(7)

COMMITTEE REPORT

HOUSE

1/15/80

FURTHER: FINANCE

Date: 1-22-80

Mr. Speaker:

The Committee on STATE AFFAIRS has had HB 534

"An Act authorizing the state, through the Department of Public Safety, to participate in the Alaska avalanche warning system; and providing for an effective date."

under consideration and (a majority of the committee) (the committee) reports it back with the following recommendations:

[X] do pass [ ] do not pass

[X] do pass with attached amendments(s)

[X] replace with CS for HB 534 [ ] same title [X] new title

and recommends ______

[ ] AND attaches a "Letter of Intent" [ ] New Fiscal Note

[ ] reports it back without recommendation

[ ] referred to the ______ Committee

MEMBERS SIGNING DO PASS

[signatures]

MEMBERS HAVING OTHER RECOMMENDATIONS:

[signature]

CHAIRMAN

H 60 (Rev. 12/78)

STATE OF ALASKA

JAY S. HAMMOND, GOVERNOR

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

OFFICE OF THE COMMISSIONER

POUCH Z
JUNEAU, ALASKA 99811
(TELEX 45-328)

January 31, 1980
000H

Re: 000H-
Avalanche Control Programs

Honorable Mike Miller
Alaska State Legislature
Pouch V
Juneau, Alaska 99811

Dear Representative Miller:

During your teleconference hearing on January 21, 1980 concerning avalanche control programs and the Avalanche Warning Center, Mr. Marco A. Pignalberi, Assistant Deputy Commissioner for Maintenance and Operations testified on behalf of DOT/PF.

The consultant report he referred to in his testimony came off the press on January 22, 1980. Enclosed are eight copies for your committee. Please bear in mind that this consultant's report has not yet been reviewed by our Department. The recommendations contained in it may be, in some cases, already implemented or planned or discounted. We will review the report and incorporate appropriate parts in our avalanche control plan.

We appreciate your interest in this important effort to protect our highway users.

Sincerely,

Robert W. Ward
Commissioner

CC: Patrick P. Ryan, Deputy Commissioner M&O

28A-T1LH

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
P.O. Box 1628, Juneau, Alaska 99802

3200
January 2, 1980

The Honorable Mike Miller
Alaska State House of Representatives
Pouch "V" State Capitol Building
Juneau, Alaska 99811

Dear Representative Mike:

As we discussed a few days ago, I am enclosing revised budgetary data to explain the two proposed appropriation bills for funding the Statewide Alaska Avalanche Warning System.

This financial plan essentially follows the original project proposal of 8/1/79 that you have, however, it is updated to reflect greater capital investments needed during the first-year of implementation. From then on for State participation, I would expect a financial need in the neighborhood of $150,000 per year. This would enable continued operation and maintenance of the system.

If any problem develops with the line-item appropriation approach, we would then have to consider existing capabilities of individual benefitting Departments to help carry the load. This would be unfortunate, as progress would probably be a lot slower in that case.

Thanks for your interest and help in this project, Mike. There seems to be good momentum for support right now, and I'm optimistic that significant progress can be made in the year ahead. Should you want to go over the financial plan in more detail, please give me a call.

Sincerely,

Bob

ROBERT C. JANES
Deputy Director of State and Private Forestry

Enclosures

F&AM #01-060
Amendment#______________

FIRST-YEAR FINANCIAL PLAN (PROPOSED)

Agency	Table is in Thousands of Dollars					
	Direct Funding-Coop Acct#				Indirect Support	Total
	1/1-6/30/80	7/1-9/30/80	10/1-12/31/80	Total		
USDA						
FS-R10	30	14	15	59	21	80
FS-RM	-	-	-	-	5	5
SCS	-	-	-	-	9	9
USDC						
NWS	-	-	-	-	20	20
USDI						
BLM	10	20	-	30	10	40
USDOT						
AR	-	-	-	-	5	5
State of AK						
DOT & PF	40	20	25	85	16	101
DNR	40	20	20	80	30	110
DPS	15	5	5	25	10	35
Boroughs						
Juneau	-	2	1	3	2	5
Anchorage	-	2	1	3	2	5
Private						
Alyeska Ski Resort	1	-	-	1	2	3
Totals	136	83	67	286	132	418

ALASKA AVALANCHE WARNING SYSTEM
and
FIRE WEATHER FORECASTING SERVICE

Implemention Plan

I. Objective: Commence first-year operations in January, 1980, with core-group staffing of the Warning Center in Anchorage installation of field observation stations, and capital investment items.

II. Direct Financing Needed: For the period January 1, 1980 through December 31, 1980, there is a total need of $286,000. Details are provided below. This amounts to 67% State, 31% Federal, and 2% other.

III. Indirect Financial Support: For the same period noted above, $132,000 of contributed support is furnished by various cooperators. This amounts to 53% Federal, 42% State, and 5% Other.

IV. Direct Financing Details:

A. Anchorage Warning Center (AWC) Personnel

1. Lead Forecaster (GS-12 @ $36,972/yr) for period 2/1-12/31/80........................$30,810

2. Assistant Forecaster (GS-11 @ $30,862/yr) for period 4/1-12/31/80........................$25,720

3. Two Fire Meteorologist Tecnicians (GS-7 @ $20,826/yr) for period 5/1-9/30/80......$17,355

4. Moving costs for two permanent forecasters..$30,000

5. Travel and per diem for training, etc.......$ 8,000

6. Office communications, rent, etc...........$ 6,115

$118,000

B. Field Stations. Installation and contractual agreements. — $ 20,000

C. Capital Investments

1. Data Collection Recall Program..............$ 6,000

2. Instrumentation.............................$10,000

3. Orographic Precipitation Models. Contract for two: Southcentral @ $76M; Southeast @ $40M..$116,000

$132,000

Sub Total $270,000

D. Overhead Assessment (@ 6%) — 16,000

Total $286,000

RESOLUTION

NATIONAL SKI PATROL SYSTEM INC. - ALASKA DIVISION
Annual Meeting - Anchorage, May 25-26, 1979

WHEREAS, The National Ski Patrol System, Inc. is a non profit volunteer organization of 23,000 individuals, with more than 300 patrollers in Alaska dedicated to protecting the health and safety of thousands of winter recreationists including, but not limited to alpine and nordic skiers using both developed and undeveloped mountainous terrain, and

WHEREAS, The State of Alaska had the highest number of fatalities, (29) in the Nation due to snow avalanches since 1970, followed by the States of Colorado and Washington with 24 and 21 deaths respectively, and

WHEREAS, Snow avalanche hazards exist throughout the State of Alaska, with: (a) 180 known avalanche paths that cross public highways and railroads; (b) over 500 human occupancy structures lying directly in avalanche paths; (c) thousands of avalanche paths within heavily used developed and undeveloped public recreation areas; (d) the Juneau area posing the greatest potential threat than anywhere in North America for a catastrophic avalanche, with resulting loss of many lives and immeasurable property damage, and

WHEREAS, central snow avalanche warning systems have proven effective in the States of Colorado, Washington, and Oregon, and

WHEREAS, there is a need for a Statewide Avalanche Warning System in Alaska, to alert its citizens to changing snow conditions conductive to severe snow avalanche danger, and

WHEREAS, the U.S. Forest Service through its Division of State and Private Forestry in the Alaska Region, has proposed a cooperative project to implement an Alaskan Avalanche Warning System (AAWS) with joint financing by various Federal and State agencies, now

THEREFORE BE IT RESOLVED, the Alaska Division of the National Ski Patrol System, Inc. strongly supports the proposed Alaska Avalanche Warning System and urges first-phase implementation to start for the winter of 1979-1980, and

BE IT FURTHER RESOLVED, the State of Alaska Legislature is urged to adopt legislation to authorize the establishment and continuation of a line item annual appropriation to the Department of Public Safety, for the purpose of representing the State's interests in the participating Departments of Public Safety, Transportation, and Natural Resources; the annual appropriation should be consistent with the enclosed suggested financial plan, based upon benefitting State agencies.

Adopted May 26, 1979 NSPS - Alaska Division

J. Scott Grundy, Division Director

ALASKA AVALANCHE WARNING SYSTEM

SUMMARY

5-10-79

1. Situation: Alaska Avalanche potential exists year around which has resulted in Alaska being the highest in avalanche fatalities in the Nation since 1970. Approx. 500+ structures are directly exposed to avalanches with the Juneau area posing the greatest potential for catastrophic avalanching in North America. There are approximately 180 avalanche paths crossing public highways and railroads. There are thousands of avalanche areas within noted developed and undeveloped recreational areas with significant potential for avalanche fatalities.

2. Need: a) Main Objective - Establish an interagency Alaska Avalanche Warning System (AAWS) on a statewide basis to inform outdoor users of changing snow conditions and related hazard potential. Institute public awareness programs through lectures and formal schooling in snow management.

   b) Secondary objective: Provide fire weather forecasting and mountain meterology for mountain climbers during the summer months; provide flooding forecasting in areas covered by the Orographic Precipitation Model.

3. Organization: The USDA-Forest Service, Division of State and Private Forestry will be the lead agency with AAWS located in Anchorage at the National Weather Service Office comprising of a project leader and two meterologists. There will be six primary field stations manned by a Temporary Snow Mgt. Tech. and 25 supplemental field stations either manned by contractual arrangements or remote instrumentation. Field Stations will be scattered throughout Kenai-Anchorage-Mt. Mckinley and Juneau Areas. USDA-FS will provide personnel ceilings for permanent employees and administrative support.

4. Project cost (Estimated)

a. AAWS Operating Cost *

1)	Staffing	170,000
2)	Supplemental Station Contracts	24,000
3)	Travel for training and Supervision by Staff	15,000
4)	Project Travel for field personnel	10,000
5)	Commercial Communications	10,000
6)	Station Mtc. & Supplies	5,000
7)	Equipment Replacement	15,000
8)	Staff office space, clerical, data transmission & meterological support	18,000
9)	Cooperative agreements on remote site mtc.	3,000
10)	Overhead Cost	42,000
	Total	312,000

b. Capital Investments (Initial)

1)	Weather instruments & radio equipment	30,000
2)	5 remote weather instrumentation stations & installation cost	75,000
3)	Orographic Precipitation models for South-central, Mt. McKinley, Southeastern	100,000
4)	Overhead cost	28,000
	Total	$233,000

* Portion of this estimated cost can be absorbed through present agencies operating program.

FINANCIAL PLAN:

Suggested financial plan by Agencies based upon beneficial Cooperators.

AGENCY	By Fiscal Year in "M" Dollars 79	80	81	82	83
USDA - FS	50	90	115	115	100
RMF	25	-	10	-	-
SCS	9	1	2	2	2
USDC - WS	3	10	25	35	30
USDI - BLM**	-	25 **	25 **	25 **	25 **
NPS	-	-	20	25	20
USDOT -AR	-	5	6	11	10
State of Ak.	-	53	82	112	112
DNR SP (25%)	-	-	-	-	-
GS (10%)	-	-	-	-	-
FL&W (10%)	-	-	-	-	-
DOT (50%)	-	-	-	-	-
DPS (5%)	-	-	-	-	-
BOROUGHS - Juneau	-	2	6	6	6
Anchorage	-	-	-	10	7
Private - Alyeska Ski Resort	2	1	1	1	1
TOTAL	89	187	297	342	312

** For Fire Weather forecasting only. cost estimated at $25,000 per year which is based upon the meterologist salaries for 4 months.

5. ACTION PLAN

PHASE I- (FY 79 & 80)

FY 79 -

a. Install remote weather instrumentation on Max's Mt.

b. Activate Primary Stations at Girdwood, Juneau and Chugach State Park

c. Activate Supplemental Stations at Thompson Pass, Isabelle Pass, Bird Cr., Turnagain Pass, 6 Mile, Grandview, Tazlina Lodge, Summit Lake, Hatcher Pass, Eaglecrest Ski Area, Salmon Cr. Reservoir, Chugach State Park and Alyeska Ski Resort.

d. Project Leader duties will be carried out by present S&PF Staffing.

PHASE II (FY 81)

a. Hire Project Leader GS-12

b. Hire one GS-11 Meterologist *

c. Activate Primary Station at McKinley National Park

d. Activate Supplemental Stations at Arctic Valley Ski Area, Kluckwan, White Pass, Kahiltna Glacier, McKinley National Park Hdq.

e. Contract Orographic Precipitation Model for Mt. McKinley

f. Install remote weather instrumentation on Mt. Juneau

PHASE III (FY 82)

a. Activate Primary Station at Moose Pass and Valdez

b. Activate supplemental Stations at Sitka and Hyder

c. Install remote weather instrumentation sites at Mt. McKinley, Mt. Troy, and Eagle River Area

PHASE IV (FY 83 and on) - AAWS in full operaton.

a. Activate supplemental stations as needed.

* Will be hired during third quarter of FY 80 if BLM enters into a cooperative agreement with AAWS to perform Fires Weather forecasting.

SEWARD HIGHWAY AVALANCHE SAFETY PLAN

Prepared by: Alcan Avalanche Services

SEWARD HIGHWAY

AVALANCHE SAFETY PLAN

Prepared by: Alcan Avalanche Services

in collaboration with: Alaska Department of Transportation and Public Facilities; Central Region, Maintenance & Operations and Graphics Section

December, 1979

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TABLE OF FIGURES

ACKNOWLEDGEMENTS

The following personal thanks are written by David Hamre, the principal author of this report.

The need for a comprehensive report on avalanche forecasting and control for the Seward Highway developed from the unusually large and frequent avalanches of March 1979. Recognizing the long-term nature of avalanche problems, Marco Pignalberi (DOT/PF) concluded it was necessary to upgrade the avalanche control program. These conclusions brought to the surface the necessity of preparing this report. Marco has provided invaluable direction and assistance, without which this report would not have been produced as comprehensively.

Field observations were essential to provide an information base. A wealth of information was provided by Jack Morrow (DOT/-PF) who is probably more knowledgeable of the Seward Highway avalanche problems than any person interviewed. Without his assistance there would be an absence of substantive data on which to base the control program.

Forecasting avalanches is a difficult task. Describing the techniques one uses in forecasting is even harder. For this reason I asked Bengt Sandahl to write Chapter IV, AVALANCHE FORECASTING FOR THE SEWARD HIGHWAY, as he is one of the foremost forecasters in the country. Currently he is the forecaster for Little Cottonwood Canyon, Utah, but his experience with avalanches in Alaska from 1954 to 1964 has proven itself invaluable.

Assistance was provided by Geoff Freer (B.C. Ministry of Transportation, Communications, and Highways), and Peter Schaerer (Canada National Research Council), in the review of signing systems and avalanche defenses in use in British Columbia. Fred

Schliess, the Head Forecaster for Rogers Pass, B.C., gave a concise and revealing interview on avalanche forecasting and control at that location.

Interviews on the history of avalanche control on the highway were provided by Bob Bursiell, Bengt Sandahl, and Jack Morrow, offering a clear perspective on previous work.

To all these people and more go my thanks for assistance given in preparation of this document. Without this help the information contained in this document would have been inadequate for the purpose intended.

PREFACE

The primary purpose of this plan is to make the need for active avalanche control on the Seward Highway obvious to all parties providing monetary and material support. In addition, this plan is hoped to provide a basis of information for the implementation of a full-time control program.

This plan gives an historical perspective on problems, documents the current situation, and provides recommendations for the direction of a control program. Numerous problems will surface as this program becomes operational and revisions will be necessary to achieve the goal of avalanche safety.

This plan cannot encompass any of these operational problems, as each is unique and will have to be dealt with individually, therefore, flexibility is emphasized.

No government or private agency may use any of the material contained herein for the purpose of establishing avalanche zoning. Only those avalanche paths pertinent to highway operations have been documented.

The authors and consulting agency take no responsibility for any legal actions arising from the operation of a control program on the Seward Highway. Clearly this document is only intended as an aid to the program and in no way is connected with the operational aspects of an avalanche control program on the Seward Highway.

The problems in documenting this information under tight time constraints have been significant. Other similar plans have taken years to design and draft. Because of the great magnitude of the avalanche problems under discussion some minor discrepancies may arise. As a result of this and the evolution of the program itself, it will be necessary to revise this document on a yearly basis.

The program's integrity will rest upon the willingness of government and private agencies to cooperate and provide the resources necessary to run a sophisticated program.

Chapter I

AN INTRODUCTION

The Seward Highway is located in Southcentral Alaska and runs 128 miles from Seward to Anchorage. Leaving Anchorage, the road soon enters the Chugach Mountains in a parallel course with the Turnagain Arm of Cook Inlet. Steep mountains rise directly from the water, therefore the road bed is restricted to the hillside above tidal flats. As the highway runs across Bird Hill, 40 miles from Anchorage, it must travel across a five-mile section of almost uninterrupted avalanche terrain. This section constitutes the most severe avalanche exposure on the highway. After Bird Hill, the highway continues through the Chugach, intersecting 42 different avalanche paths, and joins the Sterling Highway at Mile 37, terminating at Mile 0 in Seward.

There are 68 identified avalanche paths intersecting the highway between Mile 18 and Mile 105 near Indian. Several other areas show evidence of avalanche activity by damage to vegetation. There is a concentration of paths clustered from Mile 18 to 24 around Kenai Lake (7 paths); from Moose Pass to the Sterling/Seward "Y" (10 paths), around Summit Lake (4 paths), and on most of the section from Girdwood to Bird (20 paths). The remaining 17 paths are scattered between these clusters (Figure 1-1). Many paths will not reach the road regularly, primarily because of highway location.

History of Avalanche Control on the Seward Highway

Avalanche control and the systematic evaluation of weather conditions that lead to avalanche formation began on the Seward Highway in 1955, just three years after the Highway was completed. During Territorial days, the Highway was under the jurisdiction of the Bureau of Public Roads. After statehood, the Highway came under the Department of Highways and in 1977 this changed to the Department of Transportation and Public Facilities.

