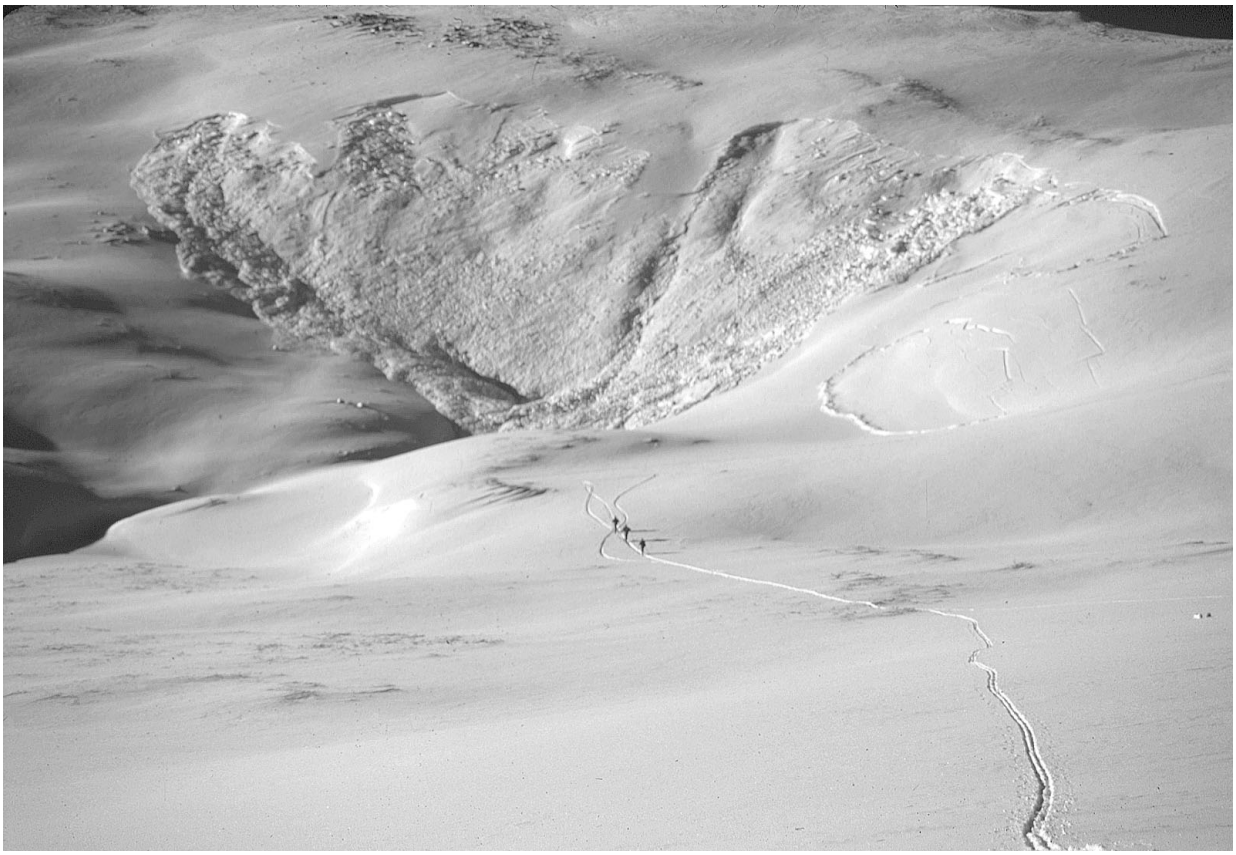
Snow and Avalanche

Colorado Avalanche Information Center

INFORMATION SERIES 56

Annual Report 1999–2000



Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado
2000

Cover: A large natural hard-slab avalanche on December 23, 1999, in Stafford Gulch on Elk Mountain near Vail Pass. The avalanche ran on the ice crust that formed on November 26 and is discussed in this report. The skiers were not involved in the avalanche. Photo by Scott Toepfer.

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DOI: https://doi.org/10.58783/cgs.is56.khbx4955

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Foreword

CGS Information Series 56 is the Annual Report of the Colorado Avalanche Information Center for the winter of 1999–2000. It describes the operations of the CAIC and the important events of the winter season.

Partial funding for this report came from the Colorado Severance Tax Operations Fund. Severance taxes are derived from the production of gas, oil, coal, and minerals.

Knox Williams
Director of the Colorado Avalanche Information Center

Vicki Cowart
State Geologist and Director

Director's Report

To our sponsors and patrons:

The fiscal year just past (1999–2000) marked not only a new millennium but also a new era for the Colorado Avalanche Information Center. Call it the era of Severance Tax Funding, and it is historic, for it represents the first direct State funding for the Avalanche Center in its 17 years as a state program.

Severance tax is paid by the producers of gas, oil, coal and some minerals, and goes into an operational account to be used for (among other things) the legislative charge of mitigating geologic hazards, which includes avalanche hazards. The Minerals, Energy, and Geology Policy Advisory Board (MEGA Board) has oversight responsibility of the fund and recommended the CAIC's proposal, which was then approved by the Colorado General Assembly.

The additional funding amounted to $116,000. The funds will help in four basic areas: (1) forecasting, (2) education/outreach, (3) data management, and (4) program management. See the section of this report entitled Severance Tax Projects for full details.

Clearly, severance tax funding cannot be our sole source of revenue. We must continue to maintain and increase funding from more traditional sources so as to maintain the stability and viability and important partnerships that sustain the Avalanche Center. But this much is certain: Severance tax funding will greatly help us reach our forecasting and educational goals, and we thank Colorado's extractive resource industry and the MEGA Board for making this happen.

Changing subjects, I want to highlight an important publication that we produced this year. It is *Avalanche Wise: Your Guide to Avalanche Safety in Colorado* (CGS Special Publication 48). It is an attractive, full-color, 24-page booklet of basic avalanche safety. Funding for this booklet was provided by the family of Ethan Morris Gell, a ski patroller at Beaver Creek who tragically died far too young of a congenital heart defect. This year we distributed several thousand copies at our avalanche awareness talks and through the CGS publications group. *Avalanche Wise* will be a staple publication for years to come.

The CAIC has completed its seventeenth year of operation, and we continue 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, Halsted Morris, and Jerry Roberts—thank you all. It's a pleasure to work with you.

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 funded by Severance Tax and cash-funded by grants and donations. In FY 99-00, total revenues were $519,554.

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

Staff: Total staff was 11. Four forecasters shared the duties of a 7-day work week during the winter season at the main office in Boulder. Two forecasters were the Silverton office, two at the Eisenhower Tunnel, one at Pagosa Springs, and one at Carbondale; they provided specific training and forecasting for CDOT. One staff member, under contract, taught classes as part of the outreach program.

Avalanche events of 1999–2000: Winter had a hard time getting started and brought minimal snowfall until mid-December. Snow in January, February, and March was above normal for almost all mountain areas, and avalanche activity was near-normal during these months. The mountain snowpack was shallower than normal almost all winter in the southern and central mountains. A total of 1,666 avalanches was reported to the Center (23 percent below the average of 2,160). There were few large storms, few extensive avalanche cycles, and no large destructive avalanches. Avalanche Warnings were posted on 22 days (10 below normal). There were eight avalanche deaths (two above normal), because with a shallow snow cover, it was easy for backcountry recreationists to trigger avalanches much of the winter. Property damage was nil.

Dissemination of forecasts via hotlines, Internet, e-mail, and radio broadcasts: The public made 65,927 calls to the CAIC hotlines this winter. In addition, we sent 98,000 forecasts via e-mail to Friends of the CAIC, and there were 192,000 hits on our web site forecast page. That is a total of about 356,000 send outs of our forecast messages. Finally, about 11 mountain radio stations broadcast our hotline messages daily.

Media contacts: As Colorado's spokes-agency for avalanche matters, we received or initiated 210 contacts with broadcast and print media.

Public education: We presented 79 avalanche seminars to 3,267 people. Additionally, we produced two educational publications, and we send an informational newsletter three times a year to Friends of the CAIC.

Funding and Budget

For FY 1999–2000, funding came from severance tax and from donations, grants, and contracts as listed below. Additionally, in-kind support is listed.

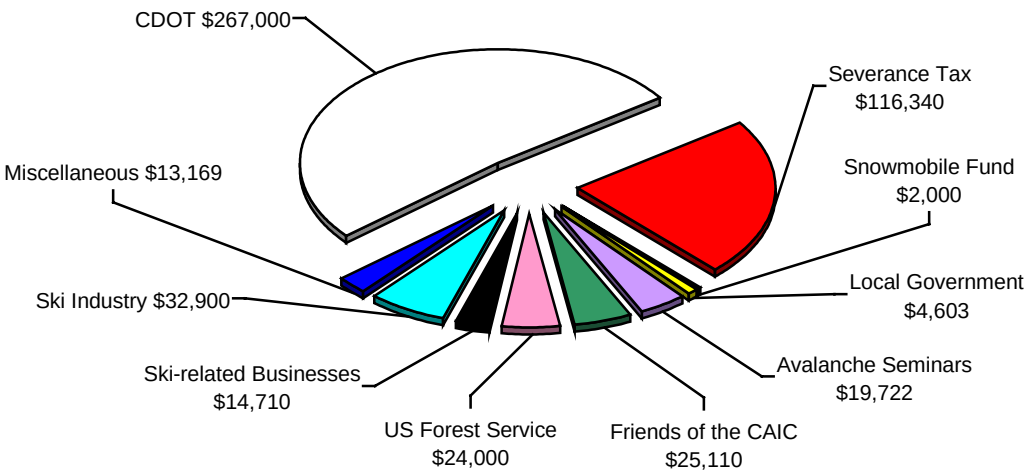
State	***$385,340***
CDOT contract for services	245,000
CDOT grant	22,000
Parks, Snowmobile Fund	2,000
Severance Tax Fund	116,340
Federal	***$24,000***
US Forest Service	24,000
Local Government	***$4,603***
Town of Breckenridge	2,000
Town of Frisco	1,000
Summit Co. District Court	978
Town of Dillon	500
Town of Vail	500
Town of Silverthorne	350
La Plata County	75
Ski Resorts	***$32,900***
Colorado Ski Country USA	20,000
Vail Associates	2,000
Breckenridge	2,000
Telluride	2,000
Winter Park	1,500
Steamboat	1,500
Arapahoe Basin	1,000
Copper Mountain	1,000
Keystone	1,000
Aspen Pro Patrol	500
Monarch	300
Berthoud Pass	100
Friends of the CAIC	***$25,110***
Avalanche Seminars	***$19,722***
National Avalanche Foundation	6,632
Colorado Mountain Club	2,625
Colorado Snowmobile Assoc.	1,557
Silverton Avalanche School	1,480
Summit County Rescue	1,000
Summit Huts	825
Steamboat Ski Haus	795
Mountain Rescue Aspen	700
Newt Wheatley Foundation	600
COR Adventures	600
Ft. Collins Mountain Shop	550
Steamboat Powder Cats	450
Colorado School of Mines	450
International Alpine School	350
Colorado Outward Bound School	300
Neptune Mountaineering	288
Vail Associates	150
Buena Vista Snowmobile Club	150
Loveland Basin	120
Mountain Miser	100
Ski-related Businesses	***$14,710***
Greg Craig (NOLS)	5,000
A Basin Enduro	1,828
Tenth Mountain Hut Association	1,550
Backcountry Access	1,500
People Productions	1,070
REI	1,000
Rescue Technology	1,000
Mountain Chalet	862
Rocky Mountain Rescue	500
Fort Lewis Outdoor Pursuits	400
Other Donors	***$13,169***
Koessler Foundation	5,000
Summit Foundation	3,437
Peter Jamieson	1,985
Justin Colonna Memorial Fund	1,000
Knorr House	800
Leslie Ross/Dam Brewery	496
Terry Bianchi/Daily Grind	451
Total Funding	***$519,554***
Estimated In-kind Support	$120,000
Colorado Geological Survey	30,000
National Weather Service	30,000
Field observations	30,000
CDOT	20,000
Hotline sponsors	10,000
Grand Total	***$639,554***

