	22	65	46	75	44	208		296	
Monarch	37	47	36	38	49		170	88%		
Powderhorn		30	34	47	60		171			
Ski Cooper	48	26	53	44	42		165			
Southern Mountains										
Purgatory		29	38	34	81		182	98%		
Red Mountain Pass	52	26	56	44	63	47	189	91%	288	97%
Telluride	46	47	44	53	88		232	122%		
Wolf Creek	62	40	35	60	98		233	88%		

Weather and Avalanche Synopsis

Table 2. 1997-98 Summary of Avalanches, Hazard Days, and Accidents

	Nov	Dec	Jan	Feb	Mar	Apr	TOTAL
Avalanches reported	270	283	1061	424	786	134	2958
Days with 1 or more slab	22	24	30	26	29	24	155
Avalanche warning periods	1	1	1	1	3	1	8
Days with warning in effect	2	2	6	2	7	2	21
NORTHERN MOUNTAINS							
Days with hazard rated ...							
LOW	7	0	0	2	0	5	14
MODERATE	3	23	9	18	16	18	87
CONSIDERABLE	11	6	17	6	13	2	55
HIGH	0	2	5	2	2	1	12
EXTREME	0	0	0	0	0	0	0
CENTRAL MOUNTAINS							
Days with hazard rated ...							
LOW	7	0	0	2	0	5	14
MODERATE	4	24	11	18	19	19	95
CONSIDERABLE	8	7	15	6	12	1	49
HIGH	2	0	5	2	0	1	10
EXTREME	0	0	0	0	0	0	0
SOUTHERN MOUNTAINS							
Days with hazard rated ...							
LOW	7	0	0	6	0	8	21
MODERATE	3	26	15	16	16	15	91
CONSIDERABLE	8	4	16	4	10	2	44
HIGH	3	1	0	2	5	1	12
EXTREME	0	0	0	0	0	0	0
AVALANCHE ACCIDENTS	10	5	28	8	19	3	73
People caught	13	7	43	11	22	5	101
People partly buried	3	1	4	2	5	1	16
People buried	0	1	8	0	2	1	13
People injured	2	0	0	0	2	1	5
People killed	0	1	1	0	2	2	6
Vehicles caught	1	0	11	0	1	0	13
Property sites damaged	0	0	0	0	1	0	1

Weather and Avalanche Synopsis

Table 3. Colorado Avalanche Accidents, 1997-98 (italics mean fatal)

Date	Location	Details
10/31	Loveland Pass	1 vehicle caught, motorist caught, partly buried and injured
11/6	Telluride	1 ski patroller caught
11/15	Berthoud Pass (old ski area)	3 bc snowboarders caught
11/16	Wolf Creek Ski Area	1 out-of-bounds skier caught and partly buried
11/22	Aspen	1 ski patroller caught
11/22	Loveland Pass	1 bc snowboarder caught
11/22	Berthoud Pass	2 bc snowboarder caught
11/22	Berthoud Pass	1 bc snowboarder caught
11/23	Anthracite Range (Crested Butte)	1 bc skier caught and injured (broken ankle)
11/28	Friends Hut	1 bc skier caught
12/13	Guanella Pass	3 climbers caught
12/30	<i>Guanella Pass</i>	<i>1 snowshoer caught, buried and killed</i>
12/30	Berthoud Pass	1 bc snowboarder caught and partly buried
12/31	Searle Pass	1 snowmobiler caught (separate incident)
12/31	Searle Pass	1 snowmobiler caught (separate incident)
1/1	Loveland Basin	1 out-of-bounds skier caught
1/1	Loveland Basin	1 out-of-bounds snowboarder caught
1/5	Boreas Pass	1 bc skier caught
1/10	Montezuma (Saints Johns)	2 bc skiers caught, 1 partly buried, 1 buried
1/10	Buffalo Pass (Steamboat Sprgs.)	1 snowmobiler caught
1/12	Yule Creek	1 loader caught, 1 worker caught
1/14	Irwin Lodge	1 snowcat ski guide caught
1/16	Copper Mountain	1 snowcat caught, 1 worker caught
1/17	Loveland Basin	1 ski patroller caught
1/17	Loveland Basin	1 snowcat caught, 1 worker caught
1/17	Vail	1 out-of-bounds lift skier caught
1/17	Bakerville	3 climbers caught, 1 buried
1/17	Snowmass	1 out-of-bounds lift skier caught and buried
1/17	Berthoud Pass (east side)	2 cars caught, 2 motorists caught
1/17	Berthoud Pass (bank slides)	6 cars caught, 6 motorists caught
1/17	Berthoud Pass	1 bc snowboarder caught and buried
1/18	Loveland Basin	2 out-of-bounds snowboarders caught
1/18	St. Mary's Glacier	1 bc skier caught
1/20	Berthoud Pass	1 bc snowboarder caught
1/20	Aspen Mountain	2 ski patrollers caught (2 incidents)
1/20	Aspen Highlands	1 out-of-bounds skier caught

Weather and Avalanche Synopsis

Table 3. continued...

Date	Location	Details
1/21	<i>San Bernardo Mtn. (Lizard Head Pass)</i>	<i>1 bc snowboarder caught, buried and killed</i>
1/26	Loveland Pass	2 bc skiers caught
1/27	Copper Mountain	1 out-of-bounds skier caught and buried
1/31	Uneva Ridge (Copper Mountain)	4 bc skiers caught, 2 buried
1/31	Mt. Yale	1 climber caught
2/5	Crested Butte	1 ski patroller caught
2/7	Loveland Pass	1 bc skier caught and partly buried
2/11	Monarch	1 snowcat skier caught
2/14	Red Mountain Pass	1 bc snowboarder caught
2/14	Barnhard Hut, (Elk Mtns.)	2 bc skiers caught
2/20	Loveland Basin	1 ski patroller caught
2/24	Copper Mountain	3 ski patrollers caught
2/26	Powderhorn	1 ski patroller caught
3/1	<i>Berthoud Pass (Russell Face)</i>	<i>1 bc skier caught; 1bc snowboarder caught, buried and killed</i>
3/1	Red Mountain Pass	1 bc snowboarder caught and partly buried
3/1	Aspen Highlands	1 bc skier caught
3/1	Vail	1 out-of-bounds snowboarder caught
3/1	Rabbit Ears Pass	1 bc skier caught and buried (hand out)
3/6	Aspen Mountain	1 bc skier caught and injured
3/8	Arapahoe Basin	1 ski patroller caught
3/10	Gothic	1 bc skier caught
3/10	Gothic, Skykyl's Ridge	1 bc skier caught
3/11	Loveland Pass	2 bc snowboarders caught, 1 injured
3/11	La Plata Mountains	1 bc skier caught and partly buried
3/11	Snowmass	1 out-of-bounds snowboarder caught
3/13	Loveland Pass	1 bc snowboarder caught
3/16	Berthoud Pass	1 CDOT plow caught and driver caught
3/16	Beaver Creek	2 out-of-bounds skiers caught, 1 partly buried
3/28	Breckenridge	1 ski patroller caught
3/29	Silverton	1 cabin destroyed (\$150,000)
3/31	Loveland Pass	2 bc snowboarders caught
4/1	Copper Mountain	1 ski patroller caught
4/1	<i>St. Mary's Glacier</i>	<i>1 hiker caught, buried and killed</i>
4/19	<i>Berthoud Pass (Russel Face)</i>	<i>2 snowshoers caught, 1 injured, 1 killed</i>

Weather and Avalanche Synopsis

Table 4. Summary Statistics of Colorado Avalanche Victims

Category	Total 1997-98	Average (27 winters)	Difference
People caught	<i>101</i>	43	<i>+58</i>
People partly buried	<i>13</i>	11	<i>+2</i>
People totally buried	<i>13</i>	8	<i>+5</i>
People injured	<i>5</i>	4	<i>+1</i>
People killed	<i>6</i>	5	<i>+1</i>