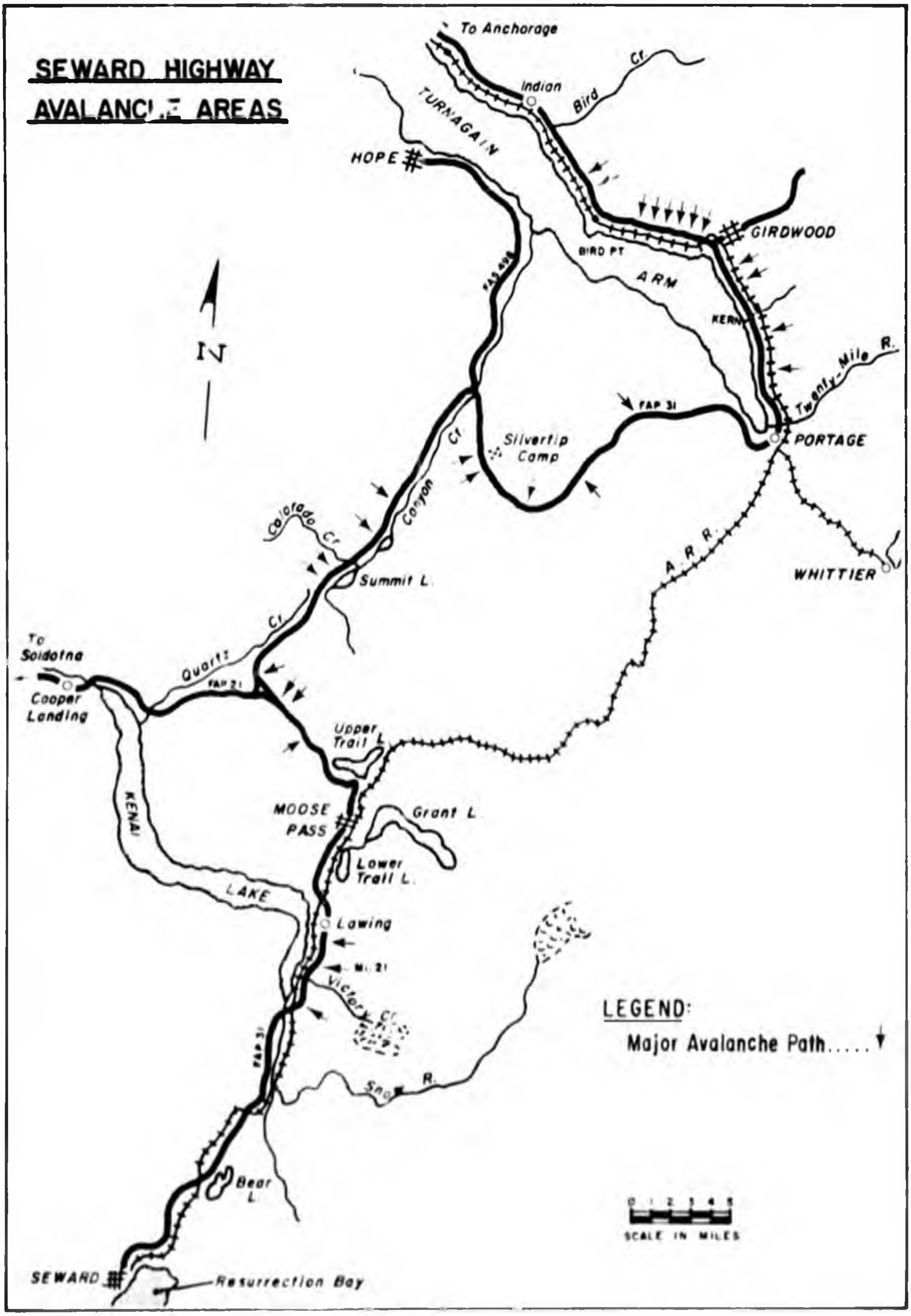

SEWARD HIGHWAY
AVALANCHE AREAS
N
To Anchorage
Indian
Bird Cr.
TURNAGAIN
HOPE
GIRDWOOD
BIRD PT
ARM
FAS 498
KERN
Twenty Mile R.
FAP 31
PORTAGE
Silvertip Camp
Canyon Cr.
Colorado Cr.
Summit L.
WHITTIER
A.R.R.
Quartz Cr.
To Soldotna
FAP 21
Cooper Landing
Upper Trail L.
MOOSE PASS
Grant L.
KENAI
Lower Trail L.
LAKE
Lawing
Mi. 21
Victor Cr.
LEGEND:
Major Avalanche Path
FAP 31
Snow R.
Bear L.
0 1 2 3 4 5
SCALE IN MILES
SEWARD
Resurrection Bay

FIGURE 1-1

From 1955 to 1957 Bob Goodwin and Bengt Sandahl established weather data as a basis for avalanche forecasts. They were able to call on the National Guard during periods of critical instability in an effort to control avalanche activity with artillery. During the winter of 1957-58, Bob Bursiel replaced Sandahl and efforts continued along the same lines.

In 1958 a formal research study of avalanche problems was initiated by the Bureau of Public Roads with major work being done on the Seward Highway and some work on the Glenn Highway. The project continued after statehood under the Planning and Research Section, Special Projects Division of the Department of Highways until the winter of 1961-62 when the Special Projects Division was disbanded.

This Division was able to work out an agreement with the U.S. Army for artillery control in weather that allowed for visual firing. This most often occurred just shortly after a storm, so the control work released avalanches approximately 50% of the time. The percentage of releases was greater in mid-winter, but there were reasonably good results even during the heavy snows of spring. Experience of U.S. Army crews in 1960 resulted in a smooth control program, which was difficult to attain in previous years due to rotation of gun crews. The end result was an increase in the percentage of avalanche release to rounds fired. This insight should speak for itself in terms of establishing the same continuity and team approach in projected control programs.

In 1959 weather instrumentation was situated on Bird Hill. From sea level to 3,500 feet, a 10-strand 1-inch cable was run from the research station located near the Whiskey Gulch mount to the top of Bird Hill. Thermistors were located at various levels to gain air and snowpack temperatures; and, an anemometer was placed at the top of the ridge to measure wind speed and direction. The thermistors worked quite well, but the wind system rimed[1]

[1] Rime - An accumulation of granular ice tufts on the windward sides of exposed objects that is formed from supercooled fog or cloud and built out directly against the wind.

heavily and eventually blew apart in a 120 m.p.h. wind. In addition, there were snow stakes located up the ridge that could be read with binoculars during clear weather. Observations showed an appreciable difference in both temperature and precipitation between sea level and ridge top stations. Using instruments and Weather Service information, the forecasters were usually able to keep a day ahead of avalanche activity which effectively aided the control aspects of the program. Using the thermistors in particular, observers could determine when milder temperatures began influencing the snowpack. When the snowpack temperatures rose, control activities were usually called for.

The winter of 1959-60 generated unusually severe avalanche activity. This was largely due to an intense storm just before Christmas leaving 11 feet of snow in the Girdwood Valley. After the first three to four feet, it was obvious to the forecasters that avalanches were going to run; therefore, a request was made to close the highway. There had never been a clear procedure established for closing the highway on the basis of an avalanche forecast. Avalanches had already closed the road by the time permission was received. There were 42 avalanches that ran between Girdwood and Bird, one of which narrowly missed the research station in the middle of the night. Three new paths were opened through conifers during this storm cycle, but generally speaking, vegetation damage was not thought to be as severe as the cycle of March, 1979.

This was the only period that full-time personnel were involved in the study and control of avalanches on the Seward Highway. The Planning and Research Section of the Department of Highways did work on the Taku Glacier to determine the rate of advance in terms of highway location, permafrost studies near Glennallen, and winter recon on several highway routes to analyze avalanche and drifting snow problems. (Interview with Bob Bursiel Sept. 1979)

In 1963 the Planning and Research Section dropped the Special Projects Division and there was little or nothing done on the

Seward Highway avalanche problem until 1967. These intervening years were periods of relatively light avalanche activity.

During the period of 1963-73 one of the most significant problems that hampered efforts to deal with avalanches was a lack of adequate equipment. It should be kept in mind that an equipment operator is one of those most susceptible to injury by avalanches in that his work necessitates exposure to potential run-out zones for long periods of time. Large machinery was not available for various reasons.

In 1967 Jack Morrow was named Anchorage District Superintendent and avalanche problems fell under his jurisdiction.

During the early spring of 1968 there was a period of avalanche activity which caused a great deal of concern. Faced with an absence of artillery, permission to helicopter bomb was requested from the FAA. They immediately decided to squash the idea. It has only been since 1975 in Alaska that this method has proven itself a relatively safe and cost-effective means of avalanche control. During the spring and summer of 1968, Morrow worked with Charles Matlock, the District Engineer, to obtain a cooperative agreement with the U.S. Forest Service providing for the use of a 75mm recoilless rifle to be fired by the Snow Ranger, Chuck O'Leary. Once the rifle was obtained, there existed a shortage of ammunition. This was soon resolved by Ret. Col. Henry M. Turner of the Alaska Disaster Office. Finally in January of 1969, all of the equipment had arrived and artillery control was accomplished on Bird Hill.

From 1969 to 1975 the 75 mm recoilless rifle was used as a means of control during and after storms that could potentially result in avalanches. There were certain limitations to the control program mainly due to the lack of full-time personnel and the necessity to shoot only under visual fire conditions.

During 1972 Department of Highways sent the Anchorage District Superintendent to the National Avalanche School. This specialized training was necessary for the activity level which was expected.

In 1974 an event occurred which caused a sudden increase in avalanche awareness in Alaska. During a large storm cycle, an avalanche occurred on the Thane Road just south of Juneau. Clean-up efforts commenced at once and while plowing debris away from the first avalanche, an operator was caught and killed by a second avalanche. All of this occurred at night in an effort to keep a road open for approximately 30 residents. A ruling that operators would not be allowed to plow avalanche debris at night resulted. This ruling still holds true today.

By 1975 Department of Highways felt that control activities needed to be expanded. Because of the long ranges involved in artillery firing and lack of visibility for visual fire during most storms, it was felt best to use a 105mm recoilless rifle for control work. Negotiations were begun with the U.S. Army and eventually resulted in a cooperative agreement between the State of Alaska; Department of Highways and the U.S. Army to provide for the loan of a 105mm recoilless rifle for avalanche control. It was decided the Department of Highways employees would fire the artillery. This resulted in a general increase in avalanche control activities on the Seward Highway.

Morrow experimented with helicopter bombing in 1975 during a severe avalanche cycle and found it to be quite effective. Occasional use of this method since then has proven it to be very reliable under certain conditions. During the March, 1979 avalanches, helicopter bombing was used almost exclusively with approximately 200 10-pound charges placed in starting zones. This method of control is relatively safe, rapid, and cost-effective.

In February, 1976, the 105mm arrived. From then until today this rifle has been the mainstay of the avalanche control program and has fired approximately 800 rounds over the last three and one-half years.

Blind fire data was initially taken from the Whiskey Gulch gun mount in 1976 to allow shooting during storms and at night. This still left the majority of Bird Hill without blind fire control capability. In 1976 there was also an explosives handling school at Mt. Alyeska covering many aspects of explosives used in avalanche control, including artillery. The Department of Highways sent two employees to this school.

<u>During the summer of 1978</u> a significant change in the program took place when Morrow assumed the position as Assistant Manager of Maintenance and Operations, leaving Larry Lucas directing the avalanche control work. Lucas carried the program through the severe avalanche cycle of March, 1979 (personal conversations with Jack Morrow October 1979).

Since the opening of the Seward Highway in 1952 there has been a constant and severe avalanche threat to vehicles using this major transportation corridor. Avalanche control programs established to date have responded to the threat in a sporadic and irregular manner. There was a period of only three years, 1959-1962, where full-time personnel were funded to work on research and control. Since 1969 control efforts have been expanding slowly, but have not made the transition to a full-scale, line item in any government budget. Inevitable gaps have occurred where protection of the public was compromised because of a lack of funding, manpower, and equipment.

Case History

Modern avalanche control is based on several important precepts, one of which is the threat of personal injury or death can be controlled to a large degree. Safety and economics will sooner or later necessitate active control programs to avoid loss of life and revenue. With this in mind, it would be worth documenting a situation that graphically portrays these concepts.

January of 1979 saw the Chugach Mountains covered with a 4 to 8-foot snowpack, seemingly stable for the most part. Temperatures had been moderate all winter, consequently, the snowpack was stable until the end of the month when a light freezing rain fell over the area. This rain froze forming a thin ice crust. A six-week period of very cold weather followed, allowing Temperature Gradient Metamorphism[1] just underneath the thin ice crust.

A series of snow storms hit the area March 4 and continued until March 22. During this period, at the 3,000 foot level on Mt. Alyeska, there was a total snowfall of 171 inches, which equated to 20.41 inches of water. Picture this amount of weight on an extremely fragile layer and steep slopes - the results were obvious and predictable.

Avalanches started immediately; growing in size and occurring frequently until the end of the storm. Artificial release of avalanches started on the 14th and continued until the 26th of March. During that time a lack of blind fire capabilities curtailed control activities on Bird Hill. As a result, there was considerable accumulation of snow. On March 19th avalanches started hitting the road. The next week many avalanches released on the highway with the situation reaching a climax level on the afternoon of March 23rd. Four large natural avalanches ran within fifteen minutes of each other, covering the road an average of 15 feet deep for nearly one mile. Figure 1-2 shows the approximate area of one of the natural avalanches and Figure 1-3 shows heavy machinery clearing avalanche debris.

---

[1]Temperature Gradient Metamorphism - The ground is near 32°F. for the entire winter. The presence of cold air on a shallow snowpack creates a steep temperature gradient between ground level and air. Warm air rises slowly through the snowpack bringing with it water vapor that has changed directly from a solid (snow) to a gas (water vapor). This process is called sublimation. Water vapor then condenses onto snow crystals higher in the snowpack in such a manner that the new crystals present the maximum surface area possible in an effort to lose heat. The end result is a large grained, loosley bonded crystal commonly referred to as depth hoar. For this report all references to this process will be referred to as T.G. metamorphism.

HOTO COURTESY OF LEWIS LEONARD

FIGURE 1-2

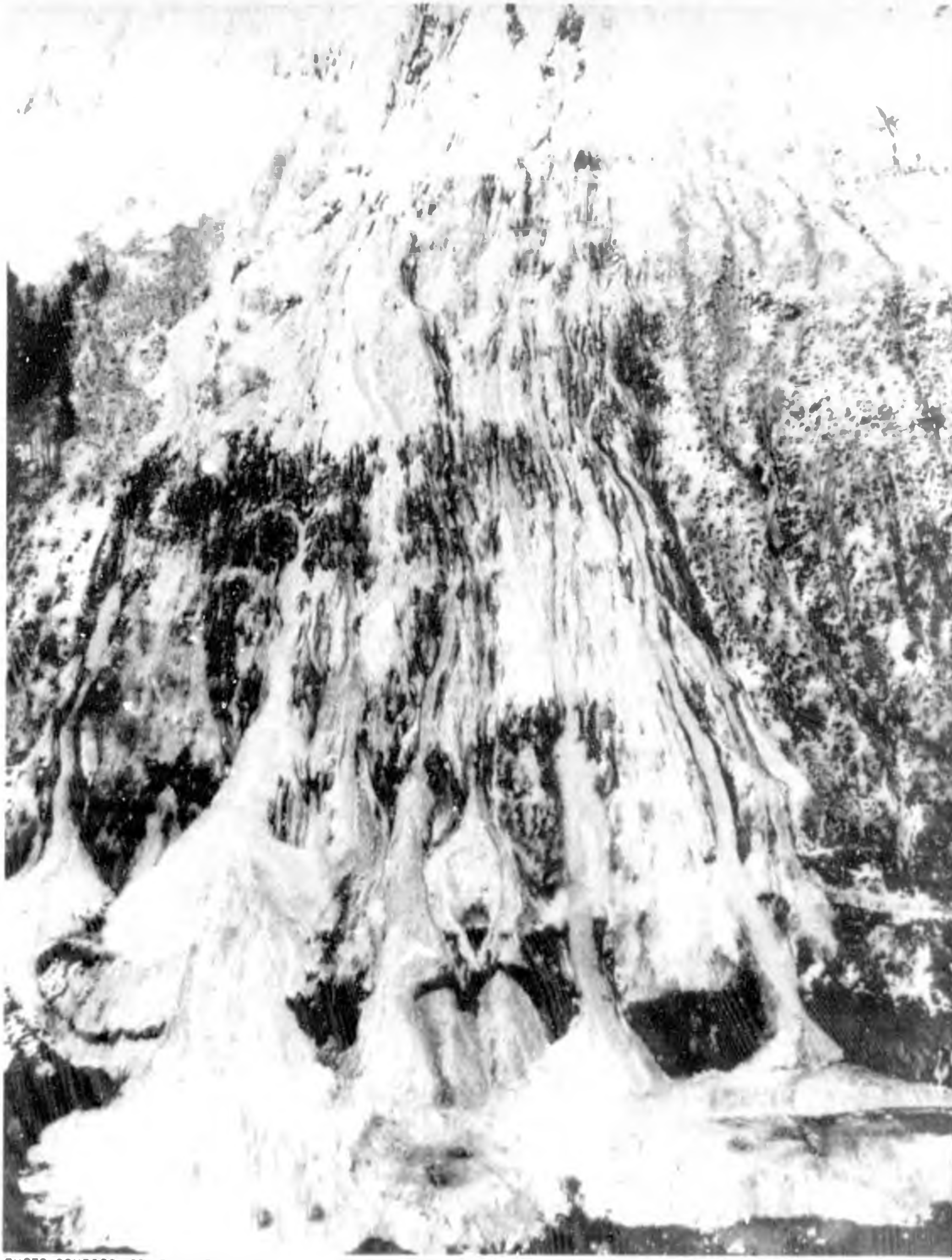


PHOTO COURTESY OF LEWIS LEONARD

FIGURE 1-3

The road was open, but fortunately there were construction activities at Potter and traffic was detained several hours. Had avalanches occurred later that day, there would certainly have been a steady flow of traffic and the outcome would have been catastrophic. Once the highway was blocked by the first natural avalanche, traffic would have backed up bumper to bumper in very short order and additional avalanche activity would have virtually inundated the roadway burying hundreds of people. The magnitude of the avalanches were such that there would have been few survivors. The first premise of avalanche control is that these situations are avoidable for the most part. This particular situation could have been avoided with an adequate avalanche control program.

For two days after the large natural releases of Friday, March 23, control activities continued to bring down more avalanches, resulting in a total of 1.6 miles of avalanche debris along the highway. An almost continuous daytime effort to open the road resulted in the removal of all debris by Sunday afternoon. Not all costs tied to these problems can be determined. There are some figures for parts of the affected operations; snow removal and avalanche control cost DOT/PF $60,000, Alyeska Resort lost $60,000 in revenue, the Alaska Railroad did not run for two days, truck transport ceased between the Kenai Peninsula and Anchorage, and electrical transmission lines were damaged.

Had control activities occurred on a regular basis during this severe storm the result would have been that numerous smaller avalanche releases would have occurred with far less debris reaching the road, fewer possibilities for the loss of life, less damage to facilities, and a much smaller economic impact.

Traffic Volume

Annual Average Daily Traffic (AADT), Fig. 1-4 has increased from 775 vehicles per day in 1959, to 3,503 vehicles per day in 1978 at Potter Flats, just outside of Anchorage. Monthly Average Daily Traffic (MADT) for the winter of 1977-1978 ranged from 1,769 vehicles in December, 1977 to 3,795 vehicles in April,

AVERAGE ANNUAL DAILY TRAFFIC

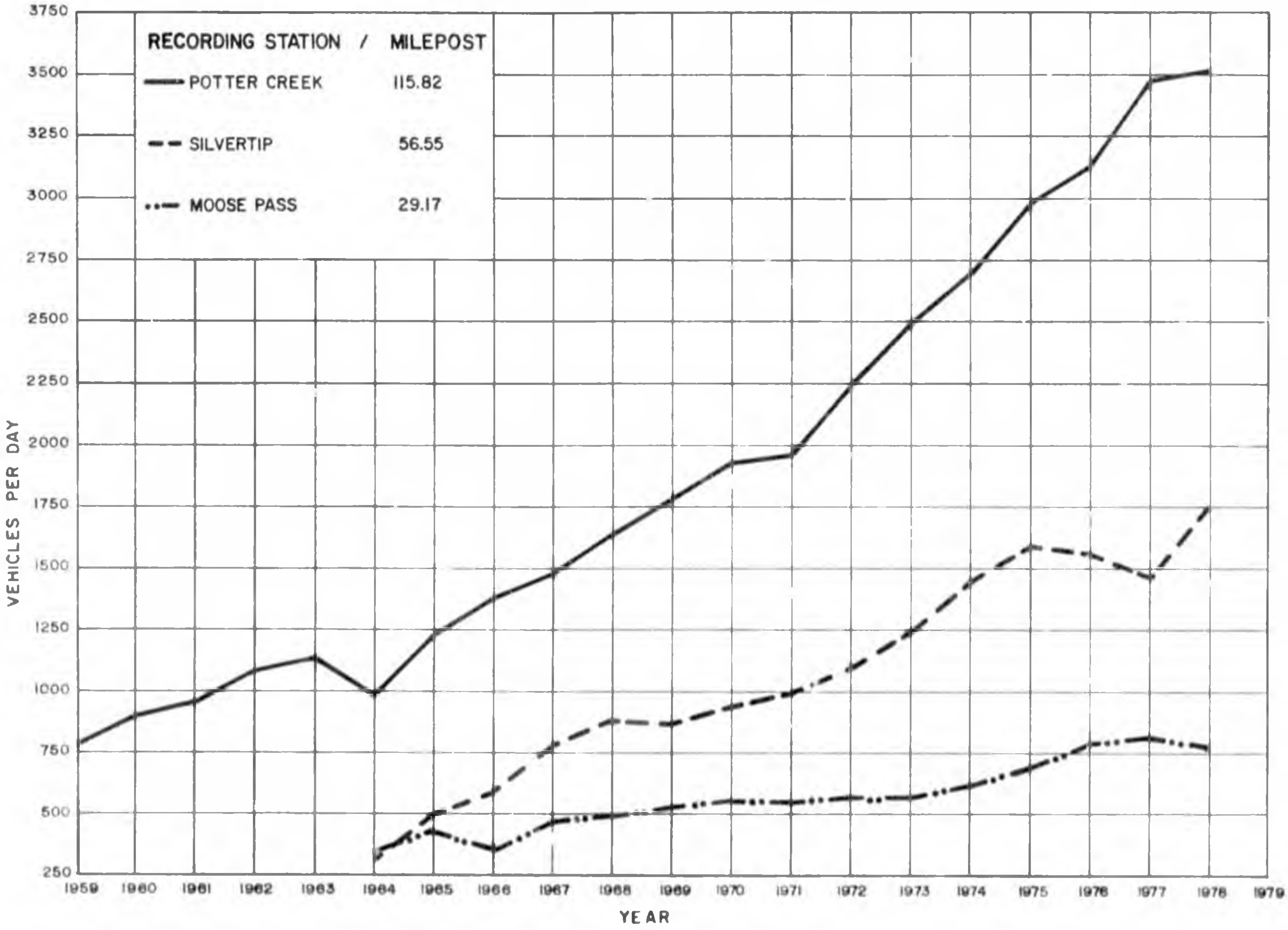


FIGURE 1-4

1978. Peak traffic periods, occurring on weekends, are roughly 50% greater than the MADT (DOT/PF, Traffic Records 1976, 1977 1978).