Friends of the CAIC

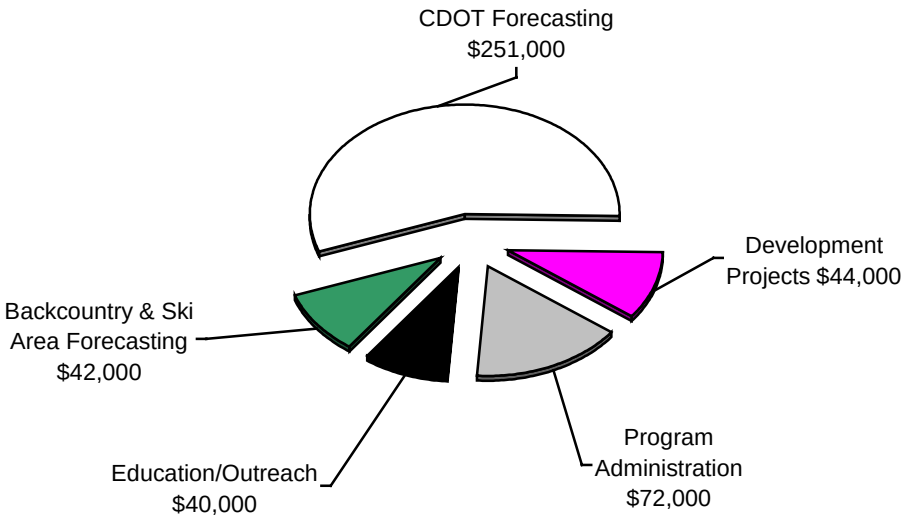
The number of *Friends* totaled 645 for 1999–2000. We thank each and every one for the grassroots support necessary to sustain the CAIC. We offered two levels of service, for $30 or $45, but many of our friends generously gave an extra donation amount. Below is a list of special friends that donated $100 or more.

Aspen Alpine Guides
Aaron Bork
John Champoux
David and April Christenson
Diana and Roy Conovitz
Doc and Ann Cornwall
Jackson Dennis
Norman “Doug” Douglas
Philippe Dunoyer
Al Evans
Sherry and Tim Gaines
Tom Hays
Richard Johnson
Lost Wonder Hut
Annyce Mayer
Kevin McCall
Halsted Morris
Kurt Morscher
Joe Puchek
Julie and George Rasmussen
Peter Rex
Tim Reinholtz
Laura and Steve Rossetter
San Juan Ski Company
Jane Storm
Randall Streufert
Cheryl Teuton
Paul Turner
Charles Ziskin

Where the Money Came From



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 cash-funded by grants and donations and from the Severance Tax Operational Fund.

Housing: The CAIC central office is with the National Weather Service in Boulder. 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 operational seven days a week and is staffed with 11 forecasters/educators. 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 mountain weather and avalanche risk information to the public, via recorded hotline messages and via the Internet and e-mail (see Section VII);
- warn of dangerous avalanche conditions by issuing Avalanche Warning Bulletins via the NOAA Colorado Weatherwire and news media (see Section VII);
- provide the Colorado Department of Transportation weather and snowpack data for reducing avalanche hazards along mountain highways (see Section IX);
- provide avalanche education through slide talks, seminars, videos, publications, and media contacts (see Section VIII);
- be the focal point and spokes-agency in state government for all avalanche matters;
- provide specialized forecasts and consulting to sponsoring agencies; and
- investigate all significant avalanche accidents (see Section VI).

Staffing and Duties at the Main Office: Personnel for the 1999–2000 season were Knox Williams (Director), Nick Logan (Associate Director), Dale Atkins, and Scott Toepfer. Collectively, this staff has more than 100 years of snow and avalanche experience. The Center was manned daily from 4:30 am to 3:30 pm, from opening day on November 6, 1999, until closing on April 30, 2000.

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; and
- handling special requests from sponsors/clients.

Highway Forecast Offices: The CAIC maintains four mountain offices to provide specific forecasting and training services to CDOT maintenance personnel. Section IX gives details of this program. These offices are operational from November 1 to April 30, with forecasting services available earlier or later as needed.

- **Silverton:** This office is staffed by forecasters Andy Gleason and Jerry Roberts, who coordinate the forecasting for the avalanche reduction program for CDOT along US 550 from Coal Bank Hill to Red Mountain Pass, Colorado 145 over Lizard Head Pass, and Colorado 110 along Cement Creek.
- **Pagosa Springs:** This office is staffed by forecaster Mark Mueller and provides forecasting for the avalanche reduction program along US 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 Stu Schaefer 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 observation sites for providing weather, snowpack, and avalanche data to the forecast office. Altogether there are about 35 manned sites, 20 of which are ski areas and the remainder are highway and backcountry sites. The Center has long supported a contract observer at Gothic, and this year began a network of back-country observers. 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. Section VIII details our efforts toward public education and safety.

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

Friends Association: The Center manages a grassroots support group called "Friends of the CAIC" which totaled 645 members in 1999–2000. For an annual donation of $30 or $45, the Friends receive three issues of The Beacon newsletter and receive the daily forecast via e-mail once or twice a day.

Weather and Avalanche Synopsis

As the winter of 1999–2000 approached, Colorado's avalanche and snow workers were cautiously optimistic for a snowy winter. A strong La Niña (El Niño's opposite twin that had formed in the Pacific in 1998–99) remained intact with its abnormally cold waters in the eastern tropical Pacific Ocean. La Niña winters bring a bias for storms coming from the northwest and tend to bring wetter conditions to the northern half of Colorado and drier conditions to the southern half, and warmer temperatures for the entire state.

Avalanche conditions depend on snowfall patterns in Colorado: not only where and how much snow falls, but also when it falls. (Snowfall patterns obviously affect the tourism and agriculture industries, too.) Experience from recent La Niña's showed a nasty split personality of drought and deluge. The winter of 1999–2000 was no different.

In its wake La Niña left behind a Colorado winter that snowfall and avalanche statistics would label it as an average to below-average winter; however, variability was the operative word during the past winter. The end-of-the-season statistics tell of a dull winter, but with closer scrutiny the winter was quite remarkable. Some months were very dry and others were very wet, and temperatures were very warm. Once again periods of drought and deluge dominated Colorado's winter weather and avalanche conditions.

This winter seasonal snowfall for the northern, central and southern mountains[1] was slightly below normal. The number of reported avalanches was well below normal, the number of avalanche warning periods and days were also well below normal. Avalanche deaths slightly exceeded the long-term average, and property damage was nil.

The winter of 1999–2000 was very warm. Preliminary data released from the National Climatic Data Center (NCDC) showed the December to February period was the warmest U.S. winter on record. Nationwide, November 1999, was the century's warmest. In Colorado monthly average temperatures were well above normal. The warmest months were November, January and February when monthly average temperatures ranged from 4 to 10 degrees (F) above normal. During each of those three months rain fell in parts of the Colorado mountains.

Snowfall

Winter was slow to start in Colorado, and in the eyes of many observers did not truly get underway until December. What little snow fell in October nearly all melted away by the end of the month. The snow-drought worsened in November. Most sites experienced one of the driest Novembers on record. For the month observers reported a dismal 2–18 in. of snowfall.

[1] The geographical regions called northern, central, and southern mountains of Colorado are used extensively in this report. The 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.

Fortunes for most sites changed in December when storms driven by northwest flow favored the northern mountains. These storms brought enough snow to blanket the central mountains and the north side of the San Juans, however. Winter continued to snub the south side of the San Juans where a desiccated Wolf Creek Pass and Purgatory received a measly 8 in. and 10 in., respectively. Though snowfall in the southern mountains was far below average, there was one remarkable exception. An early December storm brought 61 in. of snow to Cuchara Pass in the Sangre de Cristo Mountains during a 28-hour period. The rest of the Colorado mountains remained unlucky, receiving but 3–13 in.

In January winter struck with vengeance when an active northwest storm track brought snow to all mountain areas. January 2000 was nearly identical to January 1999, and many sites reported more than 80 in. of snowfall. Though January snowfalls were not nearly as impressive as in 1996, two sites in January 2000, amassed more than 100 in. of snow.

Generous snows fell on all mountains in February and temperatures stayed mild. For the month most sites received above-normal snows. Historically Colorado's coldest temperatures occur in February but not this year. Only on three mornings did temperatures—at only a few sites—dip below zero degrees (F).

Winter storms continued to smother the mountains during March. For the second month in a row most mountain areas received above-normal snows. During the month mild, spring-like weather could only briefly interrupt the string of winter-like storms.

After a snowy start to April, winter finally relinquished its hold on the Colorado mountains. During the first few days of April the mountain snowpack reached it deepest depths of the season, about two weeks earlier than average. After this period storms were few and far between and the snow cover melted quickly under the warm spring sun. By the end of the month snowfall for all sites was well below normal and the snow cover was melting fast. Winter returned one last time with a short-lived mid-May storm, but by then the snow was melting fast. On June 1, the snow cover had shrunk to only 12 percent of normal.

As mentioned earlier the periods of drought and deluge dominated Colorado's winter weather. Most people will remember the dry start and end to the season; however, the middle winter months were very snowy. Note in Table 1 the percent-of-normal totals for December–March. All sites but one received above normal snowfall. Wolf Creek Pass was the only have-not with 73 percent of normal. Only a few sites have long-term snowfall records for the six months of November–April. When the dry November and April are added the percent-of-normal values drop to 84–97 percent of normal. Not bad for a winter that started off as one of the driest on record!

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

Table 1. 1999–2000 snowfall in inches.

	Nov	Dec	Jan	Feb	Mar	Apr	Total Dec-Mar	% of Normal	Total Nov-Apr	% of Normal
Northern Mountains										
Arapahoe Basin	11	42	85	61	51	34	239	126	284	97
Bear Lake (RMNP)	15	29	70	49	51	22	199	124	236	97
Berthoud Pass	10	68	95	76	85	17	324		351	
Breckenridge	14	44	86	47	45		222	111		
Copper Mountain	16	49	79	59	65	42	252	136	310	
Eldora	14	40	60	55	33	40	188		242	
Keystone	9	42	80	52	52	13	226		248	
Loveland Basin	15	52	78	78	66	56	274		345	
Steamboat		78	113	83	50		324	133		
Vail	18	58	101	72	70	26	301	117	345	
Winter Park	17	65	94	67	56	19	282	111	318	87
Central Mountains										
Aspen Mountain		34	54	51	56		195	114		
Aspen Snowmass	11	37	71	56	80	12	244		267	
Crested Butte	14	21	70	67	61		219	130		
Gothic	15	26	70	82	68	27	246	102	288	84
Irwin Lodge		31	98	116	76		321			
McClure Pass	2	28	55	65	48	13	196		211	
Monarch	7	30	63	40	89	23	222	117	252	
Southern Mountains										
Purgatory		10	40	72	74	20	196	108		
Red Mountain Pass	13	31	52	60	76	31	219	107	263	89
Telluride		27	56	66	85		234	124		
Wolf Creek		8	44	60	76		188	73		
Wolf Creek Highway	7	8	28	57	85	21	178		206	

Avalanches

This winter a total of 1,666 avalanches were reported to the Center from November to May. This number is 23 percent below the average of 2,160. Table 2 shows the monthly distribution of these events.

In November only three avalanches were reported, a record low number for avalanche futility in November. All three fell in the Loveland Pass area. December produced relatively few avalanches (189), mainly because of few old-snow weak layers. The absence of November snows meant the depth-hoar and upper-level faceted-grain formation was very localized and mostly confined to high elevation north-facing slopes and gullies. By the end of December weak layers in the shallow snow cover became widespread, creating an unstable snow cover throughout the mountains. This weak base and January's heavy snows produced a very active avalanche month with 645 reported avalanches. Abundant snows in February continued to produce avalanches, but by the end of the month most of the deep instabilities had been

removed by earlier avalanche activity or were consolidating from warm, spring-like temperatures. Though heavy snows fell in March only 289 avalanches were reported. Most avalanches were direct action and involved only recent storm-snow, but some deep-instabilities still lingered. By April the lack of new snow and weak layers resulted in relatively few avalanches. In the absence of any significant weak layers the snowpack quickly melted away in May, and by June it was nearly gone.