**Table 5. Avalanches Reaching Colorado Highways, 1997-98
(does not include bank-slips)**

Forecast Office	Inclusive Highways	Natural Avalanches	Triggered Avalanches	Total
Silverton	US 550 Ouray to Coal Bank Pass; US 145 Lizard Head Pass; Colo. 110 (Silverton to Gladstone)	60	160	<i>220</i>
Eisenhower Tunnel	US 40 Berthoud Pass; US 6 Loveland Pass; I-70 Georgetown to Vail Colo. 82 Independence Pass	46	43	<i>89</i>
Pagosa Springs	US 160 Wolf Creek Pass; US 50 Monarch Pass; Colo. 17 Cumbres and La Manga passes	5	9	<i>14</i>
Western Slope	Colo. 133 McClure Pass; Colo. 139 Douglas Pass; Colo. 65 Grand Mesa; Colo. 24 Tennessee Pass; Colo. 82 Shale Bluffs, Snowmass Canyon; I-70 Glenwood Canyon	10	45	<i>55</i>
			Total	<i>378</i>

Detailed Winter Summary

October

Fall turned to winter in Colorado's high country on October 24. That day a strong storm hit the mountains and dropped 12-24 inches of snow by the 25th. This same storm produced upslope conditions that brought even heavier snows along and east of the Continental Divide and throughout the urban corridor and eastern plains. Storm totals were 30-50 inches of snow in these areas. This storm brought the first lasting snows to the mountains, and this layer would quickly start its metamorphosis toward depth hoar.

Concurrent with this storm was an extraordinary wind event near Steamboat Springs. On the 25th, east winds gusting to 120 mph leveled an estimated 20,000 acres of old-growth timber on Buffalo Pass.

November

A very weak storm system with strong winds pushed through the Northern Mountains to begin the month of November. Wind speeds of 20-30 mph were reported from the few observer stations up and running. Reports of 2-4" of new snow came from the Northern Mountains for this first official storm of the 1997/98 forecasting season. This weak system was followed by mild weather and clear skies until the 9th. A large blocking high pressure center set up over the western United States putting Colorado on a weak storm track that would continue until the 15th. Telluride saw 25" of new snow during this stormy period; Vail, 14"; and Gothic, 39". A weak ridge formed over Colorado on the 16th, but this ridge then flattened out and brought in more moisture on northwest flow aloft, opening the door for unsettled weather and light snows for all mountains until the 23rd. For the most part this storm cycle favored the North and Central Mountains: on the 17th-23rd, Vail got 24" and Irwin Lodge, 17".

High pressure built over the mountains until the 25th when a tricky system on southwest flow brought more unsettled weather to our mountains. For the most part this was not much of a snow producer, but on the 27th Gothic received 15.5" of new, and Purgatory, 17", prompting our first avalanche warning of the year for the Central and Southern Mountains. In the Northern Mountains, A-Basin picked up 13" on the 28th. November then closed out under bluebird skies and warming temperatures as high pressure built in from the west.

November snowfall was 102-109% of normal in the Southern Mountains, but was extremely variable in the Central and Northern Mountains: A Basin, 53%; Bear Lake, 76%; Copper Mountain, 86%; Vail, 88%; Monarch, 89%; Aspen Highlands, Breckenridge, and Winter Park, all 100%; Loveland Basin, 126%; and Gothic, 147%. For the month many shallow avalanches were reported, and 12 people were caught in slides, 3 were partially buried, and 1 was injured.

December

The month of December would be marked by a split flow pattern with storms tracking to the north and south of Colorado. This pattern is a typical result of the El Niño phenomena over the northern Pacific Ocean, and it would mean that Colorado would generally miss

Detailed Winter Summary

the main force of some rather powerful storms that would wreak havoc along the southern tier of states for the rest of the winter.

The first storm of the month arrived on the 2nd, and it favored the Southern Mountains. For the 3 days it would snow, Wolf Creek Pass landed 30" of snow whereas Beaver Creek in the Northern Mountains got 10.5". The Telluride area saw 22" of snow on the 2nd and 3rd which caused us to issue our second avalanche warning of the season, this for both the Telluride and Lizard Head Pass areas. Additionally, strong winds on the night of the 3rd brought a flurry of avalanche activity along the I-70 corridor near the Continental Divide, with over 70 slides being reported.

High pressure then covered Colorado until the 7th when weak zonal flow brought light to occasionally moderate snow for all mountains until the 12th. Initially the storm favored the South and Central Mountains: Powderhorn on Grand Mesa got 28" of new snow during this cycle, while Telluride and Steamboat both reported 20.5".

A weak cold front moved through the mountains on the night of the 15th bringing some light snow accumulations for the North and Central Mountains. Steamboat, Copper Mountain and Loveland Basin all saw 5" of new snow overnight, with rapidly clearing skies on the 16th.

Light winds, mild temperatures and clear skies would bring us to Christmas Eve Day, when a slow-moving, southerly-tracking system brought light snow accumulations for all mountains through Christmas Day. A second cold front drove through the Northern Mountains on the 26th and brought high winds which gusted into the 90s along the Continental Divide. Very cold temperatures were to follow as well, with temperature highs struggling to get out of the teens until the 29th when a very weak system brought warmer temperatures and some scattered snows to the Northern Mountains. Both Breckenridge and Winter Park reported 3" of new snow on the 30th.

Fair weather and light to moderate winds would run out the month and issue us into the new year. For the month, seven people were caught in slides, and the first fatality of the season occurred on the 30th when a snowshoer was buried in a small hard-slab avalanche near Guanella Pass.

With a few exceptions, December snowfall was well below normal. In the Northern Mountains, snowfall ranged from 44-68% of normal; in the Central Mountains, 34-72% of normal, but Monarch managed 114%; and in the Southern Mountains, 60-69% of normal, but Telluride got 120%.

January

To start the new year, a series of storms lined up in the Pacific with a track toward Colorado. The first of these arrived on the 3rd. Initially it favored the Southern Mountains and soon shifted itself to a more northwesterly flow to bring moisture into the North and Central Mountains. This first storm lasted until the 6th with the Southern Mountains seeing most-favored status and Wolf Creek Pass accumulating over 2 feet of snow. A-

Detailed Winter Summary

Basin in the Northern Mountains saw 8" and Sunlight near Glenwood Springs, 10". A short-lived spell of snow showers lasted until the 10th when the next system swung through on a speedy southwest wind flow. This system had a little longer life cycle and brought constant snow to all mountain areas until the 18th. A short break on the 19th allowed control personnel to catch up a bit before the second phase came in on the 21st.

On the 16th our third avalanche warning of the season was issued, this time for the Northern Mountains. It soon encompassed the Central Mountains and would spread to the Telluride area before it expired on the 21st. Over 200 avalanches were reported during this period. Wind speeds during the middle of the storm cycle saw gusts to 84 mph from Telluride. A-Basin picked up 44"; Gothic, 31.5"; and Wolf Creek Pass, only 6". Even though the warning expired snow did not. Snow would continue until the 26th for all mountain areas, but daily snows for all sites on the 21st-26th were light—less than 4" a day—except for 5" at Irwin Lodge and 7" at Copper Mountain on the 26th.

Fair weather, mild temperatures, and very light winds brought on a short-lived January thaw until the 30th when the next weak northwest storm trickled into the North and Central Mountains. A trace to 5" was the average snowfall on the 30th-31st.

January snowfall was above normal for all sites (but one) in the Northern Mountains and most sites in the Central Mountains, and was below normal for most sites in the Southern Mountains. In the North, Loveland Basin got 143%; Copper Mt., 133%; A-Basin, 127%; Beaver Creek and Winter Park, 120%; Bear Lake, 112%; Breckenridge and Steamboat, 106%; and Vail, 92%. In the Central, Gothic got 136%; Crested Butte, 129%; Aspen Mt., 121%; Aspen Highlands, 109%; and Monarch, 75%. In the South, Red Mountain Pass got 111%; Telluride, 96%; Purgatory, 92%; and Wolf Creek, 52%.