This is only an average. Peak volumes must be considered in order to understand the probability of an avalanche interfering with traffic. On April 2, 1978, during the height of the avalanche season, there were 8,145 vehicles counted at Potter Creek. By statistical computation, it can be assumed that an unexpected avalanche on the highway to a width of 950 feet would have collided with traffic on that day. As traffic volumes increase, the odds grow proportionately that traffic will be affected by an avalanche.

These are the reasons for the preparation of this avalanche control plan. This plan is intended to provide a basis of information for the implementation of a control program. This is by no means a solution for all situations that will be encountered in day-to-day activities. Flexibility, responsiveness, training, and experience will allow this information to be utilized to its fullest advantage in the establishment of a full-time avalanche control program for the Seward Highway.

Chapter II

OPERATIONAL CONSIDERATIONS FOR AVALANCHE FORECASTING AND CONTROL

Avalanche forecasting and control has become a fairly exact process in several areas of the country. In these areas many years accumulation of data and knowledge among seasoned forecasters has resulted in programs which operate within small margins of error.

Forecasting and control activities go hand in hand and cannot be separated in an assignment of responsibilities. Some forecasting judgments are based upon results of control work, and control work is done on the basis of a forecast. It is quite common for a forecast to be revised during control operations because of unexpected activity or lack of activity.

There are some considerations in the operation of the more intensive control programs that need mention. When artillery control is used it should release avalanches most of the time. Efficient closures and resultant scheduling of the control operation will help keep public sentiment towards the operation on a positive note. Timing of the control operations should be done to achieve the best results, particularly if there is a severe instability, however, traffic flow will have to be considered, to a certain degree, in this timing. Avalanches could trap several thousand people at Alyeska on a heavy traffic day. These are just examples, but are representative of some of the considerations used in other control programs and is noteworthy in this situation.

A plan such as this can, at best, provide a solid basis of information for the implementation of a full-time control program. It has taken fifteen to twenty years in areas with comparable problems to amass the data and experience necessary to run a sophisticated program. These areas have also been fortunate in attracting and keeping some of the finest people in the business today. Without this continuity of personnel much of the inituitive knowledge acquired in day-to-day operations is lost. This intuitive knowledge is perhaps the most important factor in the forecasting and control operation. It is extremely difficult for even the most competent forecasters to say why they do the activities necessary at the times they are done. There is usually good input from various objective parameters such as wind speed and direction, precipitation, and snowpack analysis, but there seems to be strong input from recollections of a similar storm years ago, or the distance a particular avalanche travelled, or an observation thought to be insignificant a few days earlier. This is the kind of information that is lost by shuffling personnel regularly and is probably every bit as important as the objective data gained and recorded.

There is no set procedure for running an avalanche forecasting and control program. Snow and weather conditions change constantly and as a consequence the flexibility of the program must be maintained to have the ability to re nd to problems as conditions dictate. No plan can encompass al. the potential problems and this plan specifically avoids doing that.

There are some specific limitations to the set-up of this control program. These various topics are discussed below:

Limitations to Controllability

Occasional conditions occur which result in widespread, destructive avalanching commonly referred to as climax avalanches. These occur as extreme avalanches with longer than thirty years average return interval. Vegetation along the Seward Highway is relatively sparse due to climate factors and for the most part does not present much resistance to large avalanches. For this reason it is entirely possible that over a long period of time there will be climax avalanches occurring, opening new avalanche paths. Several areas along the highway present evidence of vegetation damage indicating that this has occurred. This plan does not include all potential locations where this can occur, but an attempt was made to identify some of them. These are listed in the avalanche mapping by a slide path number (Chapter VI). It has been noted that a common misconception is that control work eliminates the possibility of these climax avalanches. While it is true that control work can reduce the effect of these widespread avalanches a good proportion of the time, there will always be conditions occurring that are resistant to the shock of artillery explosions, but react to other disruptive factors such as rapid accumulation of new snow.

Uncontrolled Avalanche Paths

Attempts were made in this study to locate gun positions that would effectively control all avalanche release zones. For the most part this was accomplished leaving some exceptions.

Until all of the fixed mounts are installed there will be problems in blind firing at certain avalanche paths. The U.S. Army should be contacted this winter to aid in setting up a means of using the mobile gun truck in conjunction with predetermined marks on the highway pavement and triangulation stakes for blind fire. This should be done at all locations requiring blind fire data (these locations are explained under Control Criteria) and at as many locations not specifically requiring blind fire data as time will allow. Eventually blind fire data should be accomplished on all avalanche paths, however, this will take a considerable amount of time.

Before Gun No. 3 is emplaced Slide Path (SP) 15 cannot be controlled effectively without considerable risk to the gun crew.

Without this mount the only means of firing on this release zone is from the highway immediately underneath the runout zone of the area being controlled.

On the Rocky Creek slide path (SP93) there are three large basins that constitute the release zone. Any of these three basins can independently reach the roadway. When emplaced, Gun No. 7 will be capable of firing on the north facing wall of the central basin; and there is a location 200 yards north of SP93 that the mobile gun truck could be used to fire on the south facing wall of the central basin. This still leaves an area approximately one-half mile across facing west that cannot be controlled from any position due to terrain features. Gun No. 8 controls the north and south basins. This area in the central basin could reach the road by itself so considerable care will have to be given to forecasting in this location.

SP1A cannot be controlled due to terrain features. Helicopter bombing can be used on any of these paths under favorable conditions, but is not reliable as the sole means of control.

Selection of Control Criteria

In order to establish a priority level for dealing with the avalanche paths on the highway, they were delineated into four different classifications: Infrequent or Frequent occurrence with an approximate return interval of three years dividing the two; and High or Low hazard according to the relative degree of hazard to a vehicle.

THIS CLASSIFICATION IS STRICTLY FOR PURPOSES OF ESTABLISHING CONTROL PRIORITIES AND DOES NOT IMPLY THAT HAZARD DOES NOT EXIST IN A LOW HAZARD AREA.

In low hazard areas avalanches usually occur infrequently, there are terrain features that somewhat buffer impact from avalanches, or the area is on the edge of maximum vegetation damage or run-out distance. The high hazard areas commonly have a run-out into water, or there is a steep bluff, bank, or cliff above which assures maximum impact to a vehicle.

Frequent Return Interval, High Hazard

Fixed mounts are recommended for firing on these paths. This will allow very accurate blind fire data to be taken for control work to be done at any time of the day or night. Guns for these fixed mounts should be brought in by a gun truck when control is needed. This has an obvious drawback in that avalanches can occur which prevent movement of artillery for control work. There may be a problem with security on the highway and therefore guns cannot be left on the platforms. Gun Position No. 2 is the exception to this if regulations will allow for a permanent storage facility and gun emplacement at a reasonable distance from the highway and public view. These fixed mounts are:

Gun Position No.	Type Weapon	Milepost
1	105 RR	99
2	105 How or 75 How	96
3	105 RR	92.7
4	105 RR	90.8
5	105 RR	44
7	105 RR	22.6
8	105 RR	20.5

RR - Recoilless Rifle; How - Howitzer

The availability of weaponry will determine the type and location of the No. 2 mount. This mount is extremely important for it controls the highest hazard area of the highway, Bird Hill, in such a manner that weapons do not have to be moved across the three miles of continuous avalanche path on the Hill. It provides the mechanism to assure control activities on this section even in the most severe storm cycles.

Frequent Return, Low Hazard

An additional mount in conjunction with the previous ones cover these paths from the following location:

Gun Position No.	Type Weapon	Type Mount	Milepost
6	105 RR	Fixed	37.4 (see attached gun position sheet)

Infrequent Return, High Hazard

These paths are covered by previously mentioned mounts or are controlled during visual fire conditions. Pavement marks and blind fire data should be acquired as time permits, but on a lower priority than the previous classifications. Some of these paths will present a significant hazard during large storm cycles.

Infrequent Return, Low Hazard

These can usually be controlled by visual firing. There may be paths that the lead forecaster requires artillery control on during storms, therefore, blind fire marks on the pavement and data can be acquired. By firing on these paths after large storms the control crews should be able to accomplish releases, reducing the volume of snow in the starting zone sufficient enough that hazards to the road will be reduced, if not controlled, for the remainder of the winter.

Following are some topics pertinent to the forecasting and control program.

Avalanche Forecasting and Control Office

A central office for the collection of information and dissemination of forecasts, control activities, and all related work needs to be established. This should be somewhere in the vicinity of Bird Hill, hopefully at the location of Gun No 2. This would not only provide for security of the gun, but would allow control work to be accomplished through the most critical section of the highway regardless of avalanche conditions. Due to the fact that the entire Bird Hill section is subject to some degree of avalanche hazard, moving control equipment through this area would be very hazardous during critical periods. By stationing a gun crew and equipment in Girdwood, and maintaining the forecasting office near Bird Point and Gun Position Nos. 1 and 2, the possibility of running into a situation where plowing cannot be accomplished because of a lack of control, and control cannot be accomplished because of a lack of plowing, is sufficiently reduced. The siting of Gun No. 2, which is dependent on the type of weapon available, will probably determine the location of this office.

Living quarters could be built to allow for 24-hour coverage. This set-up will allow for continual control activities to take place on the most hazardous section of the highway, security of the weapons and ammunition, and a rapid response to a rescue call-out. Any reference to this headquarters will hereafter be termed S.H.A. (Seward Highway Avalanche) forecast office.

Staffing Requirements

A minimum of five persons should be hired to cover the full-time staffing requirements; including a lead forecaster to coordinate the program, two assistant forecasters and two gunners. These people would probably need to work for nine months, seven months, and six months a year, respectively. This arrangement would have to be augmented by the use of two assistant gunners on an on-call basis. There is a large quantity of data that needs to be gathered to have a sophisticated forecasting system. Much of this is gathered on a daily basis, but more is acquired on a regular schedule by field observations. These field trips must include two people for safety purposes. The forecast office must be staffed by at least one person on a 24-hour basis. Considering the necessity for time off and field observations, any less than five people full-time for the avalanche season would be compromising the integrity of the system. Since all facilities will not be built this year there may not be need for all of the projected positions to be filled. It may be more advantageous to wait until well-qualified personnel are available than to move too hastily to fill key positions with personnel not fully qualified.

Hazard to Highway Maintenance and Avalanche Control Crews

Hazards to these people are very high because of the long periods of exposure in avalanche run-out zones. More than ten miles of roadway between SP1 and SP97 is capable of being buried by avalanche activity. This leaves a one-in-eight chance of being in an avalanche path along this part of the roadway. Add to this the amount of time spent clearing avalanche debris by stationary equipment and the exposure level becomes critical. Some of this exposure is part of the job and a certain amount of risk is accepted. The rest of this exposure must be relieved by the control program. There can be no hard and fast rules applied to this situation, but procedures can be forged by a time-tested and proven control program. This is where the importance of establishing a team of professionals on both crews is evident. Well-qualified and trained personnel are indispensible to an operation of this nature.

A few simple guidelines will help lower the risk factor. A three-level personnel warning system could be initiated and posted in strategic locations. In order to identify hazard they would be white (low hazard), yellow (moderate hazard), and red (high hazard). A sample sheet from British Columbia containing the information to be included in a red hazard sheet is contained in the following page. During periods requiring display of the yellow or red sheet, crews should not move through hazard zones without making the forecasting office aware of its objectives. There should always be an avalanche watch posted when crews are clearing debris. This watch must have a fool-proof method of warning crews should the need arise. All crews should wear functioning electronic locators during yellow and red hazard periods. Light rescue equipment such as collapsible probes and a shovel should be carried on all vehicles operating through avalanche zones. Radios are needed in all equipment.

HIGH

AVALANCHE HAZARD

Date:
Time:

Snowpack: Special layers ______________________

____

Temperatures ______________________

____

____

____

Weather: New snow ______ inch ______

Storm snow ______ inch ______

Temperature: Maximum ______ °F ______

Minimum ______ °F ______

Present ______ °F ______

Wind: Speed ______ m/hr ______

Direction ______

Avalanche Occurrences:
(Slope tests) ______________________

____

____

Stability of snow: ______________________

____

____

Hazard to Highways: ______________________

____

____

Weather Forecast: ______________________

____

____

Hazard Prognosis: ______________________

Avalanche Control: Road Closure at ______ hours
Control begins at ______ hours
Order of gun positions ______

Plowing Avalanche Debris at Night

This plan specifically avoids encouraging or discouraging the practice of plowing avalanche debris at night. Control work or closure will be necessary at night, therefore, without debris removal the road would remain closed all night. On the other hand, the avalanche watch will probably be unable to see an impending avalanche, thereby reducing the safety margin for the crew.

Plowing at night is an accepted practice at Roger's Pass, B.C. where a high level of integrity in a difficult situation has been maintained for a number of years in the forecasting and control operation.

Coordination with the Alaska Railroad

The Alaska Railroad runs parallel to the Seward Highway from Anchorage to Portage and again around Kenai Lake. The same avalanche paths that threaten the highway create a hazard to the railroad.

This would not be a major problem if not for the fact that the railroad has numerous operational contingencies they are required to follow which inhibit the timing of avalanche control operations on the highway. When a rail barge arrives in Whittier it must be off-loaded at the high tide. The train must then make the passage to Anchorage in less than eight hours, including barge off-load time, or it is left sitting.

Union regulations are cited as being the cause for such a situation. If avalanche control operations delay the train the DOT/PF could be charged for expenses incurred. This plan does not encompass any operational consideration for this as there is no way of knowing what working relationship can be established.

Weather in Avalanche Formation

Climate patterns in Southcentral Alaska vary radically in a relatively short distance. (Figure 2-1). Take for example the difference in annual precipitation between Whittier (175 in./yr.)