Avalanche Danger and Warnings

Table 2 shows the daily hazard 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 22 Avalanche Warning days were well under the long-term average of 32 days. (A warning day is one on which the danger was rated high or extreme and an Avalanche Warning was issued.)

Avalanche Accidents

The last part of Table 2 is a monthly listing of avalanches involving people and property in 1999–2000. During the winter of 1999–2000 the number of people caught (44) was far below the 1990s average of 64. This decrease can likely be attributed to the absence of snow in the early season and the absence of persistent weak layers later in the season. The 9 people partly buried were below the 1990s average of 14. The 11 buried matched the decade average of 11. The number injured was below average, but the number killed (8) exceeded the 1990s average of 6. No property was reported damaged.

Table 3 lists all avalanche accidents reported this winter. The fatal accidents are italicized. Avalanche Center personnel try to investigate all fatal accidents (see Section VI). It is remarkable to note the grouping of accidents by month. No avalanche accidents were reported during October and November. When the snows finally arrived in December, four accidents were reported, of which two claimed lives. Heavy snows on a weak snow snowpack created dangerous conditions in January and a significant number of accidents occurred. Both February and March were active avalanche months resulting in accidents. By April the strong snowpack resulted in few avalanches and few accidents.

When the snows finally arrived in December, four accidents were reported, of which two claimed lives.

Figure 1 represents a 10-year look at the number of people caught and killed in avalanches each winter. A most interesting feature of this past winter was that the number of victims caught decreased; however, the number killed increased. This could be attributed to bad luck, but another explanation can be inferred. A shallow snow cover exposes an avalanche victim to more rocks and other obstacles. Thus the consequences of getting caught in a lean snow year

may be more serious. The 1999–2000 data show 32 percent fewer people caught, but the number of injured victims decreased only 18 percent, and the number killed jumped 31 percent.

Table 2. 1999–2000 summary of avalanches, hazard days, and accidents.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Avalanches reported		3	182	645	427	289	114	6	**1666**
Days with 1 or more slab avalanches		2	19	28	25	25	15	2	**116**
Avalanche warning periods		0	0	2	2	3	1	0	**8**
Days with warning in effect		0	0	9	5	6	2	0	**22**
NORTHERN MOUNTAINS									
Days with danger rated…									
LOW		14	9	0	0	0	0		**23**
MODERATE		0	5	8	9	27	20		**69**
CONSIDERABLE		0	8	15	13	4	4		**44**
HIGH		0	9	8	7	0	2		**26**
EXTREME		0	0	0	0	0	0		**0**
CENTRAL MOUNTAINS									
Days with danger rated…									
LOW		14	18	0	0	2	0		**34**
MODERATE		0	13	13	8	26	20		**80**
CONSIDERABLE		0	0	17	16	3	3		**39**
HIGH		0	0	1	5	0	0		**6**
EXTREME		0	0	0	0	0	0		**0**
SOUTHERN MOUNTAINS									
Days with danger rated…									
LOW		14	19	4	0	2	1		**40**
MODERATE		0	12	10	8	19	19		**68**
CONSIDERABLE		0	0	14	17	8	2		**41**
HIGH		0	0	3	4	2	1		**10**
EXTREME		0	0	0	0	0	0		**0**
AVALANCHE ACCIDENTS									
People caught	0	0	4	16	9	12	3		**44**
People partly buried	0	0	1	7	2	0	1		**11**
People buried	0	0	2	4	2	2	0		**10**
People injured	0	0	1	1	2	0	1		**5**
People killed	0	0	2	3	0	2	1		**8**
Vehicles caught	0	0	0	0	0	0	0		**0**
Property sites damaged	0	0	0	0	0	0	0		**0**

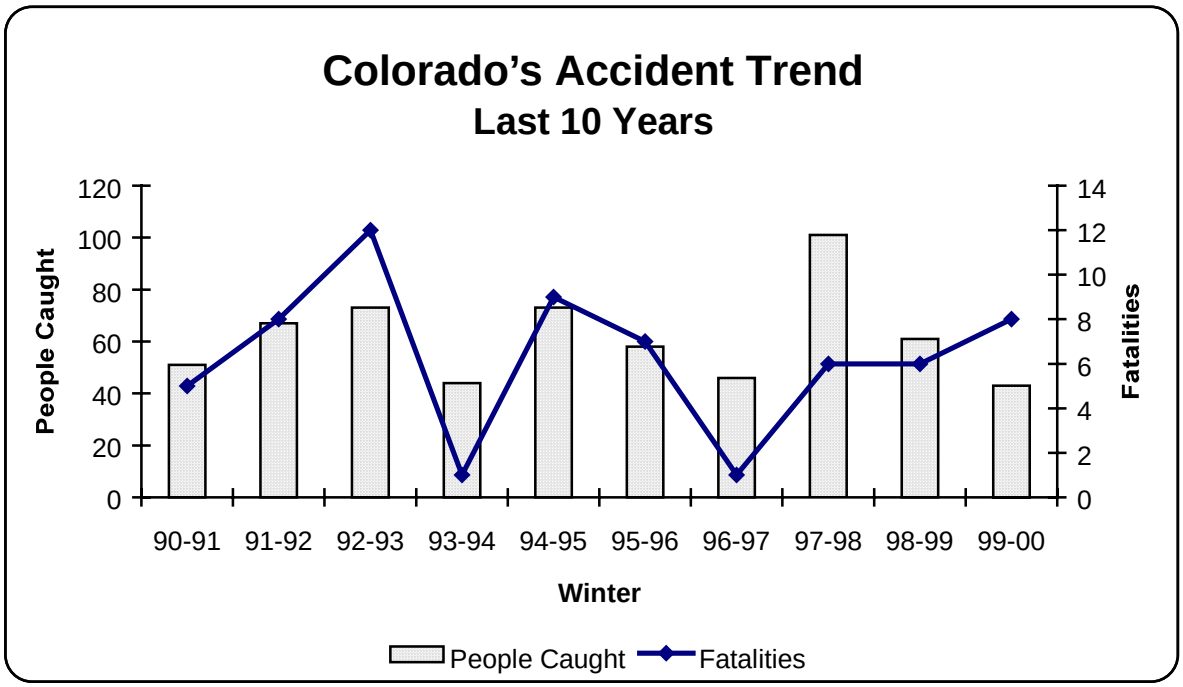


Figure 1. Colorado's accident trend in the last 10 years.

Table 3. Colorado avalanche accidents, 1999–2000 (italics indicate fatal accident).

Date	Location	Details
12/14	*Cameron Pass, Diamond Peak*	*1 backcountry skier caught, buried and killed*
12/18	South Arapaho Peak	1 hiker caught and partly buried[2]
12/19	Berthoud Pass	1 backcountry skier caught
12/21	*Quandary Peak*	*1 backcountry skier caught, buried and killed*
1/16	Stevens Gulch (nr Torreys Pk.)	1 climber caught
1/19	Telluride	1 patroller caught and partly buried
1/19	Loveland Basin	3 ski patrollers caught, 2 partly buried, 1 injured
1/19	Loveland Valley	1 ski patroller caught
1/22	Berthoud Pass	1 backcountry skier caught and partly buried
1/23	Aspen	1 snowcat skier caught and buried
1/23	*Jones Pass (nr Berthoud Pass)*	*1 snowshoer caught, buried and killed*
1/25	*Arapahoe Basin*	*1 out-of-area snowboarder caught, buried and killed*
1/25	*Aspen, Hurricane Bowl*	*1 backcountry skier caught, buried and killed*
1/25	Aspen Highlands	1 worker caught
1/25	Telluride	1 ski patroller caught
1/30	Vail	1 out-of-bounds snowboarder caught and partly buried
2/3	Breckenridge	1 out-of-bounds snowboarder caught
2/19	Vail Pass	1 snowmobiler caught
2/21	Wolf Creek Pass	1 out-of-area skier caught, partly buried and injured
2/23	Flattops, Blair Mountain	1 snowmobiler caught and buried
2/24	Silverton	2 ice climbers caught, 1 partly buried, 1 buried
2/27	Loveland Pass	1 backcountry skier caught
2/29	Loveland Basin	1 patroller caught and injured
3/8	Wolf Creek Pass	1 patroller caught
3/10	Snowmass	1 backcountry skier caught
3/11	Breckenridge	1 patroller caught
3/14	Loveland Pass, Grizzly Peak	1 backcountry snowboarder and dog caught
3/17	*Aspen Highlands*	*2 out-of-area skiers caught, buried and killed*
3/19	Red Mountain Pass	1 backcountry skier caught
3/21	Loveland Pass	1 CDOT loader caught
3/29	Breckenridge	3 ski patrollers caught
3/29	Breckenridge	1 ski patroller caught
4/16	Loveland Pass	1 backcountry skier caught
4/21	*Arapahoe Basin*	*2 backcountry skiers caught, 1 injured and 1 killed*

[2] After this accident it was presumed—but not with complete certainty—that one man had also been buried in the avalanche and remained missing during the winter. This man was found in early June well away from the avalanche. It is unlikely that he was ever caught in the avalanche but had become separated in white-out conditions from his companion before the avalanche.

Detailed Winter Summary

November

Well, what can we say about November? With miniscule snowfall, most of us would rather forget about it. High pressure dominated the Great Basin and Colorado for most of the month, and very warm temperatures were recorded statewide. Gothic reported six record high temperature days in a row, reaching 62 degrees on the fourteenth. The CAIC had opened the first week of November but promptly closed until there was snow on the ground and there was something to forecast.

On the twentieth a cold front moved in from the northwest and brought the only significant storm of the month (and reopened the CAIC). By the morning of the twenty-third storm totals were 22 in. at Steamboat, 13 in. at Vail, 14 in. at Gothic, and 9 in. at Telluride. Another light dusting of snow fell on the twenty-sixth, but some unlucky sites along the Ten Mile and Gore Ranges, and around Steamboat Springs got light rain. It was enough rain that it produced a solid 1/8-inch-thick crust that could easily support the weight of a skier and lots of additional snow. The crust would later cause avalanche problems in December. November came to an end with a strong ridge of high pressure firmly entrenched over the state.

There were only three avalanches (size 2 or larger) reported in November, and these fell along Loveland Pass on November 26 and 27. Snowpack depth was less than a foot in the northern mountains, and only about 5 in. in the central and southern mountains by the end of November. Snowfall was 25–40 percent of normal in the northern mountains and 13–29 percent in the central and southern mountains. There were no reported avalanche incidents in November.

December

By early December many folks were in panic mode, while others were lubricating the chains on their bicycles. The storm track continued unabated over Alaska, but Colorado was high and dry.

December, however, started favorably with an approaching storm on the horizon. On the second, third, and fourth, all mountain sites picked up light snow daily, getting 1–5 in. each morning; however, vigorous upslope conditions hit the Sangre de Cristo Mountains. During an 28-hour period from the third to the fourth, 61 in. of snow smothered Cuchara Pass. By the time the storm ended, up to 7 ft of snow encased the ground. As the trough of low pressure moved eastward on the fourth, our mountains saw a return to fair weather until the seventh. Then a series of storms from the northwest lined up and took aim at Colorado. These brought more or less continuous snow for the northern mountains until the twenty-third. On those 16 days, Steamboat Springs recorded 62 in.;Vail, 46 in.; and Winter Park, 44 in. of new snow. This storm system saved the Christmas ski season for resorts in the northern mountains and

made for some remarkable avalanches that released on the November rain crust. Several very large slab avalanches up to 2,000 ft across released in the Copper Mountain and Vail Pass areas.

Unfortunately the Central and Southern mountains did not fair as well. Only 23 in. of snow fell at Gothic, 19 in. at Telluride, and a meager 3.5 in. at Wolf Creek Pass.