During January, 43 people were caught in slides, 8 people were completely buried and one snowboarder was killed on the 21st in a slide near Lizard Head Pass southwest of Telluride.

February

A stalled storm system over the West Coast continued to deepen and dig southward leaving Colorado with slowly increasing high clouds for the first four days of the month. As this system began to track east, the jet stream jumped out in front of the system and brought strong winds to the San Juans on the 4th with gusts to 72 mph on Red Mountain Pass. Following this system were a series of short-wave disturbances lined up to slip across Colorado for the rest of the month. New snow would be reported at one site or another for every day of the month. (This pattern would continue for the rest of the season.) Snowfalls were never great on any one day of February, temperatures would remain generally warm, and skiing would be excellent throughout the mountains.

The reason for the warm and muggy weather was El Niño. The main storm track continued to track as far south as Mexico with only weak unsettled weather getting as far north as Colorado. The only exception to this pattern of weak storms came on the 25th and 26th as enough snow fell throughout the state to bring the fourth avalanche warning

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of the season. Snow began to fall with greater intensity on the 23rd, and from the 24th-28th, Irwin Lodge in the West Elks saw 34" of new snow; Gothic, 25"; A-Basin, 22"; and Purgatory, only 14". Wind speeds of 30-50 mph were the norm during the warning period of the 24th-25th, and 132 avalanches were reported during the warning period. Luckily though, February, usually the deadliest month of the year for avalanche fatalities, saw none. Even so, 11 people were caught in slides, 5 of whom were ski patrollers.

Snowfall was highly variable, even over short distances. In the North, A-Basin got 138% of normal; Loveland Basin, 121%; Beaver Creek, Copper Mt., and Steamboat, 115%; Vail, 110%; Winter Park, 102%; Breckenridge, 85%; and Bear Lake, 62%. In the Central, Aspen Mt., 118%; Aspen Highlands, 109%; Crested Butte and Gothic, 86%; and Monarch, 80%. In the South, Telluride, 116%; Red Mountain Pass and Wolf Creek, 90%; and Purgatory, 71%.

March

March would see a similar pattern of storms to February with the split flow circulation sending the main storm energy north and south of Colorado. Nonetheless Colorado's mountains saw snow for the first 11 days of the month as moisture was able to sneak into the high country. Snowfall amounts in the Northern Mountains, however, were never great during this first storm period, as A-Basin got 19.5" of snow and Winter Park just over 20". Aspen in the Central Mountains picked up almost 24", and in the Southern Mountains Purgatory received 28", the majority of this coming on the 6th and 7th. This snowfall brought the fifth avalanche warning of the season. This warning would only encompass the San Juan Mountains of southern Colorado. More than 100 slides were reported during the avalanche warning which expired on the 9th.

High pressure then played a leading role over Colorado until St. Patrick's Day, the 17th. Warm spring-like weather brought a welcome change from the continuous cycle of storms over the last month and a half. By now we were getting into a spring pattern of afternoon convective shower activity. Convective snow showers can bring a wide range of snowfall amounts over a small area. For instance, on the 18th Vail saw 8.5" during the day while Beaver Creek just down the road saw 18". Telluride had 15" while just over the ridge Purgatory had 5.5" on the same day. This storm on the 18th caused us to issue the sixth avalanche warning of the season as snowfall intensity of up to 4" per hour brought the snowpack to a quick critical load. This warning would quickly expire by the 19th as the weaker underlying snowpack was beginning to show signs of being bridged over by the recent snowfall. Our main concern now was for warm temperatures which could bring on a period of wet avalanche activity. We did not have long to wait as a warm airmass moved over Colorado to bring temperatures that just barely dropped below freezing at night. Almost 130 wet-snow avalanches were reported in the 48 hours leading up to the morning of March 26th. Many wet slides went unrecorded in the backcountry as Colorado went through one of its biggest wet slide cycles in years.

As is often the case, a period of warm dry weather is followed by a sizable storm. This proved to be true as several mountain sites reported their largest 24-hour snowfall amounts of the season on the 29th. Purgatory picked up a whopping 26.5" of snow in 24

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hours. Telluride saw 34" from March 27th-29th. This was enough new snow to bring us to our seventh avalanche warning of the season. Large destructive avalanches involving the entire winter's snowpack crashed down in the Southern Mountains. One slide near Telluride wiped out 20 acres of mature timber. And another large avalanche destroyed a cabin near Silverton, resulting in \$150,000 damage.

By the 30th this storm had passed us by, but another large storm would pass right over the Northern Mountains for one last blast of winter for March. Steamboat had 15" of new snow on the morning of the 31st; Winter Park, 10"; and Vail won the grand prize with a total of 18". March had gone out like a lion.

As with previous months, March snowfall showed a mixture of above and below-normal figures, but overall snowfall favored the Southern Mountains. In the North, Steamboat got 121% of normal; Vail, 102%; Bear Lake, Beaver Creek, and Copper Mt., 100%; A-Basin, 95%; Winter Park, 77%; Breckenridge, 75%; and Loveland Basin, 73%. In the Central, Crested Butte, 113%; Aspen Mt., 105%; Aspen Highlands, 97%; and Gothic and Monarch, 88%. And in the Southern Mountains, Purgatory, 165%; Telluride, 149%; Wolf Creek, 130%; and Red Mountain Pass, 97%.

March avalanches caught 22 people and killed two people. The first fatal avalanche came on March 1st when a snowboarder on Berthoud Pass was buried and killed. The second took the life of a backcountry skier near Aspen on the 8th.

April

The first storm of April was brewing over southern California where an inch of snow fell in the suburbs just outside Los Angeles—a portent of things to come for Colorado. By the 2nd a strong upslope storm along the Front Range of the Rockies was developing. At Eldora 10" of snow fell by 3pm, and 17" at Monarch by 2pm. At Telluride in the San Juans 17" of new snow was reported by 7am with another 3" by 11 am. The storm would then concentrate itself along the Continental Divide in the Northern Mountains with A-Basin, Loveland and Winter Park seeing 11-12" of new snow by the morning of the 3rd. Eldora ski area scored another foot of new snow as well bringing a soft start to spring skiing. This storm also brought on our eighth and last avalanche warning of the season. It encompassed the Telluride area and the Continental Divide from Monarch Pass to the Wyoming border. The warning was dropped the next day—the 3rd—as the new snow proved to stabilize quickly under mild temperatures. Only 15 avalanches were reported during this warning episode.

After a brief 2-day stint of high pressure a broad trough of low pressure settled back in over the Colorado Rockies on the 6th. What this pattern would do is fuel afternoon thunder snow showers for all areas over the next 4 days. 15" fell at Winter Park for the period, but only 8.5" at Gothic and 14" at Wolf Creek Pass. Then starting on the 19th, the next 4 days would bring a welcome return, although short-lived, to spring-like weather. As the next system began to slide into Colorado winds also began to increase: a gust to 96mph was reported from Red Mountain Pass on the 11th. This next storm once again proved to be rather weak, but it came with strong winds and what little new snow there

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was fell onto a hard, smooth bed surface in the backcountry as about 30 shallow avalanches were reported from the Northern Mountains on the 13th.

Once again the storm pattern began to split apart with the main energy passing well south of Colorado, but a broad area of low pressure set up over the western United States which would keep the mountains under snowy skies until April 22nd. Gothic added another 36" of snow from the 13th-22nd; Vail, 27"; and Silverton, only 5". As is usually the case, many of our observing stations began to close down in the second half of April. As we lost these observers, we begin to cut back on our reports, and the CAIC finished official forecasts on April 28th.