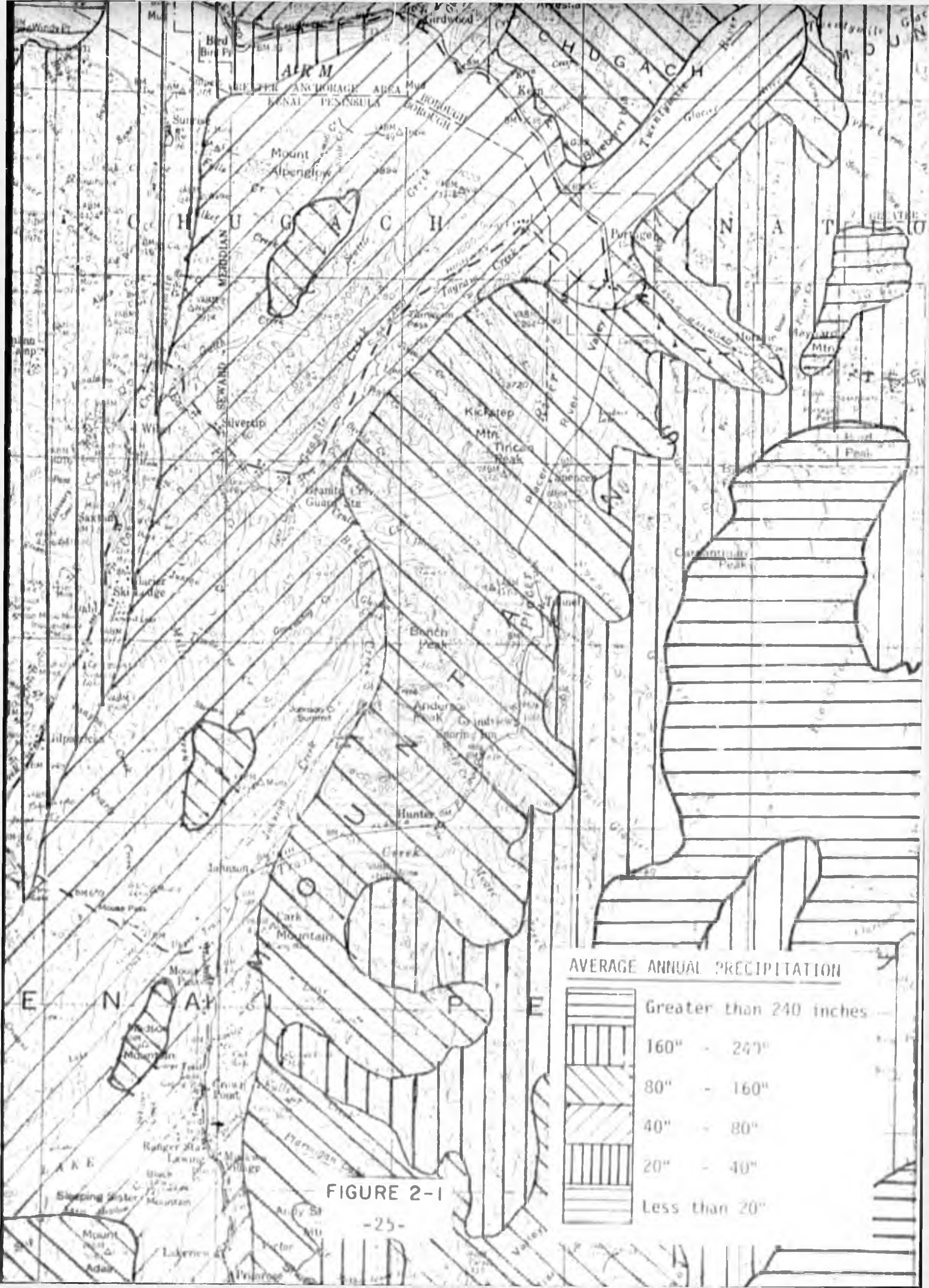
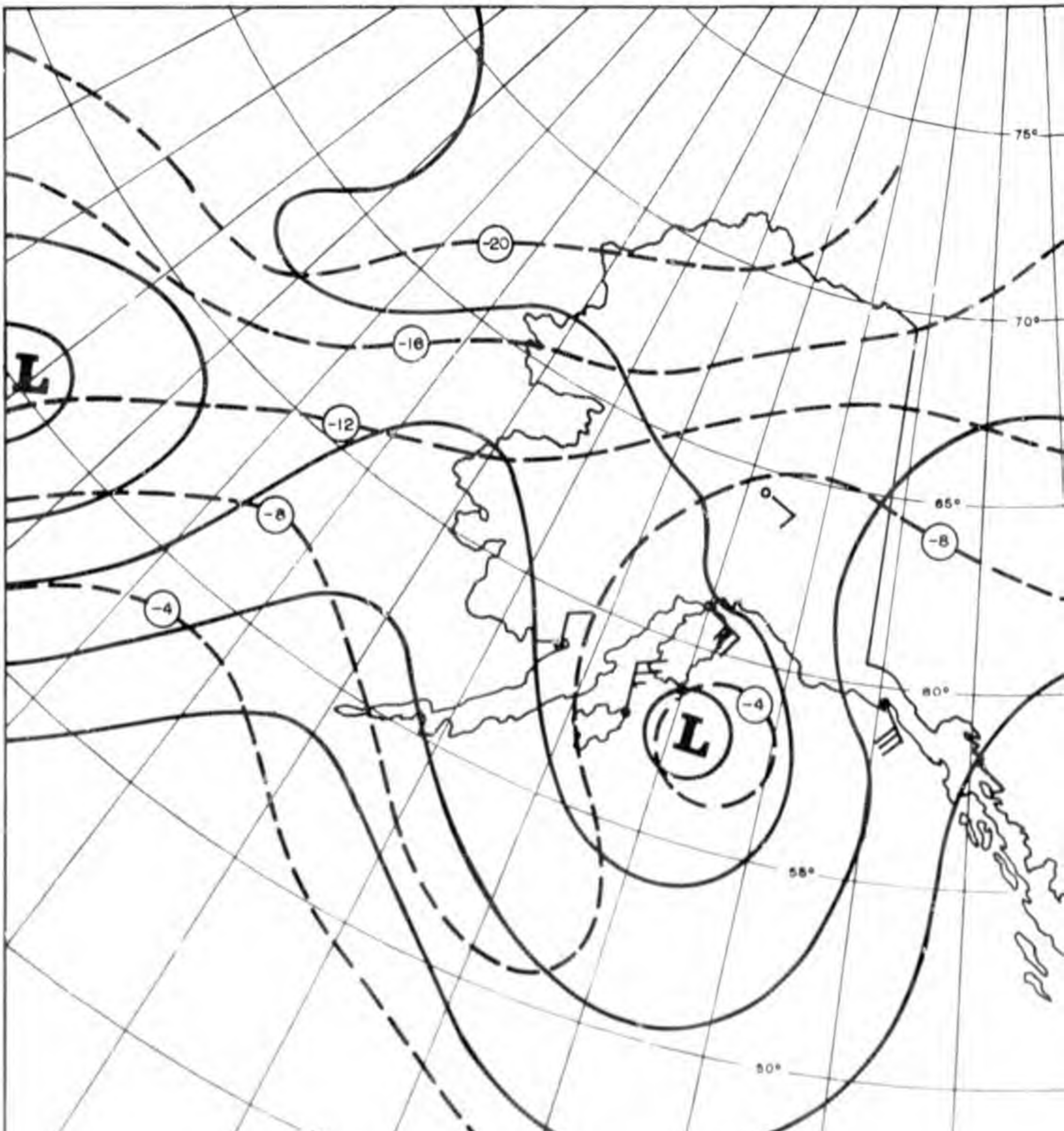
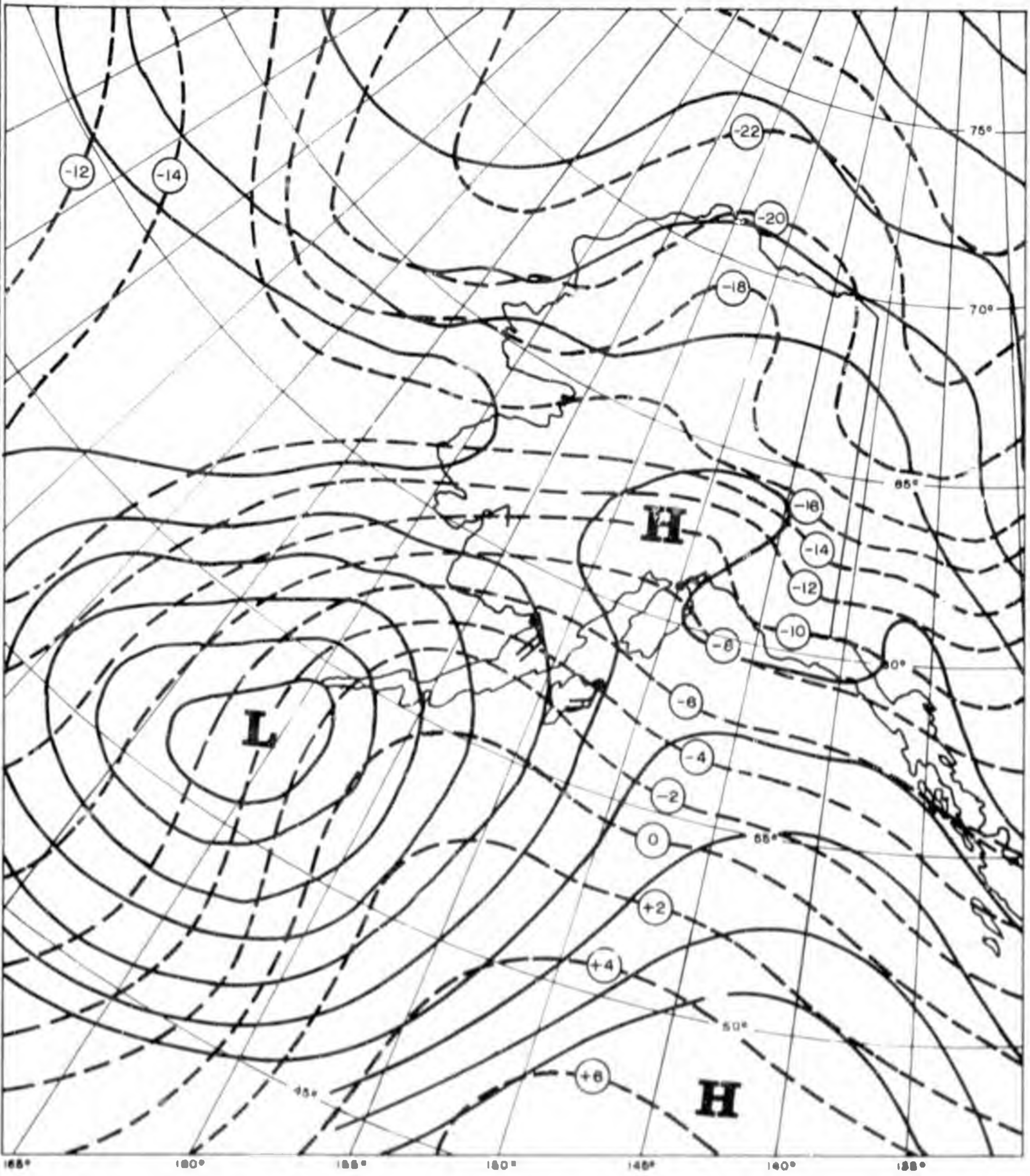

AVERAGE ANNUAL PRECIPITATION
Greater than 240 inches
160" - 240"
80" - 160"
40" - 80"
20" - 40"
Less than 20"
GREATER ANCHORAGE AREA BOROUGH
KENAI PENINSULA BOROUGH
Mount Alpenglow
Kickstep Mtn
Tincan Peak
Bench Peak
Portage
Girdwood
Granite Cr. Guard Sta
Cark Mountain
Sleeping Sister Mountain
SEWARD MERIDIAN

FIGURE 2-1



TYPE 1

FIGURE 2-2



TYPE 2

FIGURE 2-3

Collection of a Data Base

There are probably numerous records related to avalanche problems on the highway; considerable data was collected from 1958 to 1963, however, somehow misplaced or lost over the years. All of these records need to be acquired and assimilated into existing data. Future climate studies should take place to aid in forecasting. Specifically, this would include water content survey in all avalanche release zones this coming March (1980) to establish a set of parameters to judge storm accumulation in starting zones using the base level observations. Snowpack and water content observations can be gathered at various levels in the area to aid in establishing an idea of the relative difference in precipitation caused by local orographics. Combining this information with 850mb air flow patterns would be helpful for the development of an overall view of the orographical effects in the entire Chugach Range.

Chapter III

AVALANCHE FORECASTING FOR THE SEWARD HIGHWAY

Successful avalanche hazard forecasting in any area requires a good background in avalanche meteorology. Changes in the weather provide the most accurate warning as to when and where avalanches are likely to occur. With current technology, it is possible to directly observe subtle changes in the snowpack that signal the onset of failure and avalanche release. Avalanche workers are not required to have a knowledge of weather forecasting, however, they must be able to communicate with meteorologists at the National Weather Service. Avalanche workers are supplied with a forecast, and in return, supply the meteorologists with data to improve forecasts. This exchange works best when avalanche workers and meteorologists are familiar with one another's work.

Storm Watch and Analysis

It is a known fact that the vast majority of avalanches release during or shortly after storm periods. In this text, the term "storm period" is used in its broadest sense to include periods of snowfall, snow transport, or both. Each storm is a unique combination of meteorological variables. The combinations are almost infinite. Meteorological data cannot be gathered at every avalanche path of interest, therefore, for practical reasons, wind, precipitation, temperature, etc., are measured at strategic locations.

There are two broad categories in storm trends -- the standard trends and inverted trends. In the standard trends, initial storm temperatures are relatively high and temperature falls as the storm progresses. In the inverted trend, the initial temperatures are relatively cold and temperature rises as the storm progresses. There are times when, for instance, a northwesterly flow will hover over the Anchorage area and predominate through to the Turnagain Pass area producing a cold cap over that region. Precipitation, in the form of snow, is possible during this time. This is a storm in the standard trend. It is common in the Seward area for a heavy low front to move in with a southeasterly air flow. The end result is a storm in the inverted trend. These two situations would produce a different set of circumstances for the forecaster's consideration, both in areas of snow build-up and in the stability factor of the snow itself. This points out the need for good meteorological avalanche data from two or three strategic sites along the Seward Highway.

Stability Evaluation

Stability evaluations are based on six different categories of information. These include quantitative meteorological measurements, such as study plot precipitation and ridge crest winds, as well as such qualitative observations as explosive tests, test skiing, and visual observations of avalanche path loading. Several categories require close liaison between the control team and the person who makes the evaluation. At most of the sites, stability evaluation for a slope must be based on knowledge of recent avalanche activity on the nearby slopes.

The location of the Mt. Alyeska ski area is certainly a boon to the Seward Highway Safety Program. This is where a close working relationship between the Alyeska Avalanche Technician, the

Forest Service Snow Ranger there, and the Seward Highway lead forecaster will be of great and mutual benefit. Stability evaluation and control work are generally performed either by the same team or by teams working in close cooperation. Often stability evaluation and control work are so interlinked that the boundary is not clear. This interlinking is a unique feature of avalanche technology in contrast to the forecasting and control of wildfires, earthquakes, and other natural hazards. Generally, working systems of mountain rangers around the world follow similar lines. An experienced forecaster issues broad directives about the likelihood of instability and, in most cases, supervises the control work. These systems rely almost entirely on human judgment.

Snow Cover Distribution, Current and Past Avalanches

For the most part, these are simple, visual observations, however, they form the basis for the most reliable stability evaluations. Snow cover distribution is determined by direct, visual observation of whether an avalanche path is filled with snow primed for release. To begin with, significant avalanches cannot occur on a path until terrain irregularity such as boulders and brush is covered with snow, and then additional snow is deposited on this smooth foundation. For most paths, this requires about 2-1/2 to 3 feet of snow in the starting zone and track. The exceptions are paths on permanent snow fields, smooth rocks, dirt, grass, etc. where avalanches may run with as little as 6 inches coverage in the starting zone. Normally, the beginning of an avalanche season on a particular slope can be anticipated from visual observations of snow cover amount and distribution and conditions in the starting zone and track. Most of the 68 slide paths along the Seward Highway have good visual observations from the highway.

It is also helpful to statistically correlate the earliest significant, avalanche on a given path. Mr. Jack Morrow has compiled a report from his diary which gives valuable information on avalanche occurrence along the Seward Highway from 1968 to 1978. This information is contained in Appendix II. No other specific material is available for this time period for the entire length of the Seward Highway. After the beginning of the avalanche season direct observation continues to provide the most reliable information on snow build-up in the starting zones. Periodic visits by use of helicopter into areas above Bird Hill slide paths should begin on a regular basis since it would allow the forecaster to dig study pits near the actual areas of release. The proposed remote weather site on Bird Hill is an excellent location to be used as a study plot. That location is quite large, flat and the snow depth there would be fairly uniform.

Observation of Slopes with Common Aspects

Loading is sensitive to wind direction so avalanches tend to occur on slopes that have a common aspect. For example, after a storm it may be noted that avalanches or avalanche activity is most intense on south-facing slopes as would be the case on Bird Hill slide paths 1 through 6. South-facing slopes that did not avalanche during the storm should be suspected of instability. In fact, the slide paths beyond Bird Point 7-20 would also be suspect.

Observation of Slopes with Common Elevations

In an area that has a wide range of starting elevations, it may be observed that avalanche activity is confined to a particular elevation zone. For example, the higher zones may be relatively inactive, but serious instability may exist at lower elevations. This phenomenon is usually caused by wind or temperature patterns and could be particularly true on Bird Hill. When avalanche control activities are underway this fact should be kept in mind.

Forecasting Relationship between Frequent and Infrequent Paths

Based on historical data, avalanche paths can be classified according to frequency of occurrence. It is an accepted practice in a control program to defer the stability evaluation of infrequently running paths until the stability conditions of more frequently running paths are known. If frequently running paths are moderately unstable, instability can be expected on other paths. Conversely, if frequently running paths are stable, it is usually possible to evaluate the stability of infrequently running paths.

Thaw Warnings

As spring approaches, free water will accumulate within the snowpack. Many small, wet avalanches will appear in loose snow or wet slab to give ample warning that wet avalanches of increasing size can be expected. Explosives are often not an effective tool when attempting to trigger this type of avalanche. A useful remedy is to close off the area of concern during the warmest part of the day.

Snowpack Structure

During storms the forecaster keeps track of storm parameters. Between storms the forecaster has time to investigate the conditions of the deeper snowpack. This could be accomplished at the remote weather site on Bird Hill. Diagnosis of snowpack structure involves searching for weak layers; some kinds of weak layers that are definitely correlated with instability are those that contain TG grains, loose cold snow, surface hoar, graupel, radiation crystals, weak recrystalized grains, or wet snow.

Local Meteorological Data

Field observations of snow build-up on or near avalanche release zones are not often feasible because of weather. When conditions are especially critical, it is rarely possible to tour release zones of high elevation paths that threaten highways. Therefore, it is necessary to rely heavily on meteorology study plots, precipitation measurements and ridge top wind measurements. The requirement for catastrophic snow failure is rapid loading to a critical level Thus, the basic problem in making stability evaluations from meteorological measurements is to infer from the study plot and ridge top wind data whether the rate of loading and total load are approaching critical levels in the avalanche paths in question. The simplest way to use the numerical data furnished by instruments is to identify for each path or group of paths the following critical conditions: (1) wind directions that load the paths in question, (2) wind speed requirement for leeslope loading, (3) critical precipitation intensity, (4) critical total water equivalent. Each storm is monitored and analyzed. The slopes in question are evaluated as unstable when the four critical conditions mentioned above are satisfied simultaneously. The critical level of the four conditions for each path or group of paths is derived from at least three to five years of records of meteorological measurements and avalanche conditions. New data is used continually to improve awareness of critical conditions. The success of this method depends on careful record keeping of meteorological and avalanche observations. For avalanche problems in general, the importance of good records cannot be overemphasized.

Meteorological measurements are useful for evaluating wet snow instability. The important variables to monitor, at least qualitatively, are rainfall, radiation and air temperature. Heavy rain causes wet snow instability by adding weight, decreasing cohesion in the surface layer and lubricating a potential sliding surface. The amount of rain required for instability depends on the temperature of the top layers of the snowpack. If these layers are near zero centigrade before the rain, relatively little rain can cause avalanches. Cold snowpacks have a high capacity for absorbing rain. Wet snow instability grows more intense from mid-afternoon on, shortly after solar radiation reaches its peak. The melting process accelerates because wet snow absorbs far more solar radiation than dry snow, therefore the onset of wet snow instability may seem to occur rapidly. Usually wet snow instability is confined to the most recently deposited layers, to a depth of about three feet. Prolonged thawing occasionally triggers deeper or even full depth slabs. These deep, wet slabs may release any time during a prolonged thaw. As mentioned earlier, explosives seem to have little effect in activating wet avalanches; they release when ready.

Air temperature trends are known to correlate with slab stability. Rising air temperature during a storm is considered an unstable trend because heavy snow is being deposited on lighter snow. This trend would be true more often than not along the Seward Highway. Falling air temperature is considered a stable trend. This was mentioned earlier in this report as standard storm trends and inverted trends, an important factor for the forecaster to be aware of along the Seward Highway slide paths.

National Weather Service Data

The National Weather Service may assist the forecaster by providing data on wind, temperature, and humidity at the upper levels. Short-term forecasts are provided to guide immediate control decisions and extended forecasts for operational planning. Balloon wind data supplements local measurements for estimating the avalanche path loading in a large region. When local wind instruments are rendered inoperative by rime, lightning, or some other cause, balloon wind measurements must be used as a backup. Weather service personnel should, without a great deal of effort, be able to supply the raw balloon data to the avalanche forecaster. However interpreting the data and issuing forecasts for specific avalanche areas requires some effort and time on the part of the Weather Service and a reciprocal effort by the avalanche forecaster. It is easy to understand that interpretations and forecasts of small scale or local weather are inaccurate.

Forecasting mountain weather is especially complex. Nevertheless, with existing physical models, reporting networks and experience, weather forecasters usually do an effective job of predicting air temperatures, wind speeds and directions and the likelihood of precipitation. Forecasters still have trouble, however, determining the amount of precipitation for mountainous areas. Good communication between the field and the forecast center, especially during storm periods, help forecasters to adjust the precipitation forecasts and, in the long run to improve their forecasting skills. This communication is established first by working through appropriate channels; the avalanche forecaster must determine which weather center is in position to issue special forecasts and exchange information directly.

A pre-season meeting is then set up between the avalanche forecaster and the meteorologist in charge of the designated station. This could involve two stations in different locations when both have input determined valuable to the control effort. A plan for exchanging information should be developed. There will no doubt be need for renewal and improvement each year. Routine communication should involve telephone, radio, or teletype. A direct telephone link to the forecast center would seem most logical and limit operational problems. Unlisted telephone numbers which insure prompt service may be obtained, if agreed to by the meteorologist.

It may help for Weather Service personnel to visit the avalanche forecaster's areas of concern and the avalanche forecaster may benefit from inspection of the weather center. Generally, the communication plan should provide for a morning exchange of routine information with updates during emergencies. Each morning, at an established time after the balloon data is available, the avalanche forecaster should phone the Weather Service. The purpose of this call will be to furnish the Weather Service with local weather information following a format set up in a pre-season meeting.

The following types of local information may be useful to the forecaster: present state of weather, present precipitation rate, cloud cover, present temperature, dew point, local wind speed and directions, observed freezing levels, maximum and minimum temperatures during the last twenty-four hours, precipitation rate during the last twenty-four hours, evidence of front passage or other special weather phenomena. Other information that could be communicated by the Weather Service to the public includes, highway conditions, avalanche warnings, possible highway closures for control work and the times work will take place.

In return, the Weather Service may supply the following information to the avalanche forecaster: maximum and minimum forecast temperatures for the next twenty-four hours, expected amount of precipitation in the next twenty-four hours and expected times of precipitation surges, trends in ridge top wind speed and direction, freezing levels, cloud cover, and extended forecast of general weather for the next two days, three days, and seven days. How well the weather forecaster can pinpoint precipitation surges or lulls may depend on his experience and knowledge of local effects. Weather stations often have personnel with special interest in mountain weather, avalanches, skiing, etc. The avalanche forecaster should learn who these people are and work with them during critical periods.