This storm cycle contributed to the first avalanche cycle of the winter in the northern mountains, and two people lost their lives to avalanches. The first avalanche fatality of the season was on the fourteenth on Cameron Pass west of Fort Collins, when a backcountry skier died. It was only the fifteenth recorded slide of the season. Then on December 21 a backcountry skier was killed in an avalanche on Quandary Peak south of Breckenridge. The fatal avalanches resulted from a deposit of fresh slab snow on top of faceted snow at the bottom of the snow cover. (Note: At that time, a third fatal avalanche was reported on the eighteenth when a hiker was thought to be killed in an avalanche on South Arapahoe Peak west of Boulder. However, the body of the missing man was found in June 2000, 1.5 mi from the avalanche site.)

The first avalanche fatality…only the fifteenth recorded slide of the season.

December, the last month of the old millennium, ended under a dome of high pressure and a thin, weak snowpack. For the month of December no avalanche warnings were issued, and 135 avalanches were reported in the northern mountains, 29 in the central mountains, and 21 in the southern mountains. For the month, four people were caught in slides, and two people were buried and killed.

Monthly snowfall was as follows: In the northern mountains, Bear Lake in Rocky Mountain National Park, 87 percent of normal; A Basin, Breckenridge, and Vail, all 95 percent; Copper Mountain and Winter Park, both 110 percent; and Steamboat, 120 percent. In the central mountains, Crested Butte and Gothic, 50 percent; Monarch, 75 percent; and Aspen Mountain, 89 percent. In the southern mountains, Wolf Creek, 14 percent; Purgatory, 23 percent; Telluride, 71 percent; and Red Mountain Pass, 74 percent. The bias of northwest flow on snowfall is evident from these percentages.

Two months of below-normal snowfall to start the winter (except for a few sites in December) had produced a thin and very weak snow cover in the back-country, with portions of the southern mountains having a patchy snow cover at best. The faceted snow grains that made up the snowpack had set the back-country up for widespread shallow avalanches that would be easy to trigger … if and when storms put a slab layer on top of the faceted layer.

January

Snow in January would bring us back to a normal winter, at least in the northern portion of the state, while the central and southern mountains would at least see a decent boost to snow depths. The New Year began with snow falling at long last in the San Juan Mountains. Wolf Creek Pass reported 28 in. of new snow on the second, a great way to start the new year. Steamboat had 15 in. on the third, and Powderhorn on Grand Mesa picked up 22 in. A brief,

1-day period of high pressure was followed by the next incoming two-day storm on January fifth. All sites in the northern mountains got 5–10 in., with 2–5 in. falling in the central and 0–2 in. in the southern mountains.

The next storm was not far behind, and from the January 9–14 the northern mountains would again find themselves in the storm track. The central mountains would see some snow and the drought- stricken San Juans would suffer through another near miss. Thirty-seven inches fell at Steamboat and 17 in. at Vail, but only 3 in. at Silverton and 4 in. at McClure Pass. This storm led to the first Avalanche Warning of the season being issued for the Steamboat zone on the January 10–12.

A brief spring-like thaw invaded the San Juans on the thirteenth, with a high temperature of 44 degrees recorded at 11,000 ft on Red Mountain Pass, and them a dirty ridge (high pressure with lots of mid-level clouds) set up over Colorado for the next three days. Warm temperatures would remain the norm. But these would be the last of the high pressure days until the end of the month as new snow would be recorded each day until the thirty-first. Winter Park was swimming in new snow, with 58 in. during this period, while Gothic near Crested Butte reported an even 4 ft, but the San Juans were once again on the low end as Wolf Creek Pass got 22 in.

On the whole, all mountain sites saw more snowy days than clear days in January, but the storm systems on a general westerly wind flow favored the northern half of the state. In the northern mountains all sites got 135–170 percent of normal snowfall; in the central mountains, 110–150 percent; while in the southern mountains, Telluride got 120 percent; Purgatory, 97 percent; and Wolf Creek, 68 percent. The winter had turned around, smiles were back, and finally the bikes and golf clubs were returned to their proper winter closets.

Another event of note in January was the long wind cycle of mid January when winds rarely dropped below 30 mi per hour for over a week at high elevations in all mountain areas. This produced a thick dense slab on top of the weak, faceted snowpack at the ground. The combination of snow and wind led to the second Avalanche Warning for the Summit County, Eagle County, and Berthoud Pass area on January 23–28. Three avalanche deaths occurred from January 23–25. On the twenty-third, a snowshoer was killed at Jones Pass near Berthoud Pass; on the twenty-fifth, an out-of-area snowboarder was killed at A Basin; and also on the twenty-fifth, a backcountry skier was killed near Aspen. The combination of wind slab on top of facets once more proved to be deadly.

In all, 16 people were caught in slides, with 1 injured, 4 buried, and 3 killed. A total of 257 slides were reported in the northern, 195 in the central, and 201 in the southern mountains.

February

Snow in February was a little slow to start, but the month would finish strong and all mountain areas would benefit from a moist storm track. But it wasn't until the tenth that the storm cycle would return to Colorado, as high pressure, mostly clear skies and mild temperatures dominated the first 10 days of the month.

Snow did return on the tenth, and new snow would be recorded at all mountain sites every day through the nineteenth. Steamboat reported 67 in. in the 10-day storm cycle, while A Basin got 46 in., Bear Lake, 42 in., Vail, 47 in., Gothic, 73 in., Telluride, 35 in. and Purgatory, 40 in. Eldora reported the largest single-day snowfall with 22 in. on the eighteenth. Many of these days had only light winds at best, so powder snow was to be found everywhere. And so were avalanches, with 254 being reported in the 10-day span. We had Avalanche Warnings in effect on the February 13–15.

The next storm cycle was not far behind. On the twenty-second snow started and ended on the twenty-sixth. This storm brought moderate snowfall but some strong winds. Snow totals were typically 8–12 in., but Winter Park and Vail totaled 20 in. and Purgatory got 21 in. On both February 25 and 26 winds gusted to 60 mph, causing heavy blowing snow at high elevations. This led to an Avalanche Warning for the southern mountains on the February 24–25, and 52 avalanches were reported on these two days.

High pressure and fair weather returned until the twenty-eighth, but as 2000 was a leap year we had one more day for February. A Southern Mountain storm moved in right on cue and 1–7 in. of new snow fell on this bonus ski day.

For February, the northern mountains reported 149 slides, the central mountains, 114, and the southern mountains,164. The big news was that there were no avalanche fatalities, a rare occurrence for February. Nine people were caught in slides, two were injured, and two were buried. Snowfall was well above normal: in the northern mountains, Breckenridge, 105 percent; Bear Lake, 110 percent; Winter Park, 120 percent; Vail, 125 percent; A Basin, 135 percent; and Copper Mountain, 140 percent; in the central mountains, Monarch, 87 percent; Aspen Mountain, 115 percent; Gothic, 125 percent; and Crested Butte, 160 percent; in the southern mountains, Wolf Creek, 94 percent; Red Mountain Pass, 125 percent; Telluride, 145 percent; and Purgatory, 155 percent.

…no avalanche fatalities, a rare occurrence for February.

March

March came in like a lion cub, with light snow (3–6 in.) falling in the southern and central mountains on March 2 as a weak closed low moved east from Las Vegas. High pressure slid back into place on the third, but then another Four Corners low began to set up on the fifth. This brought moderate snowfall to the southern mountains on March 6–10. Storm totals were 33–41 in. at all sites in the San Juan Mountains, and this led to the largest avalanche cycle of the winter in the San Juans (about 85 slides) and an Avalanche Warning on March 7–9.

In the central and northern mountains, light snow fell daily from March 6–13. Accumulations for this storm period were: Monarch, 29 in.; Gothic, 40 in.; Winter Park and Steamboat, 30 in.; Copper Mountain, 37 in.; and Vail, 39 in. Avalanche activity was moderate: 52 slides in 7 days.

A powerful upslope storm swept across the east side of the Continental Divide on the fifteenth, with 23 in. reported at Estes Park and Allen's Park, 17 in. at Bear Lake, and 13 in. at

Eldora. This was followed by a dome of high pressure that built over the west coast on March 17 and placed Colorado in strong northwest wind flow for three days. Snowfall was scant from this system, ranging from 2 in. at several sites to 11 in. on Red Mountain Pass, but winds caused blowing snow from the snow accumulation of the storms on March 6–13. These conditions led to a fatal avalanche on the seventeenth near Aspen Highlands when two out-of-area skiers triggered a large hardslab avalanche that carried both of them to their deaths.

A strong closed low set up on the twentieth and clobbered the San Juans. By the morning of the twenty-first, 12–20 in. of new snow had fallen in the San Juans. This led to an Avalanche Warning for March 21–22.

Several weak systems interrupted high pressure over the state through the twenty-seventh, at which time a deeper trough crossed into Colorado from the Great Basin and brought snow to the end of the month. On the thirtieth snowfall increased at Wolf Creek, and in about 24 hours Wolf Creek recorded 25 in. of new snow. We issued an Avalanche Warning for the area on the thirty-first, but there was surprisingly little avalanche activity and we dropped the warning on April 1.

Avalanche incidents in March totaled 12 people caught, and two buried and killed. There were 91 slides reported from the Northern, 38 from the Central, and 147 from the southern mountains. Snowfall was mostly above normal: in the northern mountains, Winter Park, 82 percent; Breckenridge, 85 percent; A Basin, Steamboat, and Vail, all 100 percent; Bear Lake, 120 percent; and Copper Mountain, 125 percent; in the central mountains, Aspen Mountain, 105 percent; Gothic, 110 percent; Crested Butte, 150 percent; and Monarch, 160 percent; in the southern mountains, Wolf Creek, 105 percent; Red Mountain Pass, 120 percent; Telluride, 125 percent; and Purgatory, 150 percent.

April

As April began, this New Mexico-tracking storm produced upslope snows along the Continental Divide. It wasn't a strong storm, but Purgatory got 12 in. and Eldora got 5 in. of upslope snow on the first. On the second a strong cold front from Canada moved south and kicked the New Mexico storm off to the east. This storm was also short lived and blessed all the mountains with 2–10 in.

A large dome of high pressure then built over the West Coast placing Colorado on a strong northwest flow. This kept temperatures cool in the mountains until the ninth (and brought snow showers to the northern mountains on the sixth to the seventh) when the high pressure ridge axis finally moved over the state. With the exception of snow showers on the eleventh, warm temperatures would remain the norm until the fourteenth when a deep, upper level trough and cold front invaded the state. This brought a short end to the high-pressure spring skiing statewide. There were 9.5 in. of new snow in two days at Copper Mountain, 6 in. in Silverton, and 10 in. at Irwin Lodge.

April16–22 were rather uneventful, with two days of high pressure followed by two days of cold-front-induced snowfall (with up to 5 in.) followed by two days of high pressure. Then came the afternoon of the twenty-second. In an intense convective flurry, 18 in. would fall at

both Copper Mountain and Vail, and 12-16 in. in other parts of Summit County and at Berthoud Pass and Winter Park. Snowfall rates of 4 in. an hour were reported in this first real convective thunder-snow event of the season. Water contents in the new snow ranged from 12 to 15 percent, making this more a maritime event than a Colorado event. Lightning shut down all ski areas on the afternoon of the twenty-second, and then power outages resulted throughout the area as heavy, wet snow pulled down power lines. It also prompted us to issue an Avalanche Warning for the northern mountains on Easter Sunday.

Snowfall rates of 4-inches an hour…

This spectacular and destructive storm proved to be winter's last hurrah, as the rest of the month was uneventful. The only other attempt at a storm proved to die with a whimper on the last day of the month and brought only a trace to 3 in. of snow and freezing rain to the northern mountains.