April snowfall was above average. Winter Park got 148% of normal; Gothic, 132%; Loveland Basin, 115%; Copper Mt., 113%; Red Mountain Pass, 112%; Bear Lake, 109%; and A-Basin, 92%. Only three avalanche incidents were reported in April, but two these were fatal. On April 1 a hiker was killed at St. Mary's Glacier, and on the 19th a snowshoer was killed in an avalanche on Berthoud Pass on the same path where a snowboarder had been killed in March.

Daily weather, Snowpack, and Avalanche Data

The Avalanche Center relies on incoming data to make accurate assessments of current avalanche stability, and to make mountain weather and avalanche hazard forecasts.

There are two main sources of these data—the Colorado observer network and the National Weather Service.

Colorado observer network: The Center has established a network of about 33 manned observation sites in the Colorado mountains. Twenty-one of the sites are developed ski areas, from which snow safety personnel report current weather, snowpack, and avalanche data. The remaining sites are highway, heli-ski, and backcountry sites, from which volunteers or contract observers report to the Center.

Remote weather net: The Center has established a network of remote high elevation weather stations. The seven stations are located on Mt. Abrams, Red Mountain, Lizard Head, Wolf Creek, Loveland, Berthoud and McClure Passes. Forecasters can access stations via computer modem giving forecasters real-time data any time during the day or night. Forecasters can also access similar stations located at several ski areas.

National Weather Service: Avalanche Center personnel have access to all products and expertise of the NWS staff. Computerized weather maps, satellite photos and imagery, radar data, radiosonde data are all available from the new, state-of-the-art AWIPS workstations. Also available are information from manned and remote weather stations, and written analyses and forecasts. Additionally, discussions with NWS forecasters in interpreting data and products are an immense help.

Westwide Avalanche Network

As a cooperative member in the Westwide Avalanche Network (www.avalanche.org) the Colorado Avalanche Information Center serves as a repository for avalanche accident data for the United States. Information on avalanche accidents is stored in a data base at the Center and are used by Center personnel on a real-time basis and also for later analysis. Trends in avalanche accidents, relationships between survival and burial times and depths, and types of rescues are essential information to be passed on to snow scientists and the public. Lectures, field seminars, media contacts, and publications by Center personnel are some of the methods for disseminating this information.

Additionally, the Center responds to about 30 requests a year for raw or tabulated data. These requests come from the ski industry, the Forest Service, universities, snow researchers, consultants, and lawyers.

Accident Investigation

Avalanche Center personnel try to investigate all significant avalanche accidents and fatal accidents. This winter the Center staff visited several accident sites. Information obtained from field data, witnesses, survivors, and rescuers is used for current stability evaluation and for future educational purposes.

Dissemination of Forecasts

The Colorado Avalanche Information Center provides vital information to the public, specialized audiences, and sponsors. Following are the means by which the Center disperses information on mountain weather, avalanche, and snowpack conditions.

Public Hotlines

Data from about 35 field-observation sites are used to prepare forecasts for seven hotlines in Colorado. People can call for three types of information: an up-to-date mountain weather forecast, a current snow condition report, and an avalanche hazard evaluation. Phone sponsors include the USFS in Denver, Aspen and Minturn; the Mountain Shop in Ft. Collins; the Mountain Chalet in Colorado Springs; Pine Needle Mountaineering in Durango and the Summit County Rescue Group in Summit County.

This winter a total of 76,724 calls was placed to the hotlines (see Figure 2 and the table below). This total was significantly below last year because of mechanical failure, electronic mail, and increased visits to our web site. The counters attached to the Aspen and Vail hotlines failed, so we have no counts at all from these sites. Additionally, the counter on the Durango hotline, beginning in January, would stick on 1,999 so that we lost count above this number every month, and historically this hotline receives far more than 2,000 calls a month. Thus we have no accurate count of total calls this season.

Location	Phone #	Number of calls
Denver	303-275-5360	29,436
Ft. Collins	970-482-0457	5,379
Colo. Springs	719-520-0020	8,386
Summit County	970-668-0600	20,810
Durango	970-247-8187	12,713
Aspen	970-827-5687	N/A
Vail	970-920-1664	N/A

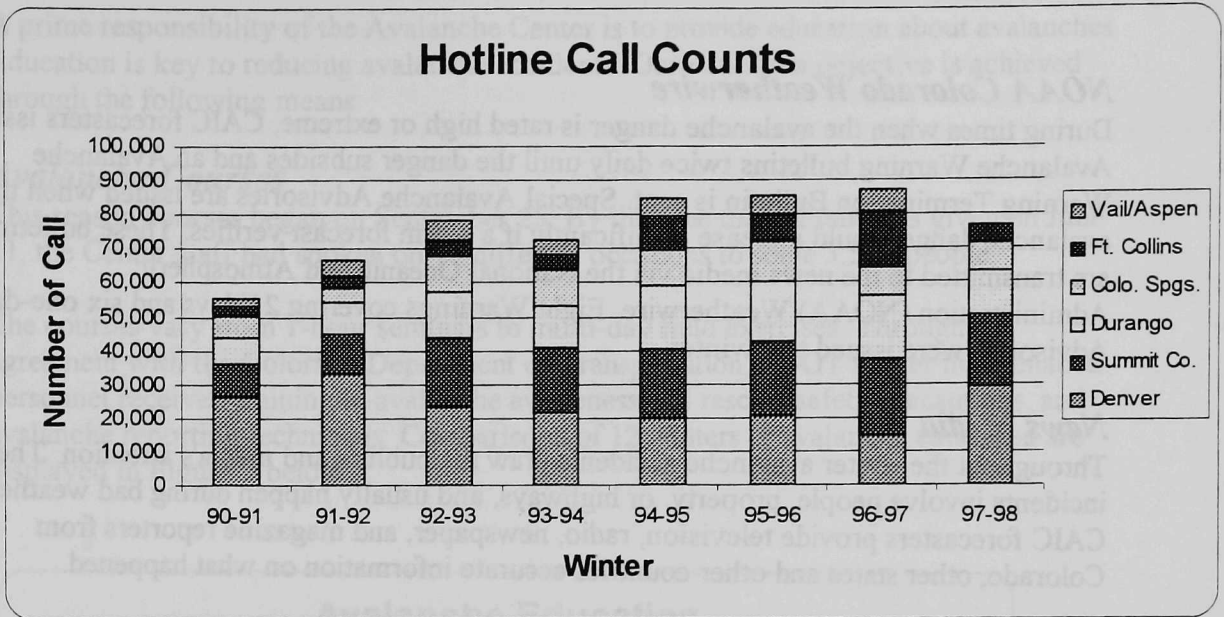


Figure 2. Hotline Use

E-mail to “Friends,” Observers and Forecasters

Our grassroots support organization, “Friends of the CAIC,” is comprised of some 518 members. For a contribution of \$25 or more, “Friends” with e-mail receive a daily mountain weather forecast and snowpack evaluation. CAIC observers and highway forecasters also get the forecast via e-mail. About 30,000 forecasts were sent to Friends. We have found this to be an effective and efficient way to distribute CAIC’s regular updates. “Friends” also use e-mail to communicate address changes, make suggestions, and report avalanche occurrences and accident information to the CAIC.

Web Site

The Center’s own web site (www.caic.state.co.us) consists of 12 different pages with a text information, pictures, and links that can be used by backcountry travelers, students and snow workers. The most popular page is the daily-forecast page; it received 53,371 contacts by the end of May.

Radio Broadcasts

The Avalanche Center continues to enjoy a large listening audience through dedicated radio stations in mountain communities. This is especially beneficial to regions where long distance telephone calls to an avalanche hotline would be inconvenient and costly. While some stations broadcast our message daily, others have been most helpful by broadcasting Avalanche Warnings and Special Avalanche Advisories when necessary. Some stations conveying these bulletins include public radio KVNF-FM in Paonia, KOTO in Telluride, KVMT in Vail, KFMU in Steamboat, and KYSL-FM in Frisco.