Since weather patterns can differ at times between the Alyeska area and Seward, it would be wise to set up a system or a network of observers. People living in or near areas of concern could provide support by reporting storm progress, taking snow samples for water content and density, monitoring the temperature, cruising the highway in their area, and checking for any kind of instability of the snowpack. Information would then be transmitted to the S.H.A. Forecast Office. Some of these persons could be on a part-time basis-some would be volunteers. As the area of known avalanche activity is vast and the responsibility for forecasting and control so critical, it is recommended there be a lead forecaster and two assistant forecasters. It would be necessary that they live in the area of concern.

Control by Explosives

The strategy of artificially releasing avalanches above highways is intended to produce small avalanches that clear out the track and either stop short of the road or deposit only small loads on the road bed. Ideally, the avalanche should stop just short of the road. Experience demonstrates that it is much more efficient to plow off many small deposits than one very large deposit. Also, the release of many small avalanches in the winter prevents large avalanches from running in the spring thaw. This type of control program is in effect in Little Cottonwood Canyon, Utah, and has proven very effective over the years. In highway control, the release of many small avalanches has a strategic advantage over waiting for one large avalanche.

Hazard forecasters, called upon to blast with artillery, hand charges, etc. must be released from liability before control begins. This may require a civil ordinance delegating authority to perform control on specific slopes for general public welfare, in full understanding of risks and uncertainty of results, since the slide paths could effect something other than the highway itself, such as power lines, railroads or personal property.

Inaccessible avalanche paths over highways are routinely controlled by artillery or helicopter. Of these two principal techniques, artillery is apt to be the more expensive since artillery ammunition combined with the purchase and maintenance of weapons entails a greater expense than hand-thrown charges and the helicopter time. It should be noted that helicopters are limited to favorable weather conditions. Since visibility constraints should not be imposed if control is to be most effective, helicopters are best used in combination with artillery, rather than as a sole technique. The avalauncher is a weapon being widely used now by ski areas throughout the west. This particular weapon has been tested to some extent in Little Cottonwood Canyon, Utah. For the most part, it did not have sufficient accuracy or range. The maximum range is 1400 yards and most shot points in Little Cottonwood Canyon run over 2000 yards. This is also true for most all ranges on shot points along the Seward Highway.

Because range is a problem, most highway control is performed with artillery weapons. Whenever possible, weapons should be fired from fixed mounts that permit accurate indirect aiming during poor visibility. Firing positions should be chosen to minimize avalanche hazard to firing crews. Recoilless rifles and howitzers, 75mm to 105mm, are suitable. Fixed mount locations for the Seward Highway, type of weapons and number of weapons are discussed in another section of this report.

Chapter IV

DESCRIPTION OF ROUTINE FORECASTING AND CONTROL OPERATIONS

Since the Seward Highway crosses 68 slide paths in its distance between Anchorage and Seward, a good cooperative effort among various agencies must be established to provide adequate public safety.

Several agencies will most likely be involved in the operation of a control program. At the time of this writing, a formalized structure of responsibilities and authority have not been established. The following is an attempt to define the roles and responsibilities of various agencies that will most likely be involved. This could change once formal agreements are placed in affect, but it does constitute a general scope of combined responsibilities. Should one of the agencies mentioned below decide against involving themselves with the control program then the outlined work will have to be done by another agency.

Outline of Public and Private Entities Involved in Avalanche Safety on the Seward Highway:

A. U.S. Forest Service; Division of State and Private Forestry
B. Alaska State Department of Transportation and Public Facilities
C. U.S. Weather Service
D. Alaska State Troopers
E. Alaska State Parks; Chugach State Park
F. Private Entities
   1. Alyeska Resort
   2. Summit Lake Lodge
   3. Bird House or Scottish Inn

Summary of Roles, Responsibilities and Authority of Agencies

A. U.S. Forest Service; Division of State and Private Forestry

Responsibility for avalanche forecasting and control has been assumed by the U.S. Forest Service in several areas of the country. This agency has the greatest expertise in dealing with avalanche problems of any public agency.

1. Maintain weather and snowpack records, make daily weather and snowpack observations, consult daily with U.S. Weather Service in Anchorage, and prepare avalanche forecasts on a site specific basis for the Seward Highway.
2. Recommend road closures for DOT/PF based on hazard forecasts; advise DOT/PF of weather, snow, and avalanche conditions.
3. Supervise and implement avalanche control activities including use of artillery and helicopter borne explosives on starting zone targets above the highway.
4. Via the S.H.A. Forecast Office, keep other agencies and the general public informed with regard to weather and avalanche conditions, timetables of impending road closures and openings, and give status of on-going avalanche work.
5. At the request of the Alaska State Troopers, or in their absence, provide leadership and technical assistance in avalanche searches and rescues.
6. Provide training and supervision necessary for the safety of all personnel involved in avalanche control operations.
7. Procure artillery ordinance from the U.S. Army and supervise its transportation, storage, and use.

B. Alaska Department of Transportation/Public Facilities

The DOT/PF has ultimate responsibility for highway safety, and consequently has final authority to decide road closures and openings necessitated by avalanche hazard.

Specific responsibilities are:

1. Remove snow and avalanche debris from Seward Highway as service priorities permit.
2. Notify other cooperating agencies and the general public of planned road closures or openings; through recorded telephone messages or electronic message boards, keep the general public informed of road conditions and avalanche control activities.
3. Maintain avalanche signing system, avalanche closure gates, and other public warning devices.
4. Participate with the U.S. Forest Service and other agencies to cover the direct cost of avalanche protection on the Seward Highway.

C. U.S. Weather Service

Through its Anchorage office weather forecasts are issued for much of Southcentral Alaska. Due to the extensive area covered by the highway, a reliable exchange of weather information will benefit all agencies and the general public.

1. Issue weather forecasts on a locality specific basis to the S.H.A. Forecast Office.
2. Provide technical assistance for the construction and maintenance of remote weather recording installations.
3. Provide interfacing necessary to establish high-speed data exchange and other related cooperative weather information exchange and recording.

D. Alaska State Troopers

All rescue activities, including avalanche, are under the Troopers jurisdiction.

1. Direct all avalanche rescue in cooperation with U.S. F.S., Division of State and Private Forestry; S.H.A. Forecast Office.
2. Provide communications facilities as needed.
3. Provide hel copter on a cost basis for snow studies work.
4. Respond to emergency situations as requested by the S.H.A. Forecast Office.

E. Chugach State Park

1. Provide permits necessary for forecasting and control activities arks land.
2. Relay avalanche and weather data to S.H.A. Forecast Office.
3. Maintain weather recording facility in Bird Creek.

F. Private Entities

1. Alyeska Resort
   a. Voluntarily relay avalanche and weather data to S.H.A. Forecast Office.
2. Summit Lake Lodge
   a. Voluntarily maintain weather recording facility.
   b. Voluntarily close avalanche gates at Summit Lake in emergency situations.
3. Bird House or Scottish Inn
   a. Voluntarily close avalanche gate at Bird Flat in emergency situations.

The success of an avalanche program on the Seward Highway depends on (1) flexibility of response to changing conditions, (2) cooperation among responsible public and private agencies. The following description of events is entirely hypothetical with regard to times and locations of personnel and equipment.

Night storms. The lead forecaster for the Division of State and Private Forestry, stationed at the S.H.A. Forecast Office, has been on a storm watch during most of the night. The amount of precipitation he has noted since the start of the storm at 10 p.m. is the indicator of the rate of hazard formation and the density an indicator of the nature of snow buildup. He has also been checking the ambient air temperature and wind speed and direction, with this information coming from a remote site on Bird Hill and Andy Simons Mountain above Kenai Lake. The anemometer readings are indicators of specific locations of hazard formation.

At 4 a.m. the hazard forecaster will start his calls; possibly his first call will be to the National Weather Service for another check on the direction of the storm. After he has gathered information from his own observations, he may also have received some calls from the part-time observers and volunteers located toward Seward.

He has, by this time, made his evaluation; control is necessary. It would mean control by indirect (blind) fire onto indicator shot points or specific locations of hazard formation. The hazard forecaster's next call, then, would be to the Department of Transportation. The time would be 4:30 a.m., asking for a road closure at 6 a.m. so control work can start at that time at gun position No. 1 firing indicator shot points 102, 107, 116, and gun position No. 2, shot point 204, 206, 212, and 218. Gun position No. 4 might shoot points 404 and 408 if a high hazard exists. The Department of Transportation, after receiving this information from the hazard forecaster, calls the State Troopers, informing them of the road closure. They could possibly ask for assistance in sweeping the highway, making sure no automobiles or pedestrians are in the area and actually close the gates.

Concurrent with the above, the lead forecaster will have to make decisions regarding control activities for the highway south of Girdwood based on field observations from the weather reporting network. Arrangements will need to be made to implement the closures and control work necessary. At this point, the Department of Transportation relays a message to the public through the Weather Service regarding road closure. Gun crews and maintenance crews are dispatched for implementation of control activities and in preparation for clearing of avalanche debris.

After firing the indicator shot points from gun positions #1 and #2, the hazard forecaster makes a quick visual assessment and decides immediately if more control is needed. If hazards show up as extreme, little decision is needed. Full control is implemented. In this case, road closure will have to be extended. If hazard is not extreme the highway will be opened to traffic by 08:30. In this case, more control work could be carried on from 10:00 a.m. to noon, when traffic volume is not increasing. If big avalanches occur in the area of control work, the maintenance crews are there to clear and open the road as soon as possible.

If a moderate hazard exists control work may be deferred until 10 a.m. This allows Girdwood-Anchorage commuters into work and Alyeska skiers to the ski area. There is a drop-off in traffic volume from 10 a.m. to noon, as noted in Appendix I. This is a good time to do major control work as there is continual daylight. DOT/PF does not remove avalanche debris at night. Exact details of control activity timing will have to be worked out as the program becomes operational but this gives some general guidelines for control of night storms.

Day storms. Storms that build a hazard during the day will require a somewhat different tactic. If it is anticipated that a hazardous level will be reached in the late afternoon or evening control activities will have to be timed to allow for clean-up of avalanche debris before dark. This would mean road closure would occur at 1:30 and graduate to a later time as daylight allows during the latter part of February, March, and April. Control activities could commence at 2:00 firing from all gun positions simultaneously to be done with control at 2:20, allowing 40 minutes for avalanche debris removal. If debris is not removed by dark the road will remain closed all night. If it is decided to forego control activities during day storms, a road closure will have to be put into effect sometime during the night. It should be obvious there are many problems with these procedures that can only be worked out after the control program becomes operational.

The lead forecaster and his assistants would collect and record weather, snow cover and avalanche data, analyze all technical data and prepare forecasts of avalanche hazards, order closures for the highway, determine when and where to use artillery or helicopter bombing, conduct avalanche control activities and do research for improving forecasts.

Public Information and Warning. An important part of avalanche hazard control is public information and education, convincing the public that zoning ordinances, ski run closures or highway restrictions are in their best interest. The avalanche worker has much on his side. Avalanches are spectacular and can be portrayed in exciting and convincing presentations via television, radio, newspapers, ski magazines, films, lectures and pamphlets. Besides the general public, some groups that may benefit from avalanche information and education include ski clubs, public utilities crews, state highway crews, ski area operators, snowmobile clubs, rescue organizations, sheriff's departments, state and federal agencies, ski schools, mountaineering clubs, local planning commissions and mining corporations. The more avalanche education for all of the public, the easier it is for the DOT/PF to close the highway for periods of control. The information program should underscore the common sense of avalanche safety.

Chapter V

AVALANCHE RESCUE

In order for a rescue to be successful, the utmost speed must be used in running the operation. Statistically, a victim's chance of being recovered alive falls to less than 50% after one-half hour. In all probability the fact that the victim of a highway avalanche is in their vehicle increases the likelihood of a live rescue and consequent time values, but the half-hour figure does reflect the necessity for speed.

As there is not a large staff of professional rescue people available to the Seward Highway control program, any rescue operations will probably involve a large variety of volunteers, DOT/PF personnel, avalanche control crews, U.S. Forest Service, and State Troopers. The latter has full responsibility for all rescue operations within the state, including avalanche. Cooperative training efforts betweeen the State Troopers, DOT/PF personnel, and the control crews could result in a reasonably efficient response to call-out. Much effort must be put forth to establish communications links, lines of authority, and layout of equipment and manpower for rescue operations in order to have the speed necessary to perform a live rescue.

In the set-up of rescue operations, the ability to utilize personnel immediately adjacent to the affected area is important. Because of the large distances involved, responses will have to come from Girdwood for the Portage-Bird series of avalanche paths, and from Moose Pass for the 19-mile-Summit Lake series. Transportation times involved from any other location, with the exception of Summit Lake itself, will preclude the probability of a live rescue. A net of potential rescuers could be established in each location to accomplish a minimal response time by utilizing the Girdwood Mountain Rescue Group, U.S. Forest Service personnel stationed in Moose Pass, and supplementing these with local volunteers.

Protection of rescue personnel is of the highest priority. It is unacceptable to place severe risks on the large number of people associated with a rescue team. For this reason the lead forecaster should be the person that guides rescue activities, as he is the most qualified to make the critical decisions involved. This is contrary to the mandate of the State Troopers requiring them to run all rescue operations, but cooperative ties can and should be worked out to allow this practice to take place under the direct or indirect supervision of designated troopers. There is a limited number of troopers acquainted with directing an avalanche rescue, therefore, in an effort to eliminate miscommunications, designated troopers should be involved. Local troopers could become trained to perform this function from Girdwood or Moose Pass in conjunction with the base rescue operations in Anchorage.

Guidelines need to be established as to the degree of hazard to which rescue operations can be committed. Each situation will be different and demand individual attention, but a few generalities can be made. Control work may be necessary in order to commit personnel; always a difficult proposition because of the likelihood of worsening the situation of the victims. Avalanche paths with multiple release zones should be dealt with very cautiously as there is a good chance that only part of these areas will have had activity, with the rest of the release zone being very prone to avalanching. Many accidents have occurred during rescues due to this situation. Regeneration of snow deposits in the release zone presents a hazard to long-term rescue. In a case where it seems certain that a vehicle is caught with a high hazard of more avalanches, it could be deemed justifiable to commit a small group of professionals to a rapid search, provided backup manpower is immediately available. This type of decision is extremely difficult to make without a solid background in avalanche forecasting, control, and rescue.

Continual training will be necessary to establish the efficiency of movement necessary for a speedy response. Call-outs should take place several times a year to keep a polished edge on the rescue operation.

Equipment must be purchased and stored at Moose Pass and Girdwood to expedite a call-out. A cache could also be established at Summit Lake to facilitate any problems there, but this would not have to be as extensive as the Level 1 caches at the other two locations. Periodic checks should be made to insure the readiness of this equipment.

Night rescue operations present unique difficulties and hazards. It would be difficult to commit personnel to such a rescue without substantial evidence of vehicle entrapment. Nevertheless, it will be necessary to make arrangements for emergency lighting facilities should the circumstance arise.

Speed and safety are the most important concepts in an avalanche rescue. Training of personnel, cooperative ties among agencies, and use of the most qualified people in decision making can accomplish duality of purpose.

Following is a listing of the positions in the chain of command of a rescue and a description of the responsibilities of each position. A list of necessary equipment follows.

There should be instructions for each phase of the rescue contained in either manila envelopes or binders at various locations. In communications stations these instructions could be centrally located so they could be readily accessible to highway crews and other people involved.

These instructions are:

1. Immediate Action: The first person to learn of an avalanche will probably notify either a government agency in the vicinity or a public facility. Basically, the person receiving this notice should: hold the witness to accompany the search party and sound the general alarm which will notify qualified rescue leaders on a priority basis.

2. Person Receiving General Alarm: The first qualified rescue leader reached by the general alarm proceeds to the nearest communications station and becomes dispatcher unless relieved by a superior in the plan's structure. Contained in this person's instructions is a list of procedures used for the immediate dispatch of columns of rescuers to the scene and a series of follow-up actions.

3. First Column Leader: Instructions for the person appointed by the rescue leader to lead the search column must be available in each avalanche rescue cache, including guidelines for screening volunteers, selecting a safe route to the accident site, and procedures used in searching for the victim. Several methods could be used according to the resources available, including dog search, use of a metal detector, course probing, or use of an electronic locator.

4. Accident Site Commander: Instructions for the person designated by the rescue leader to assume command at the accident site. This may or may not be the hasty search or first colum leader. Organizational guidelines should include organizing probelines, reporting progress to the rescue leader, removing exhausted workers, obtaining medical and transportation assistance, obtaining backup assistance, and terminating rescue operations.

5. Column Leaders: Instructions for persons appointed by the rescue leader to lead groups of rescuers to the accident. These are similar to the first column leader's instructions, but do not include some of the preliminary work that is to be accomplished by the first people at the scene.

Immediate action envelopes should be distributed and explained in all areas where an avalanche is likely to be reported. General alarm packets should only be issued to designated rescue leaders. The other three sets of instructions should be located at the avalanche rescue caches. Following is the recommended cache locations:

1. Girdwood Maintenance Station, DOT/PF - Mile 91 - Level 1 cache

2. Summit Lake Lodge - Mile 46 - Level 2 cache

3. Moose Pass - U.S.F.S. Station - Level 1

Following is a recommended Level 1 cache. Level 2 would be half as much equipment for the most part.