April snowfall was below normal at all sites: Winter Park, 44 percent; Bear Lake, 50 percent; Gothic, 56 percent; A Basin, 60 percent; and Copper Mountain, 82 percent. Avalanches, too, were few: there were 80 avalanches reported in the Northern, 8 in the Central, and 26 in the southern mountains. Avalanches caught only three persons in two separate slides. One was a small slide on Loveland Pass on the sixteenth that caught a backcountry skier. The other slide near A Basin—after the ski area had closed for the day—caused serious injuries to two out-of-bounds skiers. Friends were able to evacuate the men to their car and transport them to a Denver hospital. One man was treated for broken bones; the other man sadly suffered fatal injuries and died in the hospital two days later.

Information Acquisition

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 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.

Snowmobile Observer Network: In cooperation with the Colorado Snowmobile Association the Center two season's ago established a volunteer network of observers. Trained by the Center's staff, recreational snowmobilers take a few snow and avalanche observations during the course of their usual riding activities. Their observations are then e-mailed or faxed to the Center. This new network supplies the Center with information and data from many distant mountain areas and has created a partnership unique in the avalanche industry.

Backcountry Observers Network: We contracted with eight observers to provide additional data to the Center, which we used to provide more detail and accuracy to our forecasts.

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 staff has access to all products and expertise of the NWS staff. Computerized weather maps, satellite imagery, radar data, and radiosonde data are all available from the 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 database 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, search and rescue teams,

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 Hazard 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 some 35 field-observation sites are used to prepare forecasts for eight 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. Long-time 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 65,927 calls was placed to the hotlines, 3,059 more than last year. The following table breaks down the call counts by location. The hotlines in Aspen and Vail do not have counters.

Location	Phone #	Number of calls
Denver	303-275-5360	23,243
Fort Collins	970-482-0457	3,552
Colorado Springs	719-520-0020	6,027
Summit County	970-668-0600	16,354
Durango	970-247-8187	16,751
Aspen	970-827-5687	N/A
Vail	970-920-1664	N/A

E-mail to Friends, Observers and Forecasters

Our grassroots support organization, “Friends of the CAIC,” was comprised of some 642 members, almost 100 more than last year. For a contribution of $25, “Friends” who have e-mail receive a daily mountain weather forecast and snowpack evaluation. Instituted this season, Friends who donated $45 or more also received an afternoon forecast via e-mail. About 252 members took advantage of this, which added substantially to our budget. CAIC observers and highway forecasters also get the forecast via e-mail. 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. Approximately 98,000 forecasts were sent via e-mail to our Friends.

Web Site

The Center's own web site (www.caic.state.co.us) consists of 20+ 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 192,000 contacts by the end of May, an increase of more than 87,000 over last year.

Figure 2 below shows CAIC's total product dissemination growth from all outlets. Note how hotline use has declined as e-mailed forecasts increased beginning in 1997–98. CAIC's Web site has become very popular in a short time and an increasing number of people are now getting the daily forecast via e-mail through our "Friends of the CAIC" program.

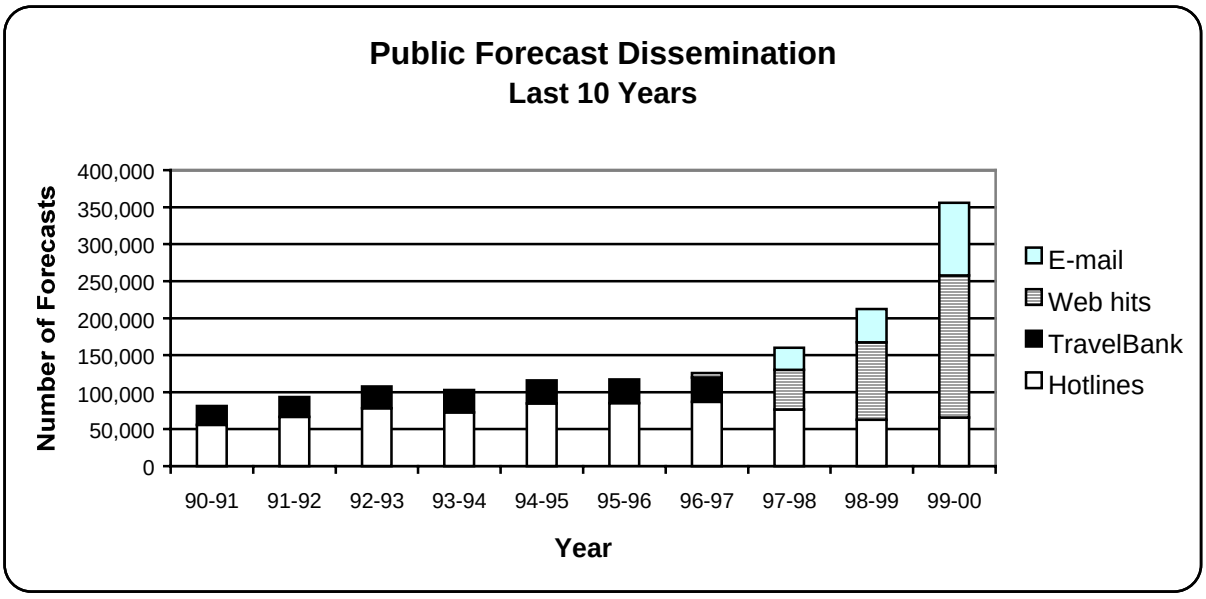


Figure 2. Public forecast dissemination.

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.

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 dispensed. 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 separate warning periods covered 22 days and several, one-day Special Advisories were issued this winter.

News Media

Throughout the winter avalanche-related incidents draw the public's, and therefore the media's, attention. These events usually involve people, property, highways, or anomalous mountain weather conditions. When this occurs, CAIC forecasters are obligated to respond to, and sometimes initiate contacts. Television, radio, newspaper, and magazine reporters from Colorado, other states and other countries are provided accurate information for broad news coverage. This winter the Center made 207 contacts with the media. For reasons of timeliness, the daily forecast is not issued through the printed media. However, it is not uncommon for the media to follow up on avalanche warnings, special advisories and accidents.

Public Education

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

Demand for avalanche education has increased in recent years. This season courses began on September 17, and the last talk was given on May, 1. By the end of the season the Center staff had spoken on 79 different occasions to some 3,267 people. Figure 3 shows the number of courses taught and participants for the last 10 winters while Table 4 lists the details.

The courses vary from 1-hour seminars to multi-day field workshops. Table 4 lists all of the programs presented by CAIC staff. The scope and content varied from a simple over view of avalanche hazard to multi-day programs covering mountain meteorology, avalanche terrain recognition, the Colorado snowpack, methods of safe winter travel, and survival and rescue techniques. Students this winter included backcountry enthusiasts, professional ski patrollers, search and rescue volunteers, law enforcement officers, snow-cat ski guides, members of ski and snowmobile clubs, the Colorado Mountain Club, USFS and the Colorado Department of Transportation.

Through our agreement with CDOT the Avalanche Center staff provided specialized training to CDOT winter maintenance personnel on avalanche awareness, rescue, safety, and avalanche reporting.

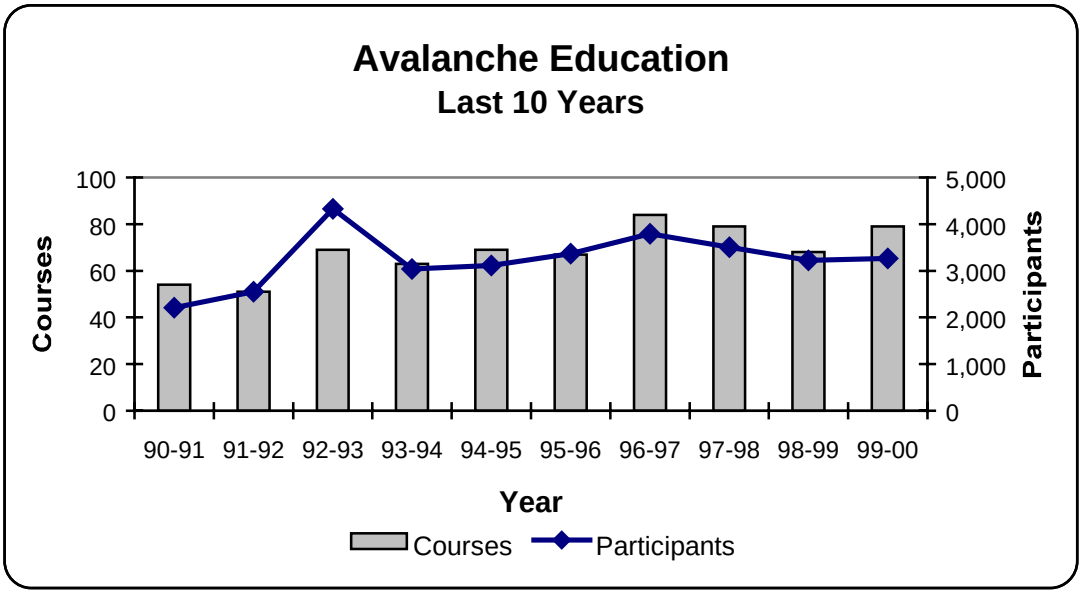


Figure 3. Avalanche education.

Table 4. Avalanche talks and seminars, 1999–2000.

Date	Personnel	Group	Participants
9/17	KW	UNC Department of Earth Sciences, Greeley	30
9/23	KW	Skyline H.S., Longmont	50
9/23	DA	ICAR, Europe	30
10/12	DA	AAAP	150
10/23	DA	General Awareness, Mountain Miser	82
11/1–5	KW,NL,DA	National Avalanche School, Incline Village, NV	205
11/5	LM & SS	CDOT, Hidden Valley	40
11/6	DA	International Technical Rescue Seminar	200
11/13	NL	General Awareness, Buena Vista Snowdrifters	35
11/15	RH	CDOT, beacon training, Patrol 15	5
11/18	DL	General Awareness, Friends of Ridgway St. Park	25
11/18	NL	General Awareness, Mountain Chalet, Colo. Spgs.	65
11/19	ST & HM	Crested Butte Search & Rescue	70
11/23	AG	CDOT, beacon practice, Cascade barn	3
11/24	AG	CDOT, beacon practice, Ouray barn	3
11/24	DL	CDOT, beacon practice, Telluride barn	4
11/24	DL	CDOT, beacon practice, Rico barn	4
11/24	ST	General Awareness, Vail Library	60
11/24	MM	CDOT, Pagosa Spgs. barn	10
12/1	DA, LM, SS, HM	CDOT, Hidden Valley	17
12/2	AG, DL	CDOT, annual avalanche training	16
12/2	MM	CDOT, Monarch Pass	9
12/4	DA	Advanced Avalanche Rescue Seminar, Summit Co.	17
12/4–5	ST & NL	Basic Avalanche Rescue Seminar, Summit Co.	55
12/6	MM	CDOT, Wolf Creek Summit	7
12/7	KW	General Awareness, Mtn. Shop, Ft. Collins	35
12/7	DL	CDOT, beacon training, Rico & Telluride	9
12/8	MM	General Awareness, Pagosa Spgs.	41
12/11–12	ST	Beacon Clinic, Francie's Cabin	12
12/13	MM	CDOT, La Manga Pass	10
12/15	AG	General Awareness, Columbine Mid. Sch., Montrose	104
12/15	DL	CDOT, beacon training, Cascade barn	5
12/16	AG	Beacon training, Silverton Search & Rescue	22
12/16 & 18	ST	Backcountry course, Bent Gate, Golden	10
12/18	DA, NL, HM	Colo. Mtn. Club instructors clinic, W side Ike Tunnel	38
12/13–14	KW	Int'l Avalanche Conference, St Vincent, Italy	160
12/22	ST	Staff training, Vail XC Ski School	20
1/4	DA	Loveland Ski Patrol	8
1/4-5	ST, HM	Colorado Snowmobile Association, Buena Vista	21
1/7	RH	CDOT, Patrol 15	7
1/7-9	ST, AG	General Awareness, Telluride	45
1/8	AG	Beacon training, Silverton Avalanche School	10
1/10	AG	Prescott College group	7
1/12	DA	Neptune Mountaineering	68
1/13	RH	CDOT, Patrols 3 & 7	10
1/13–14	ST	Beacon Clinic, Breckenridge	70
1/14–15	NL	Ski Haus, Steamboat Spgs/Rabbit Ears P.	80
1/16	DL	Awareness & field clinic, Hermosa Snowmobile Club	10
1/17	ST	General Awareness, Vail	10
1/18	RH	CDOT, Patrol 20	7