Dissemination of Forecasts

NOAA Colorado Weatherwire

During times when the avalanche danger is rated high or extreme, CAIC forecasters issue Avalanche Warning bulletins twice daily until the danger subsides and an Avalanche Warning Termination Bulletin is sent. Special Avalanche Advisories are issued when the avalanche danger could increase significantly if a storm forecast verifies. These bulletins are transmitted to the news media via the National Oceanic and Atmospheric Administration (NOAA) Weatherwire. Eight Warnings covering 21 days and six one-day Advisories were issued this winter.

News Media

Throughout the winter avalanche accidents draw the public's and media's attention. These incidents involve people, property, or highways, and usually happen during bad weather. CAIC forecasters provide television, radio, newspaper, and magazine reporters from Colorado, other states and other countries accurate information on what happened.

This winter Colorado saw a weaker (more typical) snowpack and more accidents than the previous season. There were 215 media calls to the Center in 1997-98, an increase of 43% from 1996-97.

A prime responsibility of the Avalanche Center is to provide education about avalanches. Education is key to reducing avalanche accidents. Our education objective is achieved through the following means:

Avalanche Courses

This season courses began on September 25. By the time the last talk was given on June 11, the Center staff had spoken on 79 different occasions to some 3,505 people.

The courses vary from 1-hour seminars to multi-day field exercises. Through our agreement with the Colorado Department of Transportation, CDOT winter maintenance personnel received training in avalanche awareness and rescue, safety precautions, and avalanche reporting techniques. Comparisons of 12 winters of avalanche education are displayed in Figure 3 below.

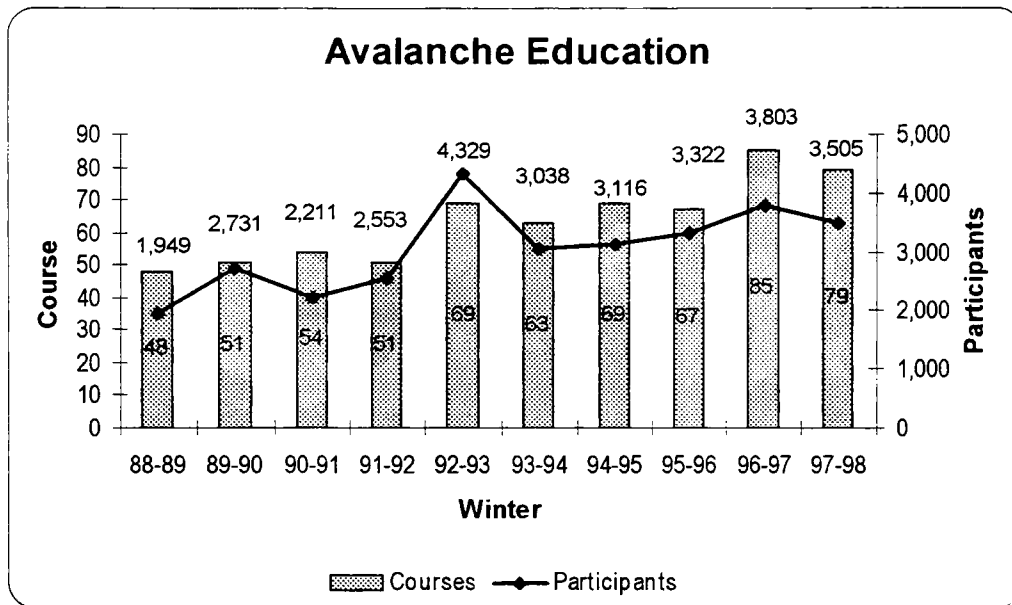


Figure 3. Avalanche Courses and Participants.

Table 6 lists all courses taught in 1997-98. The scope and content varied from a 1-hour overview to 2- or 3-day courses covering mountain meteorology, avalanche terrain recognition, the Colorado snowpack, methods of safe winter travel, and survival and rescue techniques. The students included backcountry enthusiasts, professional ski patrollers, search & rescue volunteers, law enforcement officers, and members of ski and snowmobile clubs, the Colorado Mountain Club, USFS, and CDOT.

To teach these courses, CAIC forecasters invested 452 hours in teaching, 79 hours in preparation, and 160 hours driving to the sites of the courses.

Public Education

Avalanche Cards and Brochures

The Colorado Avalanche Information Center distributes wallet-size avalanche cards with the hotline numbers and brochures explaining the "what's, where's, and why's" of avalanches. We distribute these at lectures and seminars, and include them in return letters of correspondence with the public.

Avalanche Rescue Videos

Two avalanche rescue training videos produced by the Center continue to be well received and widely distributed across North America. *Avalanche Rescue Beacons: A Race Against Time* (1995) demonstrates the proper use of rescue beacons and small-party avalanche rescue for groups in the backcountry equipped with and without beacons. *Avalanche Rescue: Not a Second to Waste* (1992) is geared toward search and rescue teams who conduct organized avalanche search and rescue missions.

Avalanche Slide Sets

For the 11th winter the Center has made available slide-sets of avalanche accident statistics in the U.S. Updated every two years these high-quality visual aids to enhance talks and seminars and have been used by avalanche educators throughout the U.S.

Forecaster for a Day

The Center offered to its field observers the opportunity to spend a full 10-hour day at the Center. They logged field data, studied weather maps and satellite photos, made the decisions necessary for a daily weather and avalanche hazard forecast, wrote the forecast, and read it into the hotlines. The intent was to give field observers the experience of actually being the forecaster. Seven people accepted the challenge and became a "forecaster for a day."

Publications

Center personnel worked on several projects for publication this year: Knox Williams and Nick Logan co-authored an article about the CAIC in *The Avalanche Review*—a publication of the American Association of Avalanche Professionals. Dale Atkins also had article in *The Avalanche Review* and in *Backcountry Magazine*.

Web Site

The Center's web page (www.caic.state.co.us) provides avalanche and mountain weather information useful to the novice to the expert. In addition to the popular daily forecast page internet surfers can get information, pictures and graphics on all sorts of avalanche and weather related topics. Dale Atkins is the creator of the CAIC web site.

Conferences

Dale Atkins presented information at several conferences including the International Alpine Rescue Commission (IKAR) annual meeting in Italy. At the Wilderness Medical Society's annual winter meeting at Snowbird, Utah, he lectured on avalanches and conducted a avalanche beacon workshop.