	Quantity
Trapper Nelson pack frame	2
Collapsible probes	20
Small snow shovels	6
Headlamps	30
Flares	100
Markers (wands with flags)	200
Wool blankets	4
Warning horn	1
Large first aid kit	1
6 volt hand lamp	6
Portable radios (walkie-talkies)	3
1-piece probes	100
Shovels, large scoop	30
Loud hailer	1
Horn refill	1
Metal detector	1
Tobbogan	1
150' rope	3
Lighting unit on trailer	1
Snowshoes	10
Electronic locater	24
Stretchers	2

(from B.C. Highways, 1979)

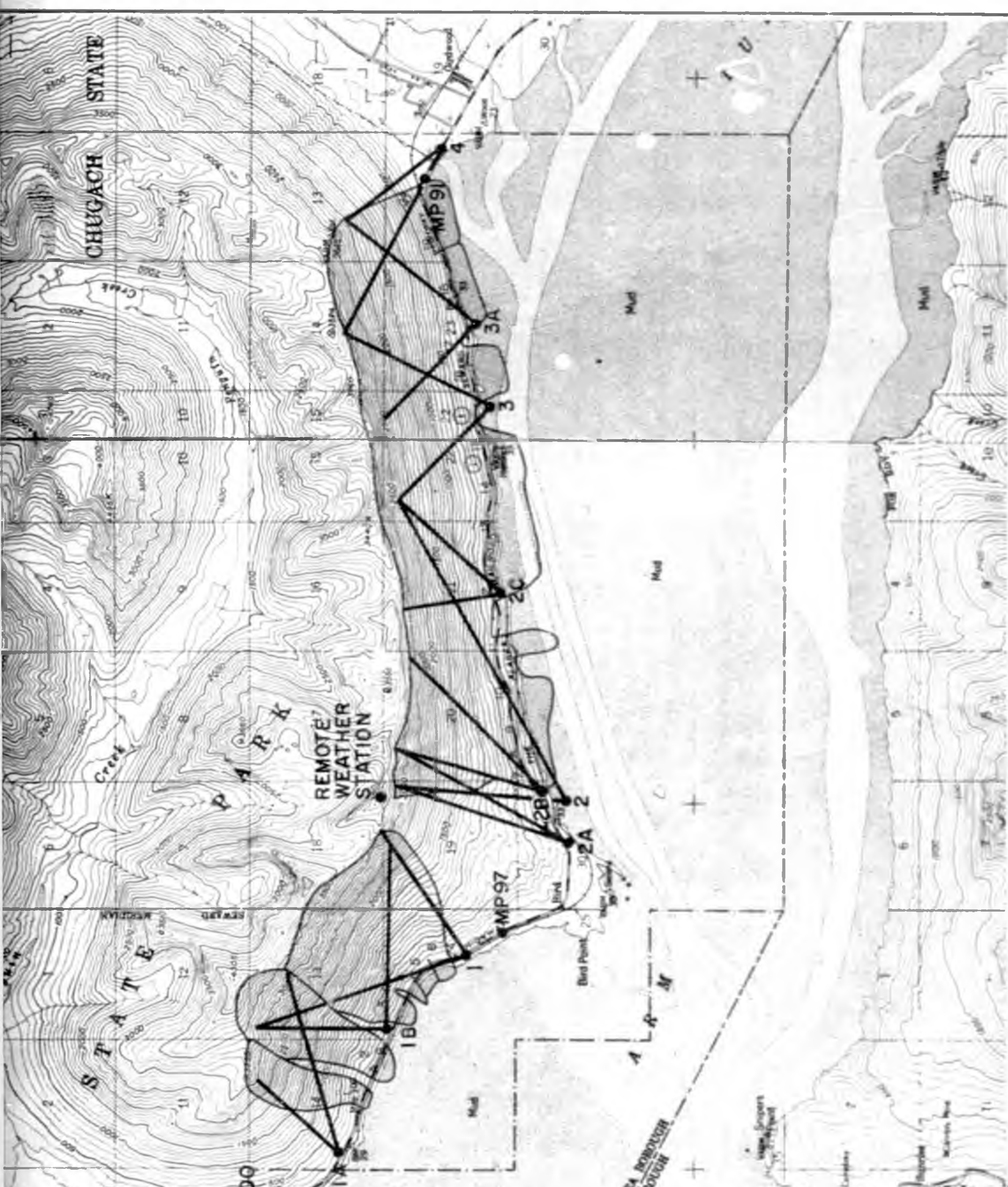
Chapter VI

AVALANCHE MAPPING

A record of identified avalanche paths is necessary to design and implement the control system. For this purpose aerial photography was used to identify avalanche paths in order to define the starting and runout zones. Incorporated into these photographs is a description of target points to be used in the control program, gun positions, and location of other facilities necessary for the control program.

For a concise view of the topography and relation of one path to another, a record of the avalanche paths was produced on 1:63;300 scale U.S.G.S. topographical maps. These contain a record of the avalanche path perimeters in red, gun positions, maximum line-of-fire, mileage marks, and remote weather stations in black. Avalanche paths designated with a number but no perimeter marks either run close to the highway or there is evidence of vegetation damage.

V - visual fire target points
MP - milepost
GT - mobile gun truck position



BIRD HILL

FIGURE 6-1

103A
102
101
104
105
107A
106A
108A
109
110
111
112
113
114
115
116
111A
109A
V
101A
112A
112B
116C
114A
116A
116D
113A
115A
116B
V
1A
1B
2A
2
1

FIGURE 6-2

109
110
111
112
113
202A
204
205
206
201
202
208
203
207
207A
204A
201A
5
6
8
2A
2
75MM
Howitzer Site
106MM
Howitzer
Site

FIGURE 6-3


REMOTE WEATHER STATION
202A
201
202
202B
203
203A
204
205
206
207
208
208B
208A
211
212
213
214
215
216
217
218
218A
301
219
218C
217A
218B
216A
216B
215A
214A
213B
213A
212A
211A
210
209
208C
207B
207A
204A
205A
204A
203B
202C
201A
7
8
9
10
11
12
2C
13
14

FIGURE 6-4

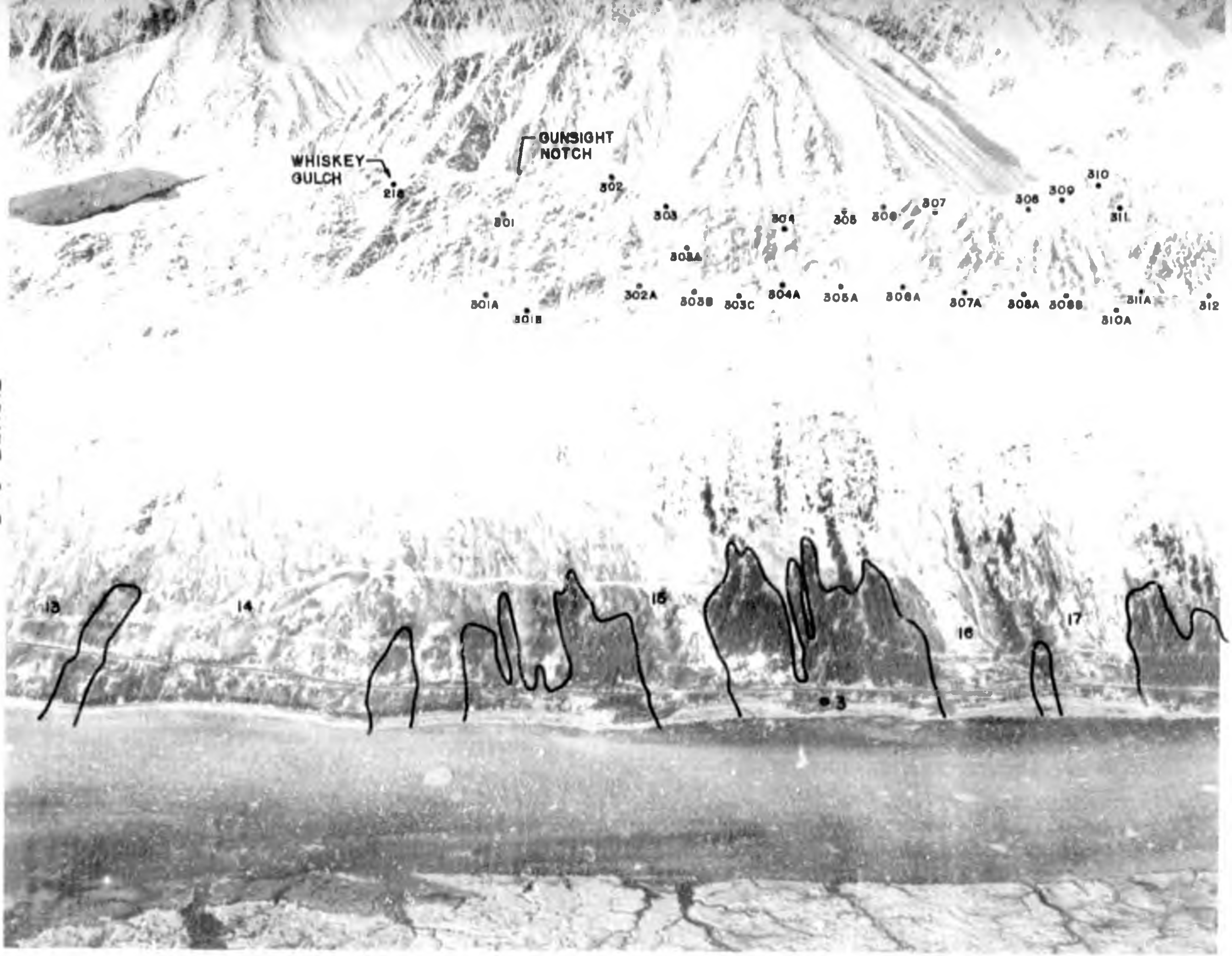
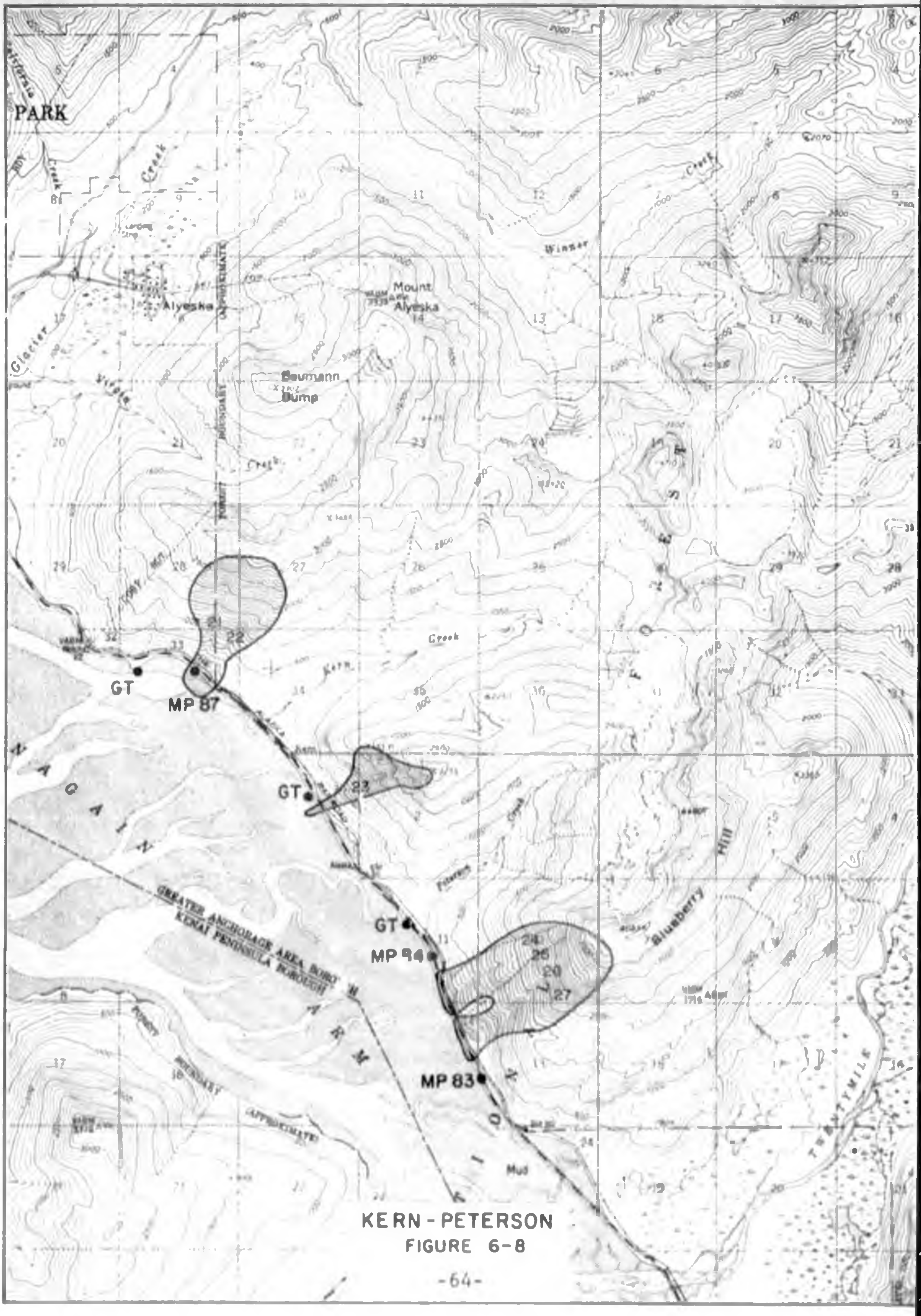

WHISKEY GULCH
GUNSIGHT NOTCH
218
301
302
303
303A
304
305
306
307
308
309
310
311
301A
301B
302A
303B
303C
304A
305A
306A
307A
308A
308B
310A
311A
312
13
14
15
16
17
3

FIGURE 6-5

FIGURE 6-6

FIGURE 6-7

FIGURE 6-7



KERN - PETERSON
FIGURE 6-8

FIGURE 6-9

FIGURE 6-10

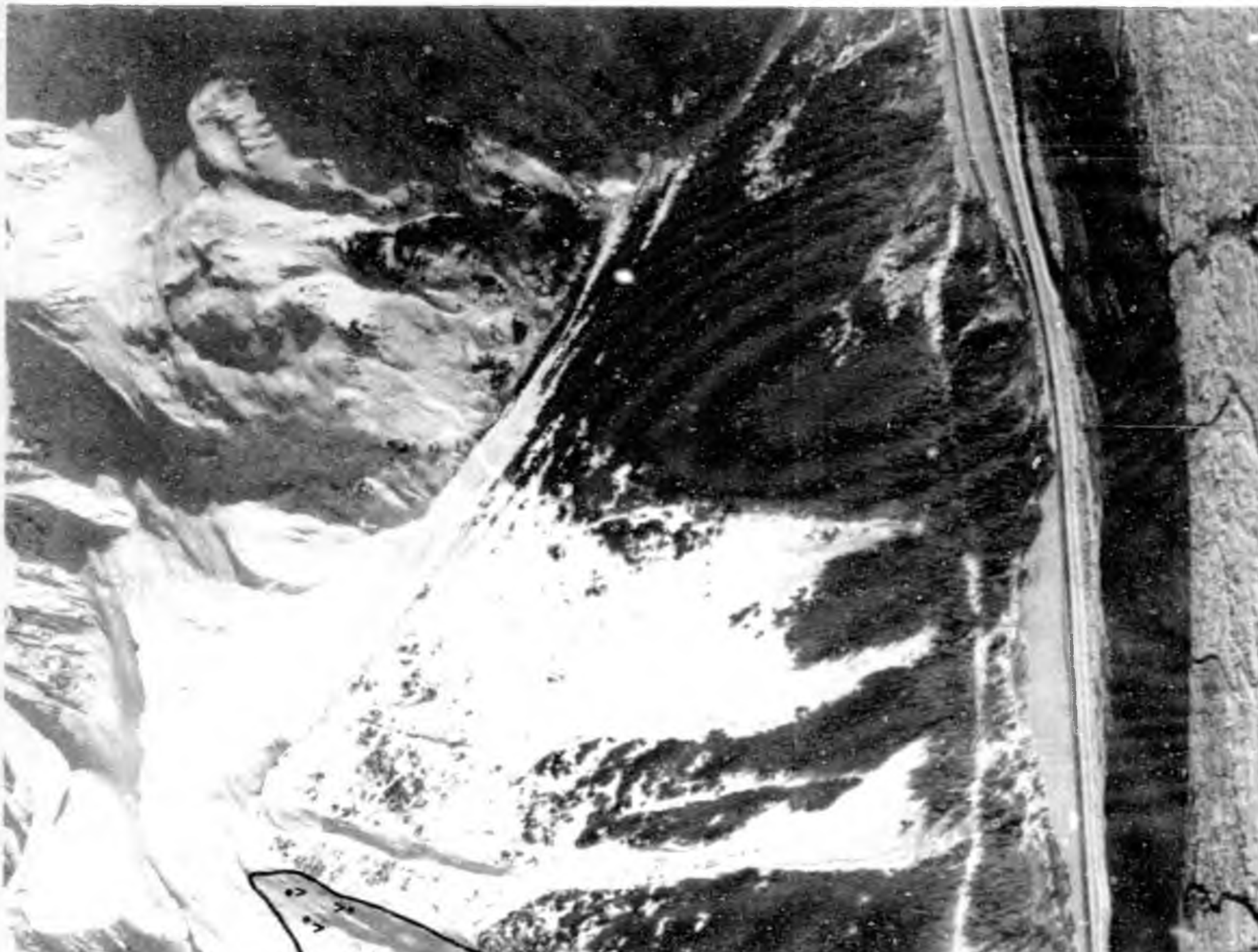
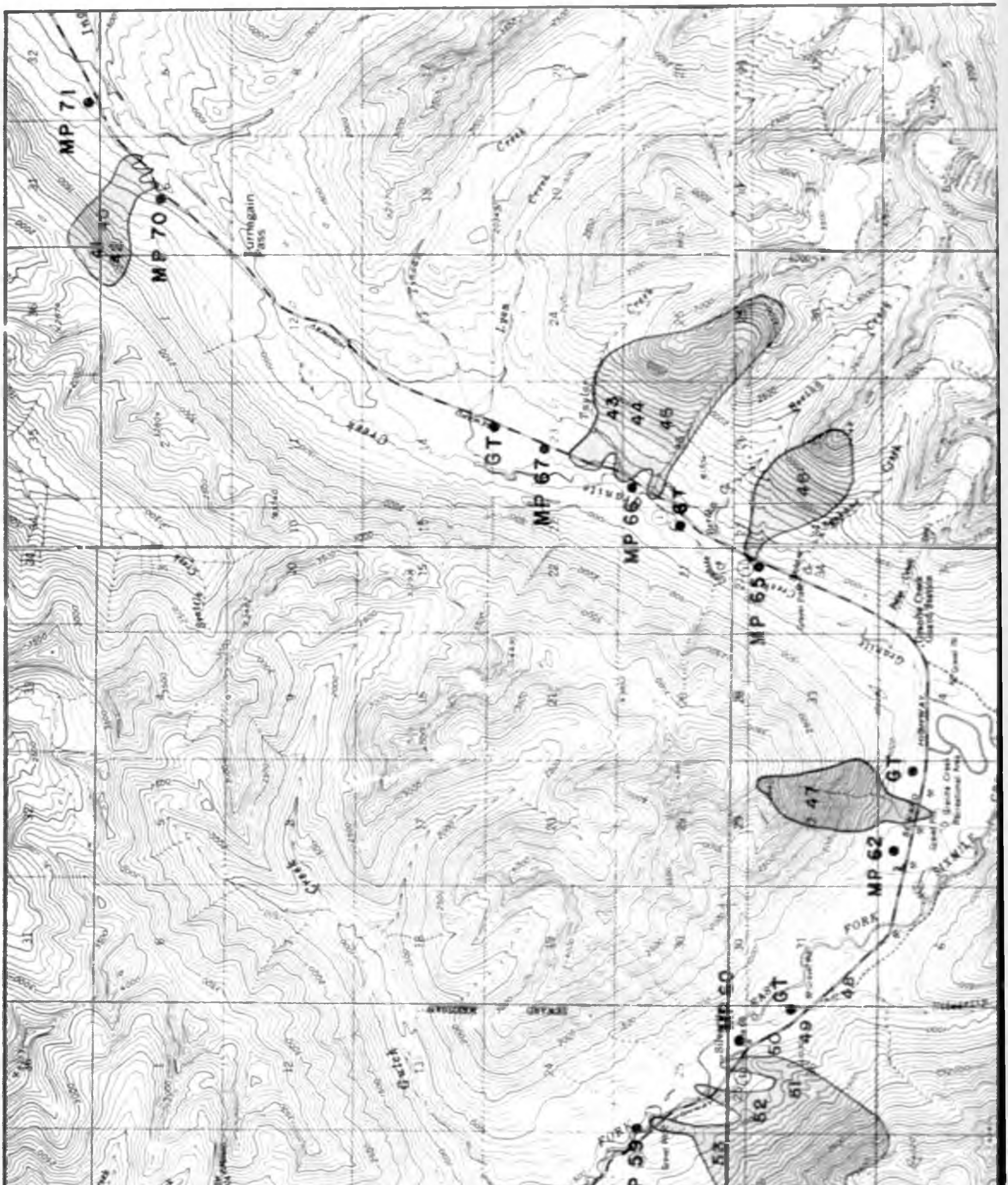