Table 4. Continued

Date	Personnel	Group	Participants
1/18	RH, SS	CDOT, Patrols 21 & 22	8
1/18-19	KW	COR Adventure, Denver	30
1/18 & 20	DA, KW	Colorado Mountain Club, Golden	42
1/19	NL, LM	General Awareness, Breckenridge Elementary Sch.	38
1/21	RH	CDOT, Patrol 6	5
1/21–22	ST	Backcountry Course, Aspen Search & Rescue	110
1/22–24	AG, DL	Silverton Avalanche School	80
1/26	DA	Neptune Mountaineering	110
1/28	ST	Beacon Clinic, Vail Ski Patrol	12
1/28-30	AG, NL	Silverton Avalanche School	67
1/26 & 29	KW, HM	Mountain Shop, Ft Collins	30
2/2–3	ST, NL, HM	Summit Co. Pro Course, Breckenridge	12
2/3	MM	San Juan Outdoor Club, Pagosa Spgs.	34
2/4	LM	General Awareness, Breckenridge Elementary Sch.	25
2/4–6	AG, ST	Silverton Avalanche School, Level 2	36
2/7, 10 &25	AG	Avalanche Awareness, Sterling College group	8
2/8-9	KW,HM	Colorado Mountain Club, Golden	40
2/11–12	NL	Wilderness Medical Society, Breckenridge	300
2/15–16	ST, HM	Gore Range Mtn. Works, Vail	10
2/20	LM	US Forest Service, Fairplay	35
2/22 & 24	DA, NL	Colorado Mountain Club, Golden	40
3/2–5	ST	AAG/Estin Hut	15
3/7	RH	CDOT, Patrol 15	4
3/7-8	NL	COR Adventure, Denver	15
3/28–30	ST	Patagonia Staff Training	22
4/12	RH	CDOT, Patrol 16	5
4/13	RH	CDOT, Patrol 22	8
4/17	ST	Metro State Meteorology Dept., Denver	25
5/1	DA	Colorado Mountain Club, Golden	90
		79 Courses ***Total***	***3,267***

To teach these courses, CAIC forecasters invested 471 hours in teaching, 169 hours in preparation, and 172 hours driving to the sites of the courses.

Professional Conferences

The Center's staff was busy attending and presenting at several national and international conferences:

Dale Atkins presented a winter-season outlook at the annual workshop of the American Association of Avalanche Professionals at Alta, Utah, in October.

Dale Atkins presented a paper on probing efficiency at the International Technical Rescue Symposium in Fort Collins, Colorado, in November.

Dale Atkins presented a paper on accident trends in U.S. at the 1999 International Alpine Rescue Commission's annual meeting in Germany.

Knox Williams presented a paper on avalanche forecasting at the Aosta Valley Conference on Avalanches in Saint Vincent, Italy, in December.

Knox Williams and Mark Mueller attended the International Glaciology Society's Conference on Snow and Avalanches in Innsbruck, Austria, in May.

Nick Logan and Dale Atkins participated in the Winter Annual Meeting of the Wilderness Medical Society in Breckenridge, Colorado, in February. Atkins wrote course materials and Logan was a guest lecturer.

Publications

Atkins, D. 1999. "The Probe Efficiency Index: A Measure of Avalanche Rescue Probe Methods." *Proceedings of the International Technical Rescue Symposium*. Fort Collins, Colorado. November 5–7, 1999.

Atkins, D. 2000. "The Probe Efficiency Index and Better Ways to Do the Coarse Probe." *The Avalanche Review*. Vol. 18, No. 3.

Elder, K. and D. Atkins. 1999. "AAAP Avalanche Course Guidelines." *The Avalanche Review*. Vol. 18, No. 2.

Mueller, M. 1999. "Austrian Avalanche Tourism and Skiing." *The Avalanche Review*. Vol. 18, No. 1.

Page, C., D. Atkins, L. Shockley, and M. Yaron. 1999. "Avalanche Deaths in the United States: A 45-Year Analysis." *Wilderness and Environmental Medicine*: Vol. 10, No. 3, p. 146–151.

Williams, K. 1999. "An Overview of Avalanche Forecasting in North America." *Aosta Valley Conference on Avalanches*. St Vincent, Italy. December 13-14, 1999.

Williams, K. and D. Atkins. 1999. *Avalanche Wise: Your Guide to Avalanche Safety in Colorado*. Special Publication No. 48, The Colorado Geological Survey. Denver, Colorado.

Web Site

The Center's web page (www.caic.state.co.us) received a new look this season. The site provides avalanche and weather information useful to novices and experts alike. 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.

Avalanche Education Materials

For the 13th winter, avalanche accident slide sets and rescue videos developed by Dale Atkins of the CAIC staff were again available and used by avalanche educators throughout the U.S.

Forecasting for Colorado's Highways

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. Now six CAIC avalanche forecasters are based in Silverton, Pagosa Springs, Carbondale and the Eisenhower Tunnel. They prepare daily stability evaluations, provide recommendations for avalanche reduction and road closures, maintain weather and avalanche records and conduct avalanche training for highway personnel. CDOT provides the funds necessary to run this program.

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. Read further to learn more about the operation and winter's events for each forecast region.

Table 5. Avalanches reaching Colorado highways (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)	43	112	**155**
Eisenhower Tunnel	US 40 Berthoud Pass; US 6 Loveland Pass; I-70 Georgetown to Vail Colo. 82 Independence Pass	9	48	**57**
Pagosa Springs	US 160 Wolf Creek Pass; US 50 Monarch Pass; Colo. 17 Cumbres and La Manga passes	0	1	**1**
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	0	7	**7**
			Total	**220**

CDOT/Silverton Forecast Office

The Silverton Forecast Office has completed its eighth winter monitoring and forecasting avalanches for some 97 slide paths along the US 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 Jerry Roberts prepared daily evaluations to keep CDOT apprised of avalanche conditions in their region.

Synopsis

This season started out slowly with very little snowfall at the end of 1999. Unfortunately, this is the best scenario for depth hoar growth in the snowpack. By the beginning of the new year a few feet of faceted snow blanketed the ground. This contributed significantly to a widespread avalanche cycle with the first big storm. Snow began falling consistently in January and continued until the end of March. The snowpack percent of average increased to nearly 100 percent in most areas by the end of March. The exceptions were Molas and Coal Bank passes that never got above 65 percent of normal. April was a dry month and average snowpack depths decreased to well below normal in most areas. The north side of Red Mt Pass was the exception at 99 percent of normal. More avalanche control was conducted this season than in years past, due to a more aggressive approach by CDOT. Jerry Roberts joined the Silverton Forecast Office this season. His expertise and experience on Red Mtn. Pass was a welcome benefit to the avalanche forecasting program. This year we hosted two interns from Fort Lewis College and Prescott College. They conducted avalanche research on various stability tests in the field.

Weather and Snowpack Highlights

The season started out slow with very little snowfall until January. Even by mid-January the snowpack was only 40 percent of average or lower. It looked like we were in a typical La Nina weather pattern. The storms were coming out of the northwest and brought little more than light moisture. Then in January, storms became more consistent and snowfall increased as weather patterns shifted to the southwest and the southwest flow brought more moisture to the San Juans. February temperatures were quite mild at times which helped stabilize much of the snowpack. March produced some large "San Juaner" storms when closed low pressure systems rotated over the Four Corners region. These brought as much as 42 in. of snow in a few days. April was warm and windy. In many places it was warm enough to create an isothermal snowpack and winds reached up to 90 mph on the peaks. The table below shows the season's snow totals.

Snow and Water Equivalent

Station	Total snowfall (in.)	Total water equivalent (in.)	Comments
Red Mountain Pass	273.0	23.82	78% of normal at seasons end*
Molas Pass	222.2	19.22	65% of normal at seasons end*
Coal Bank Pass	234.2	22.34	65% of normal at seasons end*
Monument / Idarado	186.0	16.10	99% of normal at seasons end*
Lizard Head Pass			88% of normal at seasons end
Gladstone-CO Hwy 110	181.8	16.91	NA

* all data based on SNOTEL yearly averages on 4-30-00
Note: Basin wide percent of average 64 percent.

With meager snowfall early in the year, a weak basal layer of depth hoar developed that lingered in the snowpack for most of the season. The first big storm in January created a significant avalanche cycle. Many avalanches ran to ground and most of the depth hoar was cleaned out of the avalanche starting zones. Snow fell more consistently during mid-winter and the resulting snowpack was more stable. February storms brought a moderate amount of snow. Periods of clear, warm weather between storms helped to stabilize much of the lower snowpack. As a result, when a series of large "San Juaner" storms moved through in March, most of the avalanche activity was confined to the upper snowpack. April was warm and there was a wet-slide cycle in the beginning of the month when temperatures rose and the snowpack became isothermal. Many of these avalanches occurred late in the afternoon and some as late as 8 o'clock at night. In one instance the Brooklyns ran and hit Highway 550 at 7:30 in the evening.

Avalanche Mitigation

Avalanche control missions were conducted on 23 days this season, most in February and March. The 105 mm Howitzer and helicopter were used for avalanche mitigation this winter and the Blue Point Group on Red Mountain Pass was specifically hit hard using the avalauncher. Control work was very successful this season due to a new approach by CDOT whereby explosive tests were done on a more regular basis. The resulting avalanches were often smaller and less spectacular, running only to the edge of the road. However, this is effective control work for three reasons. First, it keeps snow from building to dangerous depths in the avalanche starting zones. Second, there is a minimum amount of debris on the highway for cleanup. And third, the road is closed for less time overall. While there are more spot closures, there are fewer full gate closures.

Highway closures

	Red Mountain Pass	Molas/Coal Bank passes	Lizard Head Pass
Spot closures	20.25 hours	9.00 hours	1 hour
Full gate closures	33.50 hours	6.75 hours	0 hours

Comments from Silverton residents were positive about this efficient procedure. During the previous season, which had more snowfall, Red Mtn. Pass had 110 hours of full gate closure. This year there were 33.5 hours of full gate closure and 20 hours of spot closures. Although the two winters were different in snowpack and weather patterns, the new approach to control work by CDOT contributed significantly to the fewer number of hours that the pass was closed.

Avalanches Reaching the Road (size 2 or larger) and Length of Centerline Covered

Highway	Natural	Triggered	Depths and length of debris at centerline
Hwy 550/RMP [Hit road]	42	89	1–10 ft x 10,215' (2,105 ft of total was from natural releases)
Hwy 550/RMP [did not hit road]	27	119	NA
Hwy 550 Molas/Coal Bank	11	95	One natural hit road. 23 triggered hit road. 1–6 ft x 1,620 ft
CO 145/Lizard Head Pass	3	4	None hit the road.
CO 110 to Gladstone	5	1	None hit the road.

Avalanche Incidents

There were only two avalanche incidents reported in the forecast area this season. The first was near Eureka at the end of February. It happened on an ice climb named Stairway to Heaven when two ice climbers were caught in a slab avalanche. One was partially buried and dug himself out and then recovered his partner who was completely buried. Both survived. The other incident occurred in Porphyry Gulch near Red Mountain Pass on March 19th. A skier was caught in a small slide, partially buried, and escaped uninjured.

Media Contacts and Avalanche Training

Forecasters in the Silverton office made twelve media contacts this season. Many were with local newspapers on articles involving avalanche forecasting and control work along Highway 550. Other notable media contacts included NBC television on avalanche forecasting for Highway 550 and the Philadelphia Inquirer on backcountry avalanche safety and awareness relating to the avalanche fatalities on the east coast this winter.