Public Education

Table 6. Avalanche Talks and Seminars, 1997-98

Date	Personnel	Group	Participants
9/25	D. Atkins	IKAR, St. Vincent, Italy	36
10/15	D. Atkins	Colorado Mountain Club, Golden	88
10/21	D. Atkins	Mountain Miser, Englewood	87
10/23	DA, NL, LM	CDOT, Hidden Valley	32
10/29	D. Atkins	Alpine Rescue Team, Evergreen	18
11/2-6	KW, NL, DA	National Avalanche School, Incline Village, NV	250
11/3	M. Mueller	CDOT, Wolf Creek West	6
11/12	N. Logan	Buena Vista Snowmobile Club, Buena Vista	85
11/12	S. Toepfer	Patagonia, Denver	15
11/13	DA, LM, CF	CDOT, Hidden Valley	27
11/14	S. Toepfer	Alpineer, Crested Butte	220
11/14	N. Logan, D. Atkins	Colorado Geological Survey, Denver	16
11/15	D. Atkins	Colorado Mountain Club, Golden	32
11/17	S. Toepfer	Vail Nordic Ski School, Vail	24
11/17	S. Toepfer	Eagle Co. Awareness, Vail	150
11/18	D. Lewis	Columbine Middle School	40
11/18-19	S. Toepfer	Breckenridge Outdoor Education Ctr., Francies Cabin	20
11/19	D. Atkins	Alpine Rescue Team, Evergreen	12
11/20	N. Logan	Summit County Awareness, Breckenridge	160
11/23	D. Atkins	Backcountry Skiers Alliance, Francies Cabin	9
11/25	S. Toepfer	REI, Denver	30
12/1	A. Gleason, D. Lewis	CDOT, Silverton	25
12/2	K. Williams	The Mountain Shop, Ft. Collins	60
12/2	D. Atkins	Snowcraft Industries, Littleton	12
12/2	N. Logan	Colorado Mountain College, Summit High School	26
12/3	S. Toepfer	Mountain Sports, Boulder	30
12/3	N. Logan	The Mountain Chalet, Colorado Springs	100
12/4	D. Atkins	Keystone Ski Patrol, Keystone	24
12/6	D. Atkins	Summit County Rescue School-Advanced, Summit Co.	30
12/6-7	N. Logan, S. Toepfer	Summit County Rescue School-Basic, Summit Co.	130
12/9	DA, LM, CF	CDOT, Hidden Valley	34
12/9	M. Mueller	Public Awareness, Pagosa Springs	24
12/10	A. Gleason	Ouray School, Ouray	15
12/10-11	S. Toepfer	Keystone Science School, Keystone	20
12/11	D. Atkins	Colorado Outward Bound, Leadville	17
12/12	K. Williams	Newt Wheatley Memorial, Vail	6
12/13	A. Gleason	San Juan Co. Search & Rescue, Silverton	55
12/16-17	N. Logan, S. Toepfer	Summit County Professional Course, Breckenridge	50
12/17	D. Atkins	Alpine Rescue Team, Evergreen	32
12/20	N. Logan, D. Atkins	Colorado Mtn. Club Instructor Clinic, Jones Pass	14
1/5, 7 & 10	KW, DA, ST, NL	Colorado Mountain Club, Golden & Jones Pass	40
1/6	S. Toepfer	Snowmobile club, Woodland Park	80
1/9	A. Gleason	Prescott College, Silverton	8
1/9-11	S. Toepfer	Telluride Avalanche School, Telluride	60
1/13	N. Logan	Breckenridge Ski Patrol, Breckenridge	25

Public Education

Table 6. continued...

Date	Personnel	Group	Participants
1/14	D. Atkins	Neptune Mountaineering, Boulder	42
1/14	K. Williams	Newt Wheatley Memorial, Vail	20
1/14 & 17	D. Atkins	Tenth Mountain Hut Association	12
1/15 & 17	S. Toepfer	Bent Gate Shop, Golden	15
1/16	M. Mueller	CDOT/Pagosa Springs	16
1/16-17	N. Logan	Mountain Rescue Aspen, Aspen	125
1/21 & 24	K. Williams	The Mountain Shop, Ft. Collins	28
1/23-25	AG, DL, ST	Silverton Avalanche School-Level 1, Silverton	80
1/27	K. Williams	Weathercasters Summit, Steamboat	25
1/30-31	A. Gleason, D. Lewis	Silverton Avalanche School-Level 1, Silverton	84
1/30 - 2/1	S. Toepfer	Hidden Treasure Yurt, Eagle	8
2/3	M. Mueller	CDOT/La Manga Camp	9
2/3, 5 & 8	KW, DA, ST, NL	Colorado Mountain Club, Golden & Jones Pass	40
2/6-7	N. Logan	The Ski Haus, Steamboat & Rabbit Ears Pass	80
2/6-8	A. Gleason, D. Lewis	Silverton Avalanche School-Level 2, Silverton	54
2/9	K. Williams	Pueblo Snowmobile Club, Pueblo	30
2/18	M. Mueller	CDOT/Monarch Pass	13
2/14-15	S. Toepfer	Newt Wheatley Memorial, Vail	15
2/19	A. Gleason, D. Lewis	CDOT Rescue Training, Silverton	6
2/20-21	K. Williams, D. Atkins	Colo. Sch. of Mines-Outdoor Rec., Golden & Jones Pass	17
2/20-21	S. Toepfer	Babes in the Backcountry, Francies Cabin	20
2/21	A. Gleason	Home School Group, Silverton	27
3/4	N. Logan	Breckenridge Elementary School, Breckenridge	35
3/4-6	S. Toepfer	Hidden Treasure Yurt, Eagle	10
3/6	D. Atkins	Eldora Mountain Ski Patrol, Eldora	12
3/9, 11 & 14	DA, KW, NL	Colorado Mountain Club, Golden & Jones Pass	48
3/14	A. Gleason	San Juan Co. Search & Rescue, Monticello, UT	25
3/19	D. Atkins	Loveland Ski Patrol (NSP), Denver	54
3/21	D. Atkins	Colorado Mountain Club, Golden	38
4/7-8	S. Toepfer	Pikes Peak Alpine School, Pikes Peak	11
4/23	S. Toepfer	Women's Backcountry Aval Course, Francies Cabin	17
4/27	D. Atkins	Colorado Mountain Club, Golden	40
6/11	D. Atkins	Rocky Mtn. Wilderness Medical Conference, Estes Park	175
		79 Courses	Total 3,505

Forecasting for Highways

Six CAIC avalanche forecasters work closely with the Colorado Department of Transportation (CDOT). Based in Silverton, Pagosa Springs, Marble and the Eisenhower Tunnel, they prepare daily stability evaluations and provide recommendations for avalanche reduction and road closures. In 1992, Silverton was chosen for the location of the first CAIC-CDOT avalanche forecast office. Following a successful trial run under heavy winter conditions, the Statewide Avalanche Reduction Plan officially took effect on October 1, 1993. CDOT provides the funds necessary to operate this program.

CDOT / Silverton Avalanche Program

The Silverton Forecast Office has completed its sixth winter monitoring and forecasting avalanches for some 97 slide paths along the US Highway 550 corridor from Coal Bank Pass north to Ouray. Additionally, this office is responsible for avalanche forecasts along Colorado 145, Lizard Head Pass. Colorado 110 (Silverton to Gladstone) is also inspected for avalanche activity and snowfall accumulations.

The forecasters work closely with plow drivers who contribute valuable storm data and slide observations to help formulate the forecasts. Training, including procedures for avalanche rescue and personal safety, is provided to CDOT workers and others. This winter Lead Forecaster Andy Gleason and Doug Lewis prepared daily evaluations to keep CDOT apprised of avalanche conditions in their region.

Weather summary

November opened with mild temperatures and little snow cover except at the highest elevations. A 5-day storm that began on the 9th dropped 21 inches of snow on Red Mountain Pass. But this was followed by mild days and cold nights. Depth hoar developed throughout the snowpack and a heavy, wet snowfall at the end of the month resulted in a number of natural avalanches at the higher elevations. Only a few small events reached the highway. The now faceted snowpack set the stage for avalanche activity in the coming months.

With the exception a few storms, December, January and February were dominated by either high pressure or a split flow. Snowfall was light and overall precipitation was below normal. Winds, however, were strong. Snow in many of the avalanche starting zones was redistributed to locations lower in the tracks and this is where some avalanches started. Many slides were brought down with explosives but fewer than half reached the highway. The shallow snowpack, combined with mild temperatures, allowed many of the south-facing paths to melt out almost completely between the meager snow cycles. Snow on shady aspects continued to weaken and even much of the wind slab had faceted. A storm on February 23-25 began with light, 5% snowfall which got heavier with time. This formed a persistent weak layer that lasted well into March. While there was little natural avalanche activity, control work released large slides that deposited up to 10 feet of debris on the road in some locations.

The first week of March opened with a major storm that deposited 20-30 inches of snow in a 48-hour period. This was followed by a significant warming trend that lasted until the

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25th. On the 26th, the biggest storm of the season moved in and brought up to 35 inches of fresh snow in 4 days. After a brief lull, the last significant snow-producer of the winter came on March 31 to April 3 with up to 18 inches of fresh snow. These last three storms brought the snow water equivalent from well below normal to near normal by the end of April.