FIGURE 6-10

FIGURE 6-11



TURNAGAIN PASS – SILVERTIP
FIGURE 6-12

FIGURE 6-13

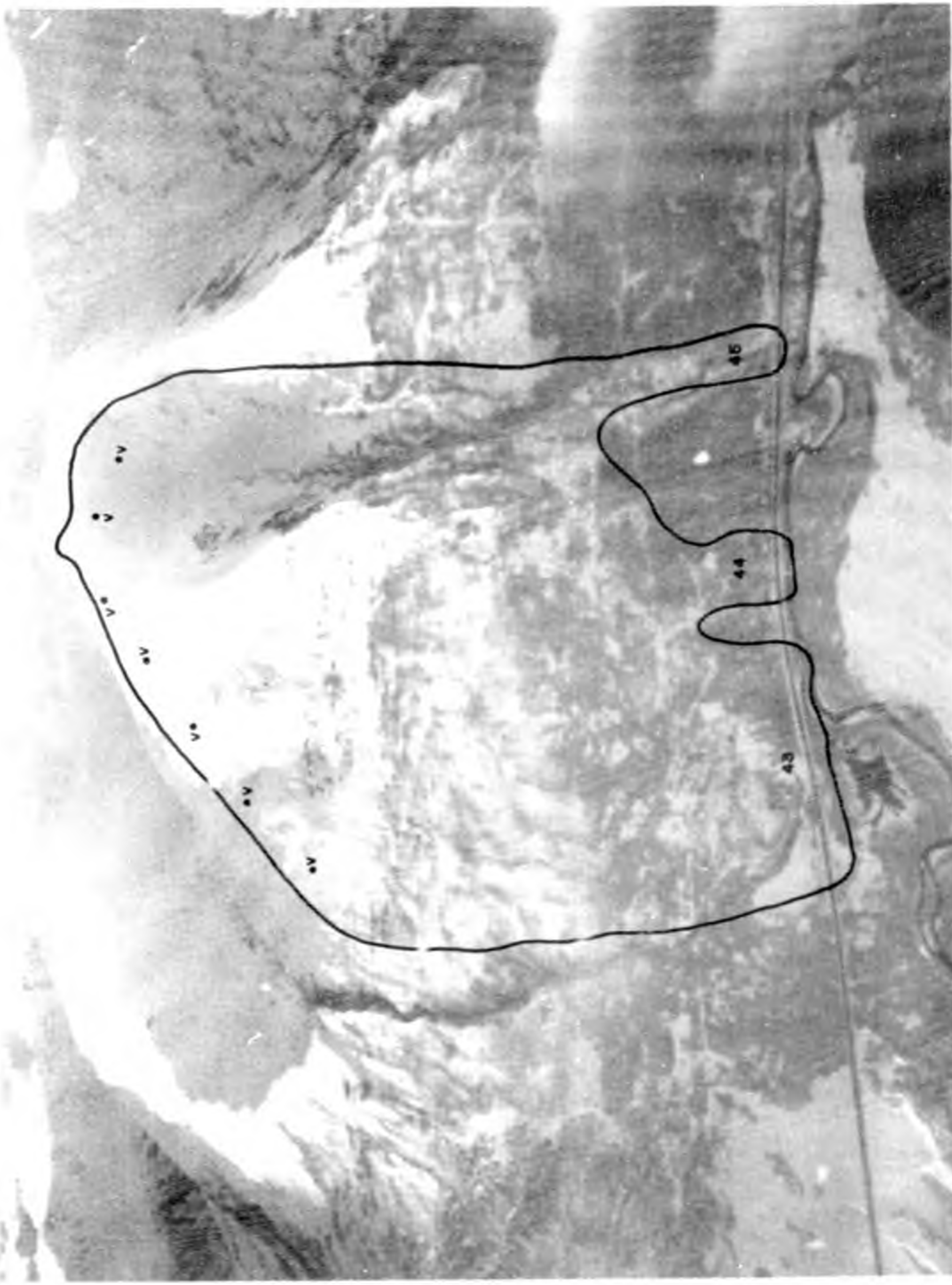
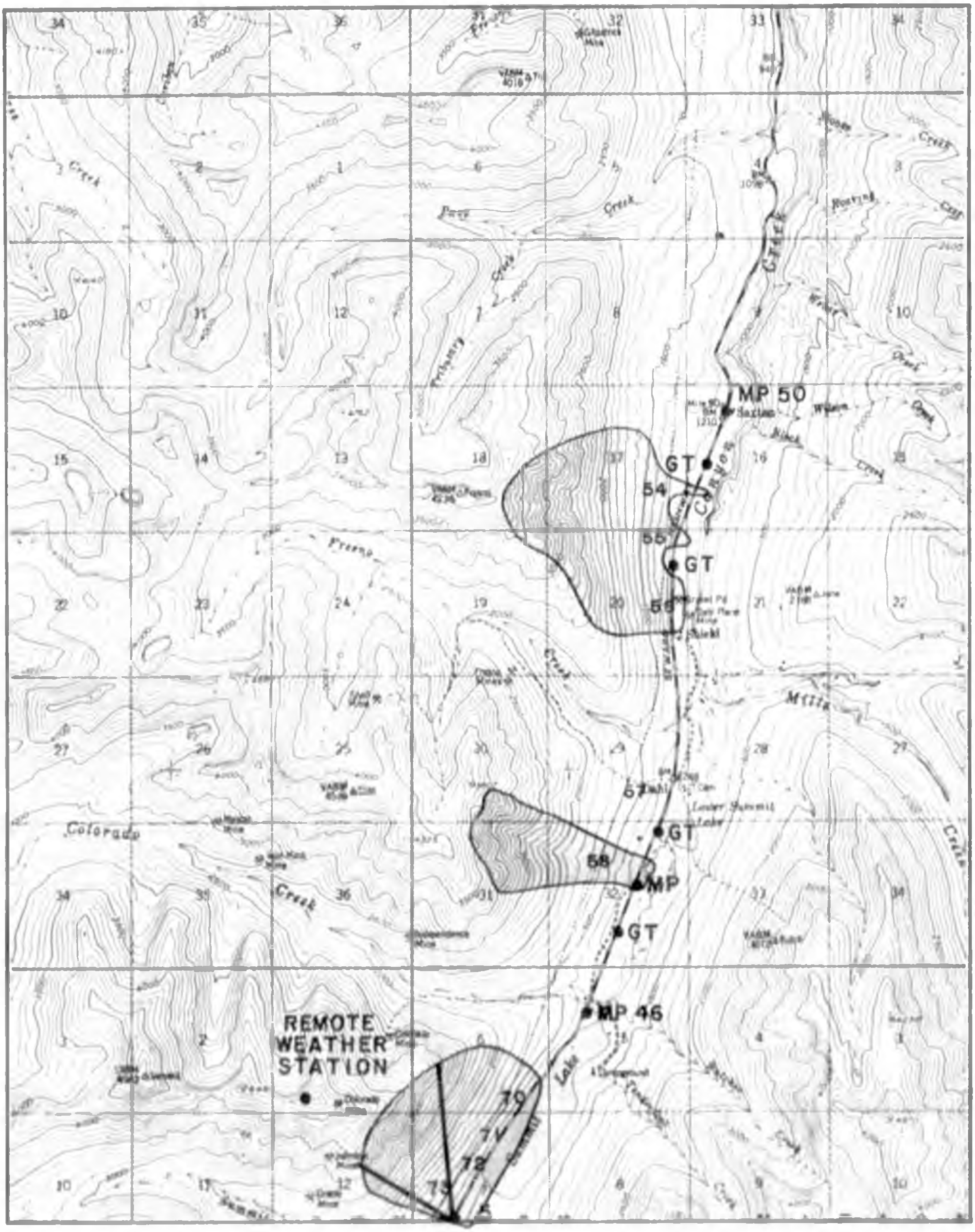


FIGURE 6-14

FIGURE 6-15



SUMMIT LAKE

FIGURE 6-16

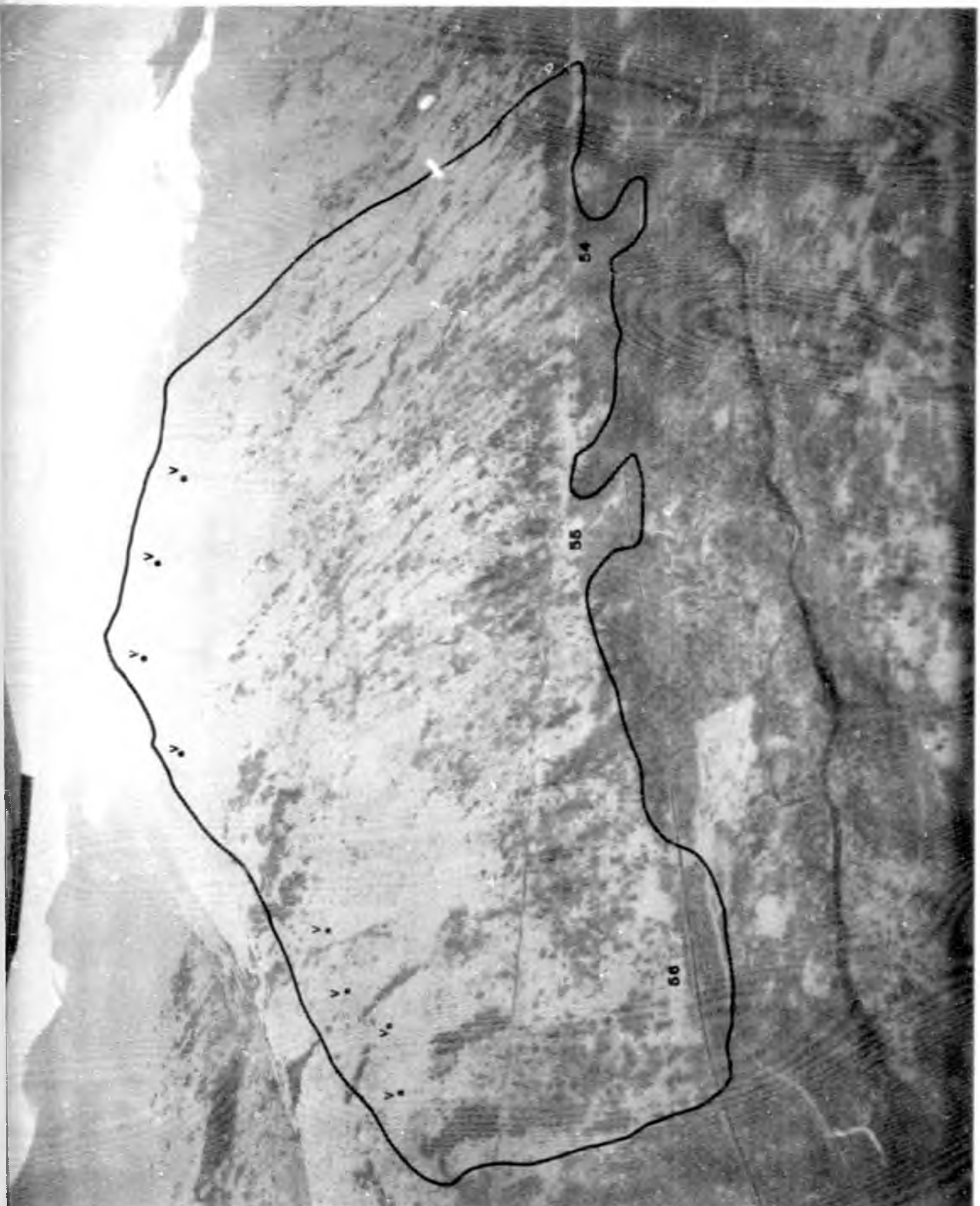


FIGURE 6-17

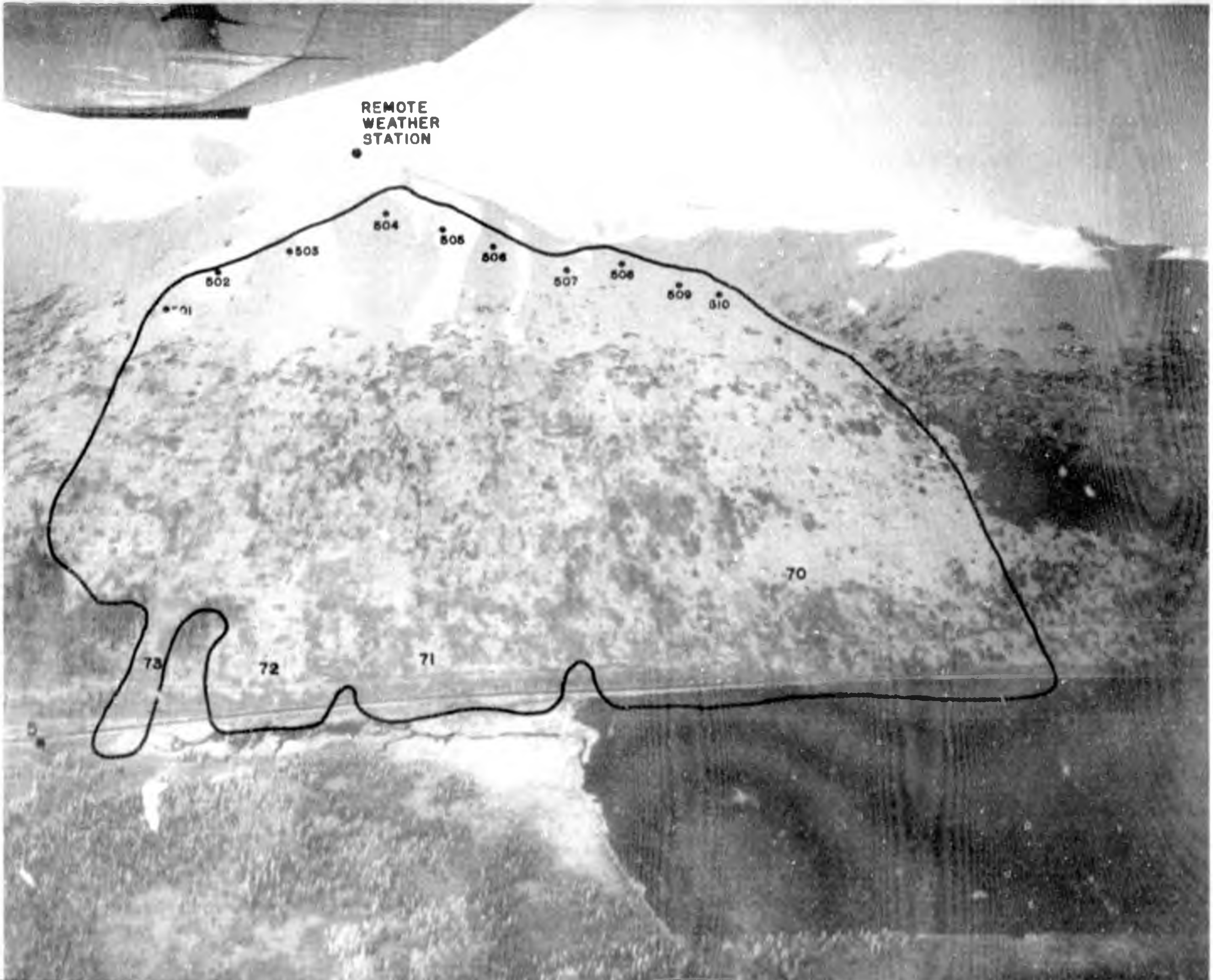
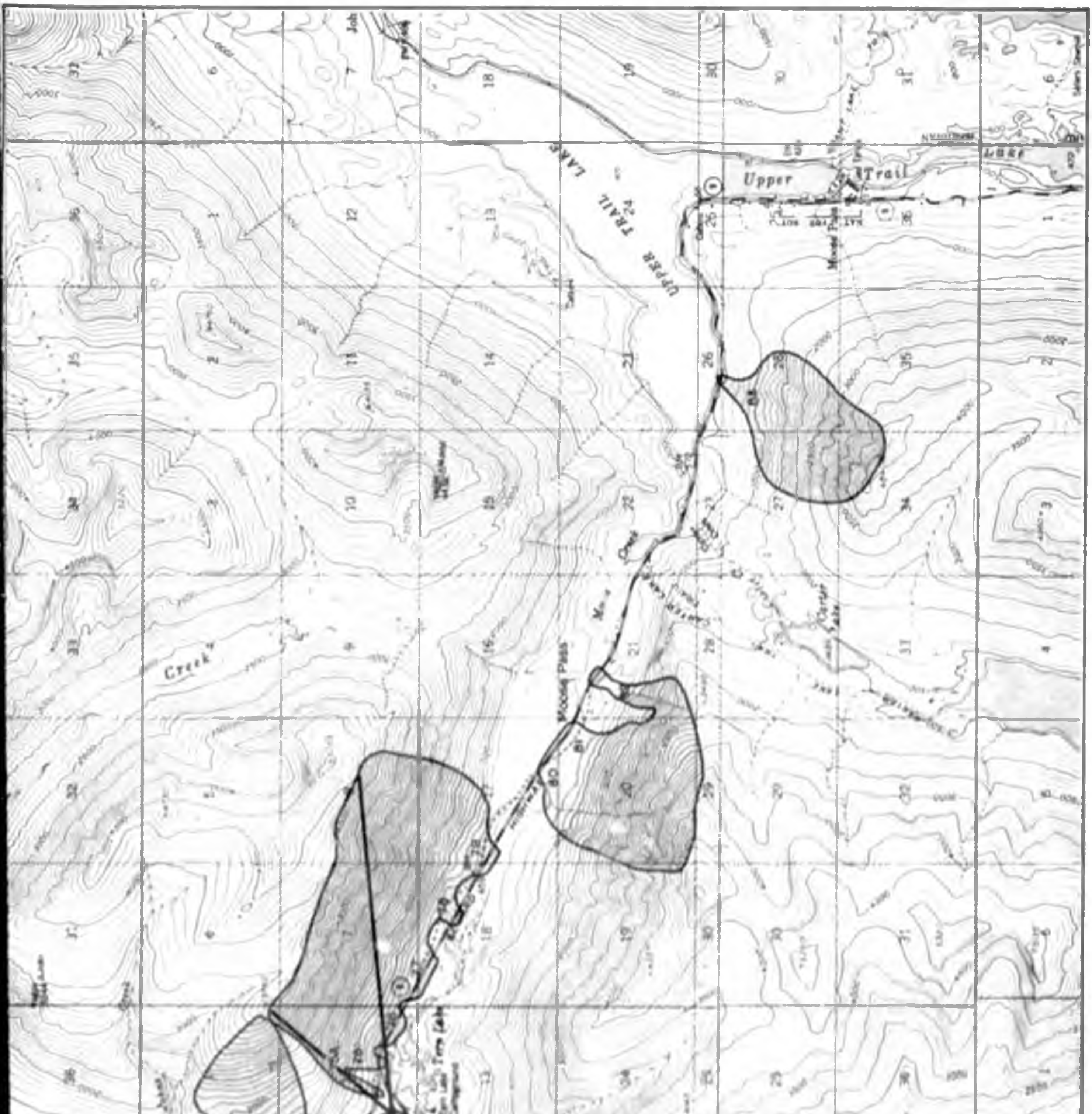