Avalanche training reached 490 people this winter, including CDOT personnel and the general public. The forecasters dedicated some 206 hours preparing for, and teaching courses.

CDOT/Pagosa Springs Forecast Office

This office is located in the CDOT maintenance barn in Pagosa Springs and staffed by Mark Mueller. The office has completed its seventh winter of forecasting for US 160, Wolf Creek Pass; US 50, Monarch Pass; and Colorado 17, Cumbres and La Manga passes.

Synopsis

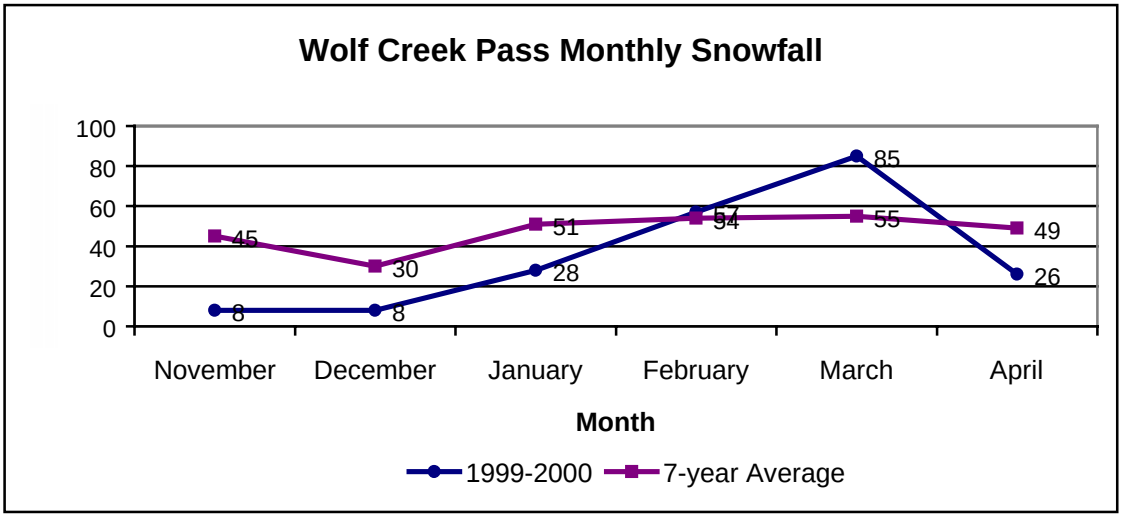
Seasonal snowfall amounts were well below normal at Wolf Creek Pass and Cumbres/La Manga passes, but near normal at Monarch Pass. Avalanche activity effecting the highways was limited and reflected the lack of snowfall. Highway Avalanche Advisories were issued from November 22 to April 21. Several pre-emptive avalanche control missions were conducted but no highway closures were necessary for avalanche danger.

Weather and Snowpack Highlights

The forecast La Nina conditions and less than normal precipitation were, unfortunately, all too accurate this winter. Maximum snow depths were not achieved until the end of March or the beginning of April at all sites.

At Wolf Creek, Cumbres and La Manga passes snowfall in November and December was near record minimums. The largest snowfalls arrived late in the season which was similar to the previous winter. Maximum snow depth at Wolf Creek Pass was 72 in. on April 1. Considering that the snow depth on January 1, 2000 was only 8 in., this was quite a rebound from the dismal start. On April 19, during a strong but dry storm, a peak wind gust of 98 mph was recorded at the anemometer site (11,800 ft) at the top of the Wolf Creek ski area. This is the fastest velocity recorded here in six seasons.

At Monarch the season started dry but a northwesterly, upper air flow in January helped bring 200-percent-of-normal precipitation for the month and a 60-in. storm caused the season's first avalanche cycle. March also brought 200-percent-of-normal precipitation that caused some surface avalanches to reach the highway and avalanche control work was required. Monarch Pass finished the season with near-normal precipitation.



1999–2000 Snow Water Equivalent (inches)

Site	Nov	Dec	Jan	Feb	Mar	Apr	Total / Percent of Average
Wolf Creek Summit [1]	[5]	0.90	2.90	6.90	7.00	1.90	19.6 / 55
Upper San Juan [2]	[5]	1.10	3.60	7.70	6.50	1.90	20.8 / 67
Cumbres Trestle [3]	[5]	0.70	3.40	3.90	5.20	1.30	14.5 / 62
Porphyry Creek [4]	0.30 [5]	1.70	3.80	2.40	4.80	1.70	14.7 / 88

[1] Wolf Creek Pass Snotel site at Wolf Creek summit, south of the highway, 11,000 ft
[2] Wolf Creek Pass Snotel site at Wolf Creek access road, 10,200 ft
[3] Cumbres Pass Snotel site NW of Cumbres Pass, 10,040 ft
[4] Monarch Pass Snotel site NW of Monarch Pass, 10,760 ft
[5] Such meager amounts of snow fell in November that recording precipitation was difficult

Snotel is a system of remote snowfall measuring instruments operated by the National Resource Conservation Service to aid water resource managers in forecasting snowpack water content and runoff. This data can also be used by avalanche forecasters to provide daily snowfall water equivalent data from sites that cannot always be visited in person.

A more fragile snowpack structure often accompanies dry winters and this year was no exception. Since the severity of avalanches effecting the highway is often more dependent on the snowpack structure than the amount of snowfall or snow water equivalent in a storm, this condition was viewed with concern and each new storm was monitored closely. Fortunately, the storms were not strong enough to trigger widespread avalanche activity. Of the 20 avalanches were recorded at Wolf Creek Pass, only four were larger than Class 2.

Avalanche Mitigation

Avalanche control missions successfully eliminated fragile snowpack layers before widespread avalanching could occur. Two control missions were necessary on Wolf Creek Pass on February 14 and 26 and on Monarch Pass on January 27 and April 1st. No control missions were necessary on Cumbres or La Manga passes. Significant avalanche debris (8 ft x 300 ft) covered Monarch Pass after avalanche control work on January 27, but other road hits left only small deposits. Total seasonal traffic delays were limited to 3.75 hours for two avalanche control missions at Wolf Creek Pass and a similar duration for two missions at Monarch Pass.

Avalanche Research

During extended periods of low avalanche danger, ongoing research is conducted into the nature of avalanches effecting the highways, particularly at Wolf Creek Pass where a wealth of historical weather and avalanche data is available. This year, current and historical data was collected and stored on the new computer, thus providing easy access to this information for further study.

A related project is to identify snow stability trends that lead to avalanche activity effecting Wolf Creek Pass. The most recent examination into historical weather and avalanche data shows that most late season storms, generally after mid-March, have had little or no effect on the pass. This was born out this season (and the previous two seasons) when the winter's biggest storm came in late March. While there was significant new snow, there was no threat the highway and avalanche control work was unnecessary. Other trends have been observed and documented and will be presented at the International Snow Science Workshop this Fall.

Snowpack conditions in the avalanche track are an important contributory factor for snow to reach the highway. Future research will concentrate on how to quantify these features for even more accurate avalanche forecasting.

Avalanche Education
Six avalanche awareness courses were given this winter, including ongoing training for CDOT personnel and two classes for the general public. See Table 4 for details.

CDOT/Eisenhower Tunnel Forecast Office

This was the seventh season of operation for this office which is housed in the CDOT engineers building (Road Control) at the west portal of the Eisenhower Tunnel. Lead forecaster Lee Metzger and coworker Stu Schaefer staffed the office.

The forecast area, CDOT Region 1, includes US 40, Berthoud Pass; US 6, Loveland Pass and Interstate 70 from Georgetown to Vail. Cameron and Independence passes are monitored when required. Snowfall and weather data are gathered daily from snow study plots located at Road Control, Berthoud Pass, Loveland Pass, Vail Pass and the highway shop near Arapahoe Basin. Forecasters are on duty from November 1 through April 30 but continue into May if snow conditions warrant.

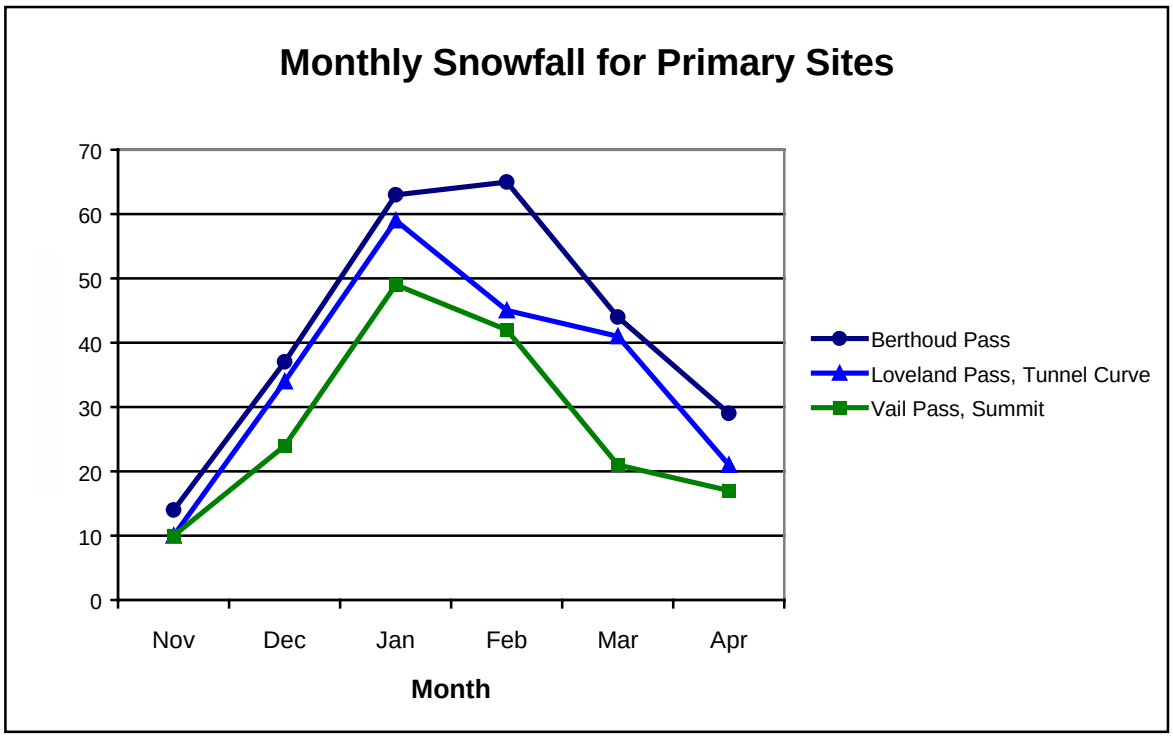
Synopsis
As with other forecast regions, the season started very slow. Snowfall in November was the lowest ever recorded by this office and snow did not start to accumulate until mid-December. By the end of February, study plots were very close to average. But the weeks to follow brought a rapid decrease in snowpack depth. Season totals from Vail, Berthoud and Road Control were 20–30 percent below normal at the end of April.

Weather
Snowfall is monitored from six study plots located throughout the forecast area. Five of these sites have been collecting data since the office opened in 1993, building a database for future reference. Snowfall amounts were significantly below average this winter. Vail Pass was 75 percent of normal; Berthoud Pass, 82 percent and Road Control only 70 percent of normal.

Winds and temperatures are monitored from two weather stations located on Loveland and Berthoud passes. Temperature is also recorded at the Road Control study plot. Overall, temperatures were warmer this year. Strong winds this winter contributed greatly to the avalanche activity as snow drifted into avalanche starting zones.

Monthly Snowfall (inches)

Location	Nov	Dec	Jan	Feb	Mar	Apr	Total
Berthoud Pass	14	37	63	65	44	29	**252**
Loveland Pass, Tunnel Curve	10	34	59	45	41	21	**210**
Road Control (Ike Tunnel)	5	26	48	43	33	25	**180**
Vail Pass, summit	10	24	49	42	21	17	**163**
Vail Pass, Narrows	13	24	56	39	17	4	**153**
Arapahoe Basin	7	26	41	43	27	27	**171**



Snow and Avalanche

Due to the very light snowfall early season, temperature gradients dominated the snowpack in all slide paths holding snow. Significant avalanche activity was expected as soon as a slab developed on top of the ensuing depth hoar. This occurred in mid-January and avalanche control work released slides that ran full depth to the ground, thus eliminating most of the underlying weakness. Interestingly, many paths that traditionally run were able to endure this slab and never failed at all. From then on, average and consistent snowfall created a fairly strong snowpack and there was only minimal avalanche activity the rest of the season.