Snowfall was measured at Coal Bank Pass, Molas Pass, Red Mountain Pass, Monument (East Riverside), Lizard Head Pass, and Gladstone sites. Soil Conservation Service (SCS) Snotel sites along the corridors were also accessed for data. The following is a record of this winter's snowfall and water equivalent (in inches) along US Highway 550.

Station	Nov	Dec	Jan	Feb	Mar	Apr	Total
Coal Bank	54 / 4.9	32 / 2.6	47 / 4.5	50 / 4.5	85 / 8.9	34 / 3.2	300 / 28.5
Molas	38 / 2.5	29 / 2.6	40 / 3.3	43 / 3.5	70 / 7.6	19 / 2.1	238 / 21.5
RMP	52 / 5.8	26 / 1.9	57 / 4.5	45 / 3.8	63 / 7.1	47 / 5.2	288 / 28.3

Remote weather stations located on Red Mountain #3 (above Red Mountain Pass at 12,890'), on Mt. Abrams north of Red Mountain Pass, and near the summit of Lizard Head Pass measured wind, temperature and relative humidity. These weather stations are invaluable to avalanche forecasting, especially during storm periods and when roads are closed with no access to the snow study plots.

Snowpack and avalanche summary

With little snowfall early-season, a basal layer of depth hoar persisted on all aspects in the San Juan Mountains. During periods of large diurnal temperature fluctuations, the entire snowpack became faceted. The developing near-surface facets merged with the depth hoar about mid-pack. This created a snowpack that in itself was not dangerous but it was a very unstable foundation for subsequent snows. These conditions persisted into February and an interesting avalanche resulted. On February 11, a large and rare loose-snow avalanche released on the Twin Bridges path. It ran 400 vertical feet and spread to 200 feet wide at the bottom. It did not reach the road.

With the snowpack composed mostly of depth hoar, the first major storm of the season on March 5 resulted in widespread avalanche activity. A warm period in mid-March produced a wet-snow cycle and by the end of the month the largest storm of the winter produced many class-4 and some class-5 (largest for that particular path) avalanches. The Ophir Road avalanche path deposited more snow on the road than had ever been recorded—18 feet deep for 100 feet along the road. Avalanche debris in the Uncompahgre Gorge from the East Riverside path was deeper than any CDOT employee had ever seen. It reached above the snowshed and bulldozers had to push snow away from the shed in case more slides came down.

Road closures

Some 220 avalanches reached highways in the San Juan Mountains this winter. Red Mountain Pass was closed for a total of 100.75 hours this winter due to avalanches and some 4,955 feet of centerline was covered. Molas and Coal Bank passes were closed a

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total of 18 hours. Colorado 110 to Gladstone was closed for 18 hours and a total of 230 feet of that roadway was buried by debris. On US 145 over Lizard Head Pass, only 80 linear feet of road was buried from avalanches this winter.

Accidents

Diligent forecasting and avalanche control work kept the highways safe in the southwest mountains this winter. Although more than 200 slides reached roads, no avalanche accidents occurred on the highways.

Research/Internship

Once again, the Silverton Avalanche Forecast Office had the benefit of an intern. Mark Fisher, a senior at Western State College in Gunnison was a valuable asset to the program. He helped by gathering snowpit data and assisting the forecasters with remote snowpit data collection. He also completed a project that compared the use of a compression stuff sack with a normal stuff sack for use with the "stuff block stability test." The internship program will continue as it benefits the avalanche forecasting operation.

CDOT / Eisenhower Tunnel Avalanche Program

This was the fifth winter of operation for the avalanche forecasters in CDOT Region I. Lead Forecaster Lee Metzger and Cathy Fraser staffed the forecast office this winter, located in the Road Control/Engineers building on the west side of the Eisenhower Tunnel. The forecasters provided daily avalanche evaluations and recommendations for avalanche control or road closures when necessary. The areas of operation for this office includes US 40, Berthoud Pass; US 6, Loveland Pass; and I-70 from Silverplume to Vail. The forecasters also monitor conditions on Colorado 82 over Independence Pass and Colorado 14 over Cameron Pass.

An avalanche forecast is made each day and distributed to CDOT maintenance shops and offices. It provides information on the avalanche potential affecting the highways and also includes a summary of the weather forecast and recommendations for avalanche reduction or road closures. These are based on data from two remote weather stations, and from five snow study plots located on Berthoud, Loveland and Vail passes. Other input comes from the Avalanche Center, local ski areas and plow drivers.

Pertinent avalanche training is given to CDOT personnel. It focus on avalanche characteristics, case histories, problem solving scenarios, the CDOT Avalanche Rescue Plan and hands-on training with rescue equipment. Trained highway maintenance personnel provide useful information to the forecasters.

Weather summary

Snowfall, wind and temperatures were very close to the long term average. Monthly snowfall amounts were slightly below normal except for December. On Berthoud Pass, only 5 winters have been drier in 45 years of keeping records there. For much of the winter only weak weather systems made it into Colorado. High pressure and split flow

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did their best to shunt the storms around us, or weaken them significantly before they got here. The only storm of consequence came January 16-17 when the storm board at the tunnel recorded 7 and 15 inches respectively.

Well-placed snow study plots are used to measure cumulative snowfall, storm totals, 24-hour accumulation and snow water content. Most sites are checked daily, others periodically and during storms. The following are snowfall data (in inches) for each site this winter.

Study Plot Location	Nov	Dec	Jan	Feb	Mar	Apr	Total
Berthoud Pass, Q-12	38	27	48	35	24	32	204
Eisenhower Tunnel	38	16	47	45	30	27	203
Loveland Pass east	43	20	52	31	38	25	209
Loveland Pass west	35	18	54	36	32	25	200
Vail Pass	46	14	48	33	36	14	191
Narrows	28	11	45	36	36	10	166

Snowpack and avalanche summary

This winter's snowpack was shallow and weak for most of the season. Depth hoar developed in the fall and contributed greatly to the avalanche problem. Strong winds drifting snow into the avalanche starting zones soon became a problem.

The avalanche season started early. At the end of October there was little snow on the ground but winds gusting over 100 mph deposited enough snow in the Seven Sisters avalanche paths to produce avalanches to the road. On the 31st, Sister #3 released naturally and covered the highway. While the forecasters were in the process of closing the road and clearing traffic, a second slide released in the same path and struck a passing vehicle. It broke out the windows and filled the car with snow, but there were no serious injuries.

Fortunately, many of the larger paths ran early in the winter and cleaned out the weak snow layers near the ground. With no major storms, control work regularly kept the starting zones cleaned out. When avalanche debris did make it to the road it was easy to clear away.

There was one exception. The storm on Martin Luther King weekend produced enough snow and avalanche activity to close Berthoud and Loveland passes, and I-70 from Georgetown to Vail. Traffic was thick and the weather foul. The Stanley avalanche path on Berthoud Pass ran naturally and covered the road. One car slammed into the debris and got stuck. On the west side of the pass, several cars were hit by small bank slides and pushed against the guardrail while other cars ran into the debris. Cathy Fraser and some 75 people were stranded in the lodge at the Berthoud Pass ski area overnight. On I-70, one large bank slide on the west side of the tunnel ran to the highway and two cars plowed into it. In spite of all this activity there were no injuries or damage.

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The table below shows the number of road closures and amount of time the passes were closed this winter. The loop road over the west portal of the Eisenhower Tunnel connects the east- and west-bound lanes. It also provides access to the Road Control building where the forecast office is located.

Highway	Number of Closures	Total Time
US 40, Berthoud Pass	16	33
US 6, Loveland Pass	24	107
I-70 corridor & Vail Pass	11	19
Loop Road	4	18

CDOT / Pagosa Springs Avalanche Program

The Pagosa Springs Forecast Office, located in the CDOT maintenance barn and staffed by Mark Mueller, completed its fifth winter of operation this spring. In the avalanche business it is thought that it takes 5 years experience to know an avalanche area, so this is somewhat of an occasion. Avalanche advisories were issued from November 17 to April 27. The forecast region includes US Highway 160, Wolf Creek Pass; US 50, Monarch Pass; and Colorado 17, Cumbres and La Manga passes.