The Seven Sisters avalanche paths on Loveland Pass were a perpetual problem. They can produce natural slides to the road with very little new snow and wind, which happened on a

few occasions this year. The vast majority of control work and road closures are due to these seven slide paths. By March and April most avalanche paths had a moderate-to-strong snowpack. With no major storms, the end of the winter came and went with little further activity.

Avalanches Reaching the Road (size 2 or larger) and Length of Centerline Covered

Highway	Natural	Triggered	Depths and total length of debris at centerline (ft)
I-70/Georgetown to Vail	1	3	3 x 195
US-6/Loveland Pass	8	37	3 x 1,340
US-40/Berthoud Pass	0	7	3.5 x 108
Loop Rd (Ike Tunnel)	0	1	5 x 20

Office Operations

Significant equipment upgrades were made this season. First, new phone lines enabled the forecasters to have a dedicated line to access remote weather stations. Second, an upgraded computer system was installed this spring. This combination will enable the forecasters to have both e-mail and Internet capabilities next season.

Backcountry Observations

Most backcountry avalanche observations were recorded in January and February when enough weight from new snow finally collapsed the weak depth hoar near the ground. Thirty slides were recorded in January and more than 20 in February. A small avalanche cycle occurred in April when temperatures warmed rapidly, but most slides were shallow and small.

Avalanche Incidents

A skier-triggered slide in February reached the highway near the top of Loveland Pass but a beacon and probe search confirmed no one was in the slide. On April 2, after an insignificant snowfall, Seven Sisters No. 4 and No. 6 released naturally. Five vehicles were trapped between the debris until a path could be cleared to evacuate them. No vehicles were hit by the avalanches. The forecast region had two backcountry avalanche fatalities in January, one each on Berthoud and Loveland passes.

Avalanche Education

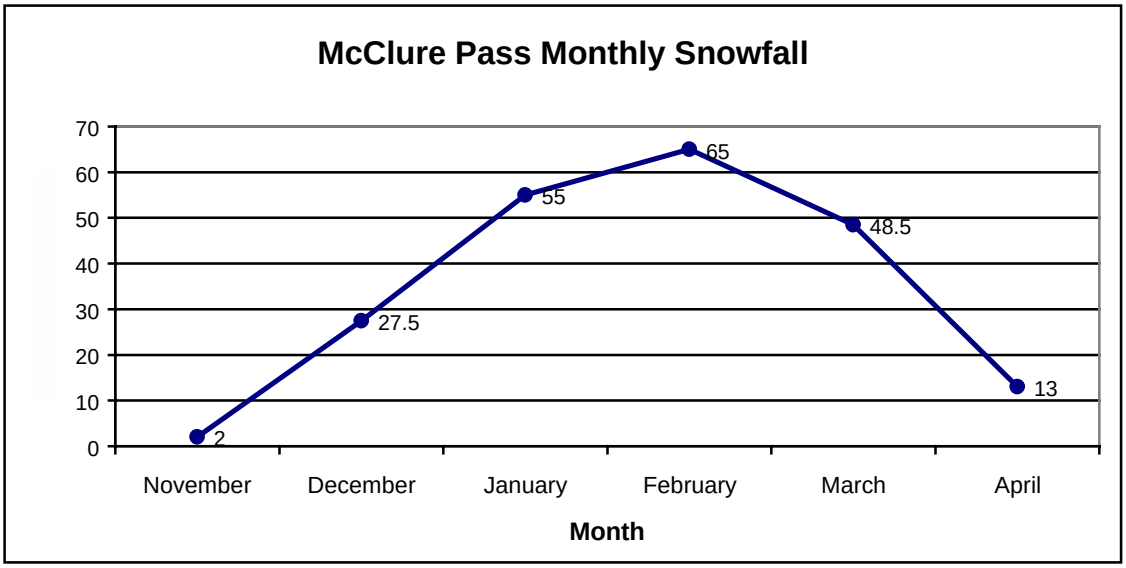
Avalanche training was done throughout the winter and more than 150 people were contacted. Many informal shop discussions were held about current avalanche conditions and avalanche beacon operation. CDOT personnel were issued new Tracker DTS beacons this winter which stimulated a great deal of interest in avalanche rescue practice.

CDOT/Western Slope Forecast Office

The Western Slope Avalanche Forecast Office, based in Carbondale, provides avalanche forecasting services to Region III, Maintenance Section 2, for four highways in the central Colorado mountains. This office is also responsible for the opening of Independence Pass in the Spring. Colorado 133 over McClure Pass near Marble is the primary area of responsibility with additional forecasting for Colorado 139, Douglas Pass; Colorado 65, Grand Mesa, and U.S. Highway 24 at Battle Mountain. Forecaster Rob Hunker issued 48 regular season Avalanche Hazard Advisories to CDOT from November 22 to April 11. Communication between this office and CDOT was enhanced by the use of e-mail for the dissemination of Advisories and other correspondence. Also, CDOT standardized its avalanche beacon inventory by purchasing new Tracker DTS beacons for every patrol in the region. The simple operation of the "Tracker" boosted morale and confidence for all CDOT personnel. This office also commented through newspaper interviews on three occasions in regard to two backcountry avalanche fatalities in the Aspen area.

Weather

Drought conditions were the fear and the reality from October through December. On December 31 precipitation was 16 percent of average and the snowpack was only 32 percent of average. During the 10-day storm event of January, air temperatures were warmer than average which produced periods of rain below 9000 ft. February and March snows were regular but lacked a major storm event. In fact, no storm this winter was considered major enough to create a significant avalanche danger to the highways. As the season progressed, the average McClure Pass snowpack depth and water content increased to 87 percent on March 31. Wind speeds were generally average but the fastest velocity ever recorded from this site, 46 mph, came on March 5. This year will be remembered as mild with just enough snow to create dangerous avalanche conditions. The following table shows monthly snowfall totals on McClure Pass.



Snowpack and Avalanche Summary

The sparse, early season snow cover was soon transformed into the classic, cohesionless Colorado depth hoar, forming a weak basil layer near the ground. This faceted grain growth continued through the early part of January before being destroyed by rain at elevations below 8,500 ft. But above 9,000 ft., with heavier snows in January and February, a tender strength versus stress relationship developed at the interface of the basal depth hoar layer and the slab above. This was complicated further with an ice crust and surface hoar shear planes in mid-pack.

In February faceted grain growth in the basal layer slowed and bridging developed in the overriding slab. The danger persisted as a major storm event could surely collapse the slab. However, this heavy precipitation storm event did not occur. The regional snowpack gained considerable strength during the first week of March and continued to do so through the rest of the month.

There were only three road closures in Region 3 during the season, two on Grand Mesa (February 16 and March 23) for avalanche control work, and one on McClure Pass on February 22. The latter, however, was due to a massive rockslide. A small wet loose avalanche cycle occurred on Battle Mountain on March 27 but the debris did not reach the highway. This was another unusual winter for Grand Mesa because it is normally closed from five to nine times for avalanche control work. In fact, this was an unusual winter for all the avalanche areas on McClure, Douglas and Battle Mountain passes because no avalanches reached these roads. Not even a significant wet avalanche cycle occurred this year. With dry conditions in early April, the snowpack began to melt out and the avalanche season ended by mid-April. An uneventful summary of road closures and avalanches reaching the highways is shown below.

Road Closures and Number of Avalanches Reaching the Road

Highway	Natural	Triggered	Road Closures
CO 133/McClure Pass	0	0	1*
CO 65/Grand Mesa	0	7	2
CO 139/Douglas Pass	0	0	0
US 24/Battle Mountain	0	0	0

* rock slide

Severance Tax Projects

We used severance tax to fund several projects that will help us make better forecasts and expand our outreach. Some had immediate results in the form of a product, while others were projects lasting more than a year and will produce deliverable results in the near future. Here are brief descriptions of the projects.

Loveland Pass Safety Brochure
In December the CAIC produced and printed 1,000 copies of a new pamphlet entitled Loveland Pass Avalanche Areas. This pamphlet has photos and descriptions of the avalanche areas that are often skied and snowboarded on Loveland Pass, and it is our hope that the pamphlet will promote safety among the area's frequent users. A second printing of 500 copies was made when the original supply was quickly exhausted. Project leader, Nick Logan.

Weather and Avalanche Database
Beginning in 1983, the CAIC had recorded much of its incoming daily data in handwritten logs. For years we had wanted to transcribe the data but did not have the funds for the project. Finally severance tax funding gave us the opportunity to convert these 17 years of data to an Access database. A data-entry operator converted 13 years of data this year, and the job will be finished next fiscal year. These historical data will be available for retrieval by the forecasters, for research projects, and for developing nearest-neighbors models. Project leader, Nick Logan.

GIS Highway Map
For several years in the 1990s Dale Atkins developed a Highway Avalanche Atlas that included every avalanche path in Colorado that could affect a state or federal highway. Now we are converting the atlas into a GIS product. This will eventually be available on CD-ROM and will have photos, maps, and physical and historical data attributes for these slide paths. It will be a valuable tool for CAIC forecasters, CDOT maintenance and engineering personnel, and land-use planners. About half the job was done this year, and it will be completed next year. Project leader, Dale Atkins.

Web Site Upgrade
Several years ago Dale Atkins developed the CAIC web site on a shoestring. It was an immediate asset for us, for it made thousands of people aware of the services and products that we provided. Severance tax funds gave us the opportunity to give our site a cosmetic facelift and more substance in the form of additional pages and content. Dale got the revised web site online in November with a more user-friendly format, more accident data, and information on products and publications. Project leader, Dale Atkins.

Web Site Clickable Map
Dale has been working on a clickable map that will show the 10 avalanche zones of the Colorado mountains. The idea is for a user to click on a zone, town, or mountain range and get current snow, weather, and avalanche data , and danger ratings. We want to display avalanche danger in a graphic that shows the danger by elevation and aspect (compass bearing).

However, we ran into problems that delayed this project, but we expect it to be operational next year. Project leader, Dale Atkins.

Avalanche Forecast Model (Nearest-Neighbor Model)
Nearest-neighbor avalanche forecast models have been used in Europe for 20 years (and at Jackson Hole, Wyoming). With inputs of current snowfall, wind, temperature, snow depth (and other field data), the model searches an historical data base to find the 10 days in the data set that nearest match the input data. The model then displays the avalanche activity that occurred on those 10 days, which gives the forecaster a heads-up on what could happen.

For 15 years we have talked of developing a nearest-neighbor model for specific sites in Colorado, and now severance tax is making it happen. We have entered into a contract with the Department of Geophysics at the Colorado School of Mines to test several models using several data sets. We expect to have a test model for Red Mountain Pass, and perhaps Berthoud Pass, by December 2000. Project leader, Dale Atkins.

Back-country Observers Network
For many years the Utah Avalanche Forecast Center has relied on a small group of well-trained back-country skiers to gather snow and avalanche data, on a pay-per-observation basis. We have wanted to do the same in Colorado but never could afford to. Now we can. Last year Scott Toepfer found eight observers for key back-country areas, got them under contract, and had them gather and send data to the CAIC forecast office in Boulder. Next year we will give further training to refine the observations in this continuing program. The data add detail and accuracy to our daily hotline messages. Project leader, Scott Toepfer.

Avalanche Educator
We hired Halsted Morris to teach 10–12 avalanche courses, which helped us meet the demand for avalanche education by the public and took some of the burden off the forecast staff. Halsted did an excellent job, and next year will help coordinate our training calendar in addition to teaching a full slate of classes.