Weather summary

In mid summer, meteorologists began to warn us of an impending strong El Niño and a potential severe winter. By researching our own weather records in relation to El Niño, it was likely we would have near-normal snowfall in the southern mountains. That is what we received. Forecasters were also correct in forecasting a more favorable upper air flow for the second half of the winter. The maximum snow depth at Wolf Creek Pass reached 89" on March 29.

In addition to measuring new snow depth, a sample is weighed to determine its water content. This tells the forecaster how much actual weight (and increased stress) has been added to the snowpack. The nearby Snotel site at the top of the pass showed precipitation to be 98% of normal. Snowfall and precipitation (in inches) are summarized below for the 10,880-foot pass.

Nov	Dec	Jan	Feb	Mar	Apr	Total
59 / 7.5	43 / 3.7	31 / 4.0	45 / 4.0	82 / 12	42 / 4.6	302 / 36.6

Avalanche summary

Avalanche activity was very limited this winter. By the time significant snow fell in the second half of February, the snowpack had strengthened considerably, especially in the tracks below the avalanche starting zones. Several avalanches released that had crown fractures almost ten feet deep. The snow, however, stopped half way down the path. Sixty-six avalanches were observed along Wolf Creek Pass this year. Thirty-six ran naturally and 30 were triggered with explosives.

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The following table shows the number of avalanches that crossed the highway on Wolf Creek, Monarch, Cumbres and La Manga passes.

Highway	Natural	Triggered	Length of centerline covered
Wolf Creek Pass	1	1	50'
Monarch Pass	2	8	800'
Cumbres/La Manga	2	0	none

The west side of Wolf Creek Pass was closed for a total of 30 hours for avalanche control work and Howitzer targeting. Access to the Wolf Creek Ski Area from the east was unimpaired by avalanches but was closed on the morning of March 29 because of the increasing avalanche danger on the west side of the pass.

Monarch Pass also had traffic delays, three times for avalanche control work and once due to wet slides at Quarry View and Big Slide. Colorado 17 over Cumbres and La Manga passes was closed one time for avalanche control work.

Despite normal snowfall, this winter will be remembered for the lack of avalanche activity that affected the highways. The addition of the 105 mm Howitzer to the avalanche control program made for significant improvements in the timeliness of control efforts. Excellent training of the gun crews made this weapon an immediate and effective part of the control program.

After 5 years of forecasting, the forecaster has made several observations about the nature of storms and avalanches on Wolf Creek Pass: 1) The amount of new snow or precipitation is not a good indicator of potential avalanche activity. 2) The predominant type of avalanche affecting the pass is a slab avalanche that contains old snow layers. 3) Avalanches caused by wind transport alone are isolated. 4) Large, wet snow avalanches are rare. 5) While some storms will produce avalanches, the magnitude of the activity will be determined by snowpack factors.

CDOT / Western Slope Avalanche Program

This marked the fourth winter of operation for the Western Slope Avalanche Forecast Office which was the fourth CAIC branch office established to forecast for mountain highways. This office, staffed by Rob Hunker, was moved last fall from Marble to Carbondale for efficiency and convenience. Avalanche forecasting is provided to CDOT Region III, Maintenance Section 2. The forecast is disseminated to 17 stations within the CDOT/CAIC organization. A total of 50 avalanche hazard advisories were issued from October 25 to April 29.

Colorado 133 over McClure Pass near Marble is the primary area of responsibility in this forecast region. This two-lane pass is a vital link for commuters between Paonia and the Carbondale/Aspen areas. All of the avalanche danger lies on the east side of the pass with some 20 paths in less than 2 miles. This area is unique in two ways. First, its lower

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elevation well below timberline has overall warmer weather with associated affects on the snowpack, including occasional rain. And second, portions of the Chair Mountain subdivision lie in the runout zones of the two largest avalanche paths in the group. This precludes most artificial avalanche reduction efforts.

The forecaster closely monitors avalanche potential on Colorado 139, Douglas Pass; Colorado 65 on Grand Mesa; Colorado 82 at Snowmass Canyon and the Shale Bluffs area near Aspen. Other areas include Colorado 65, on Grand Mesa and Colorado 24 at Battle Mountain over Tennessee Pass.

Snow study plots are maintained along each highway and a remote weather station is situated at the top of Lone Tree Bowl which threatens McClure Pass. Subdivision homeowners below the bowl provide housing and electricity for the base station that is linked via radio telemetry to the sensors near the rim of the bowl. CDOT Weather Scans also provided data to collectively help determine the avalanche potential above the highways.

Weather Summary

From a statistical standpoint, the winter of 1997-98 was an average year. Precipitation, air temperature and winds were about normal for the season.

Snowfall on McClure Pass during October and November was 155% of average. A split flow was the dominate weather pattern for the month of December which routed storms around Colorado and resulted in dry conditions. In January and February, consistent but light snow fell with no extremes in temperatures, winds or precipitation. Additionally, there was not a significant rain event on McClure Pass this season which sometimes occurs. Total precipitation recorded at the SNOTEL weather station near the summit of the pass was consistently just above average while surrounding stations were well below average for most of the winter. March and April were snowy and the two major storms this winter came during the first and last weeks in March. Total precipitation at the end of April was 140% of average. The following table shows a breakdown of monthly snowfall totals on McClure Pass.

Nov	Dec	Jan	Feb	Mar	Apr	Total
44"	22"	65"	45.5"	75.5"	44"	296"

Snowpack and avalanche summary

Early-season snowfall, cool air temperatures and a dry December combined to create a typical Colorado snowpack with faceted grains in the basal layers. By the end of December, snowpack strength was largely governed by elevation and temperature inversion. The shallow snowpack at Battle Mountain was the weakest in the region, followed by Douglas Pass and the McClure Banks. At mid elevations, around 10,000 feet, the snowpack at McClure Bowls and Grand Mesa was gaining strength, but its strength was still marginal. On December 9, Colorado 65 on Grand Mesa was closed for explosive control work. The mission was successful with several class-2 avalanches that covered the highway.

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In January and February the snowpack was prime to produce full-depth avalanches throughout the region with the next major storm. But that storm didn't come and large avalanches didn't run. However, three natural avalanches did hit the road at Battle Mountain on January 17 which closed the road until plows could remove the debris. Grand Mesa was closed twice, February 9 and 26, for control work. Small avalanches crossed the road each time. On February 10, three class-2, wet-loose slides ran to the edge of the road on Battle Mountain. During the first week in February the snowpack on McClure Pass gained considerable strength from equilibrium metamorphism—a process that continued for the rest of the season. This was the most stable snowpack this area had seen in 4 years. It contained no significant weak layers to cause shear failure and depth hoar was not extensive at these lower elevations.

During March and April the McClure Pass and Grand Mesa snowpacks continued to gain strength. Maximum snow depths reached 92 inches at Grand Mesa on April 17th, and 79 inches at McClure on the 18th. Bonding in the lower snowpack had progressed well and any new snow stuck well to the old snow surface. Only two small, wet-loose slides ran to the centerline on McClure Pass during a wet cycle March 24 and 25. Grand Mesa was closed on March 19 for a control mission that produced small slides across the road. One small, wet avalanche ran to the edge of Colorado 24, Battle Mountain, on March 26. Grand Mesa was closed on April 3 for control work which was the last road closure for the season for all highways in the region.

A summary of road closures and avalanches reaching the roads is shown below.

Highway	Natural Avalanches	Triggered Avalanches	Road Closures
Colo. 133, McClure Pass	2	0	none
Colo. 65, Grand Mesa	5	45	5
Colo. 139, Douglas Pass	0	0	none
Colo. 24, Battle Mountain	3	0	1