REMOTE WEATHER STATION
502
503
504
505
506
507
508
509
510
70
71
72
73
5

FIGURE 6-18



SEWARD-STERLING

FIGURE 6-19

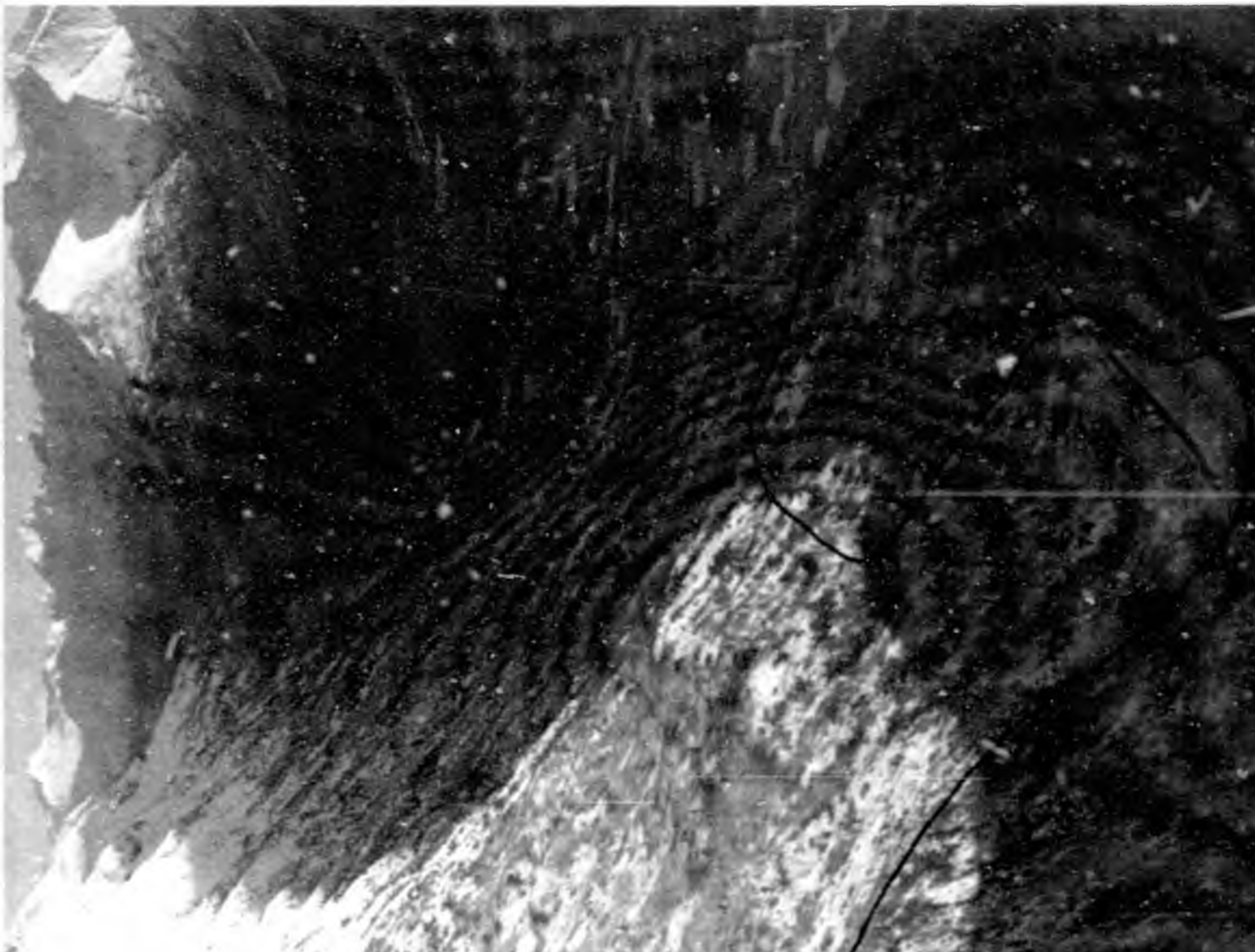
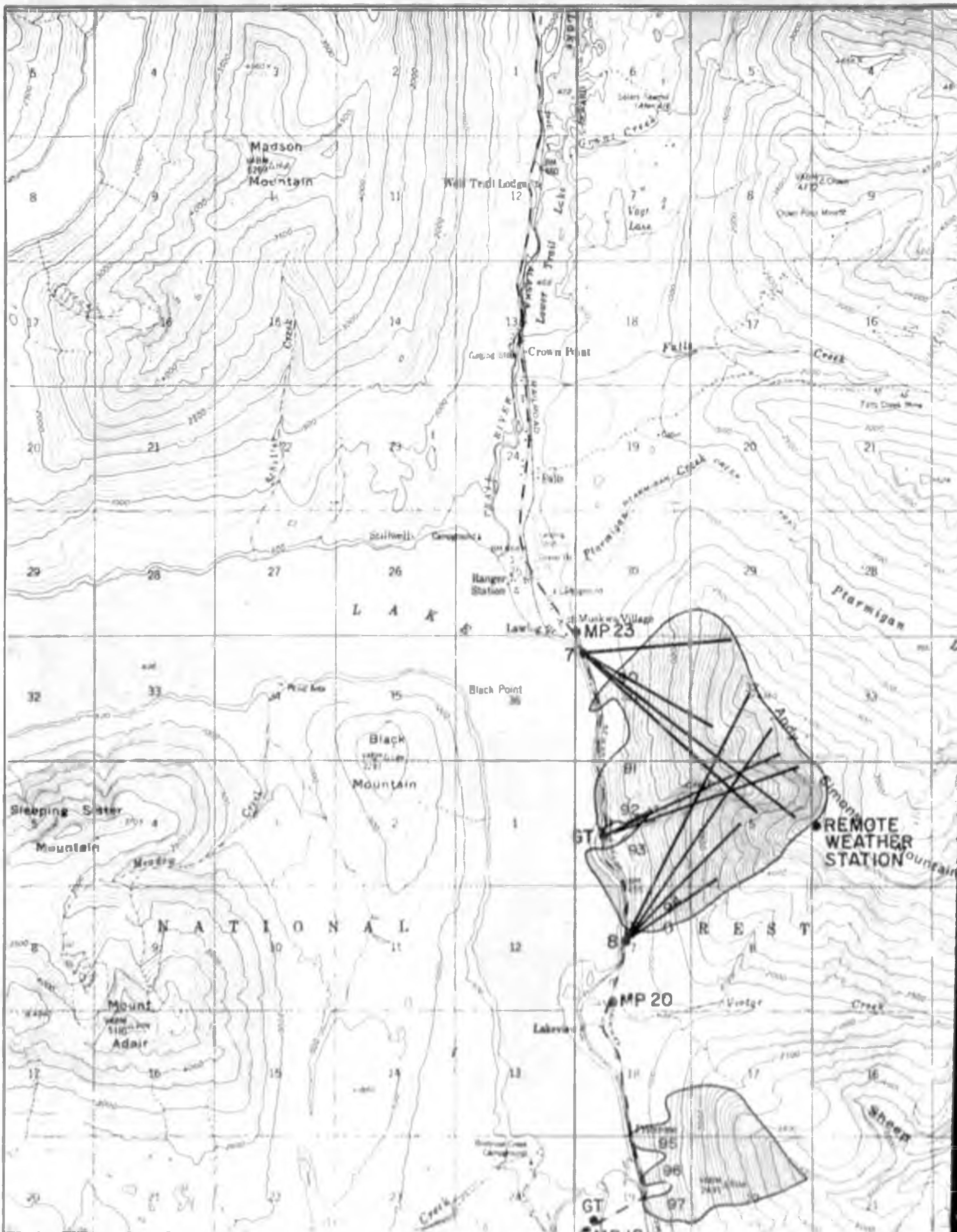


FIGURE 6-20


601
602
603
604
605
606
607
608
609
610
611
612
613
614
75A
75
76
77

FIGURE 6-21



KENAI LAKE
FIGURE 6-22

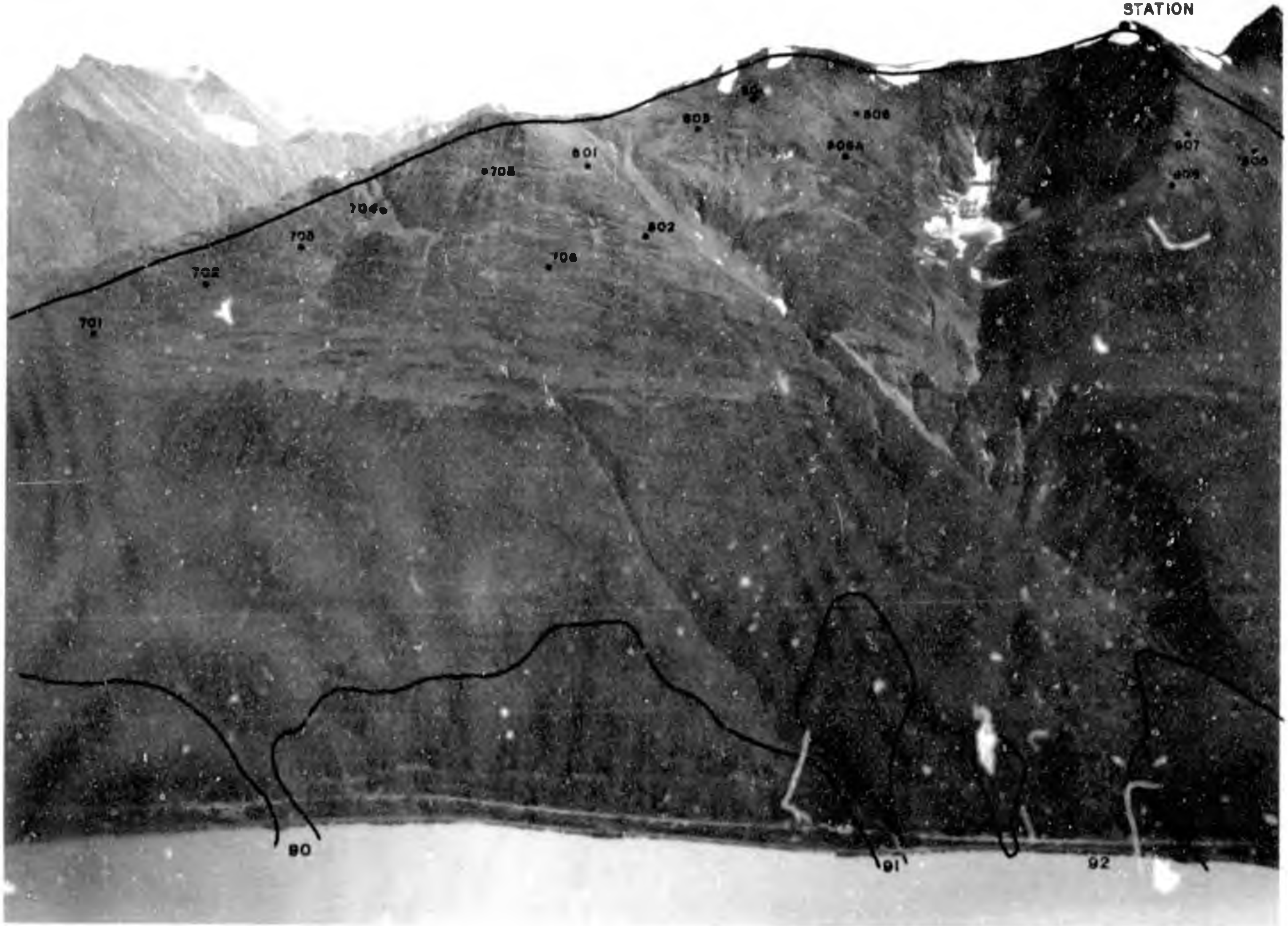


FIGURE 6-23

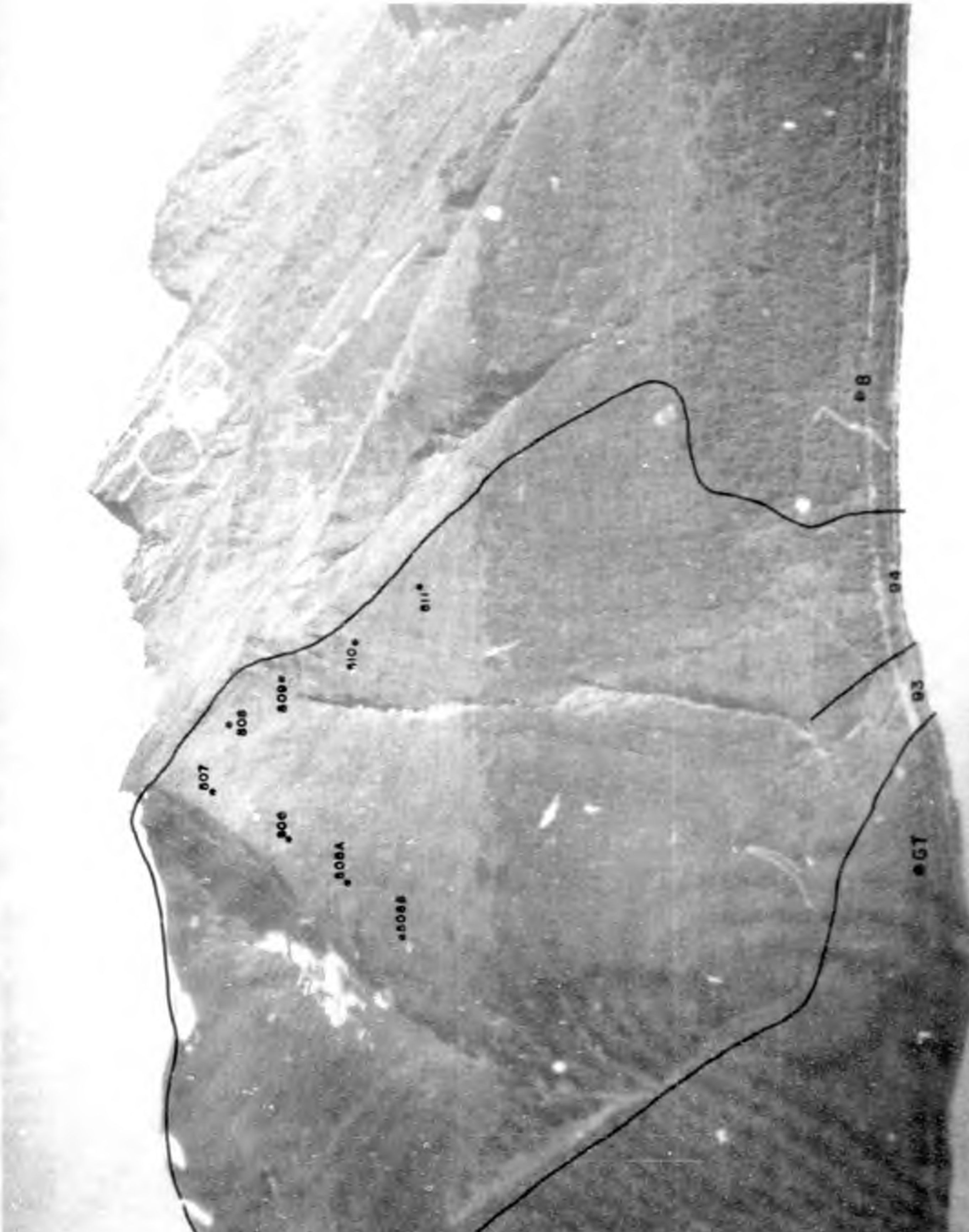


FIGURE 6-24

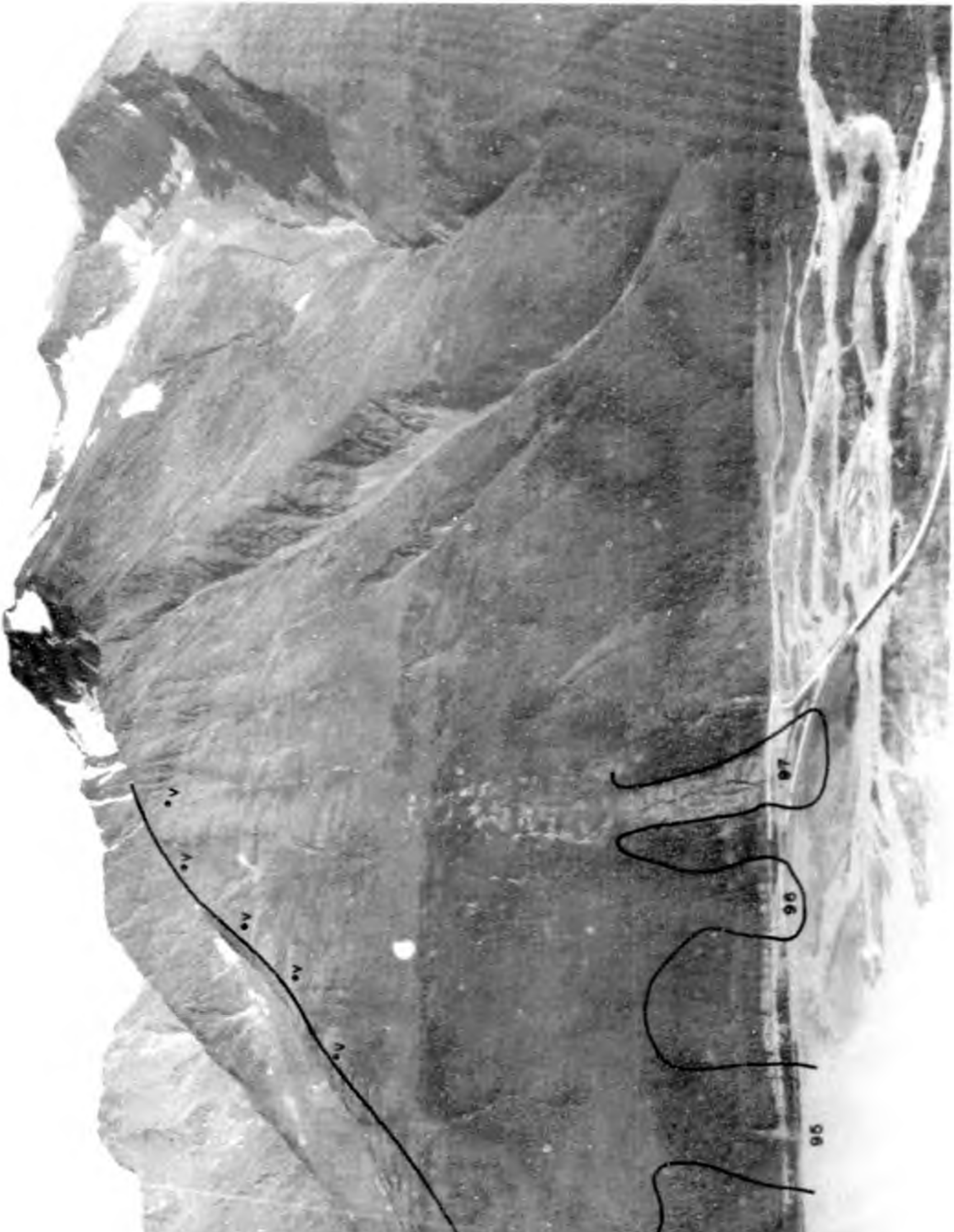


FIGURE 6-25

Chapter VII

SIGNING SYSTEM

During the course of this project a trip was taken to British Columbia, Canada to review the signing system in use in several different highway locations. There are numerous highways that are threatened by avalanches in B.C. Funding is available for artillery control only on certain critical passes, largely due to the high cost of acquiring weaponry in Canada. Because of this they have established signing as their first priority in dealing with avalanche problems.

The situation in Alaska somewhat parallels the Canadian one. There are several highways with low traffic volumes which are not practical to control. The Seward Highway is not one of these. Hazard to the public can be reduced considerably by reducing the amount of time spent in avalanche run-out zones. The use of signs is an attempt to alert the public to the fact that they should not stop in certain areas. Should a natural avalanche block the passage of vehicles it is possible that someone will remember the warning sign and leave the hazardous area. With any luck, they may also have the common sense to warn other traffic. This will help reduce the likelihood of a number of cars being buried as a result of stopping in a run-out zone.

In setting up a signing system there should be considerable attention paid to the placement of the closure gates and large electronic message boards in order to have efficient closures and the least possible inconvenience to the public.

Type 1	"Avalanche Area - Do Not Stop"
Type 2	"Avalanche Area next ___ miles - Do Not Stop"
Type 3	"End of Avalanche Area"
Type 4	Closure gates, two types
Type 5	Electronic Message Board
Type 6	Electronic Closure Sign

Type 1 and Type 3 signs must be installed on all potential avalanche paths.

Type 2 signs should be used at locations specified in the inventory.

Type 4 gates should be installed at miles 18,24,30, on two directions of the Sterling-Seward "Y", miles 46,46.5,80,90,90.6, and 99.5

Type 5 signs would be on a priority because of the high cost. First priority would be at Potter Flats and Girdwood to cover Bird Hill. As more money becomes available, DOT/PF might consider establishing these on the outskirts of Kenai and Seward.

Type 6 signs will probably be the lowest priority but could be used at Bird adjacent to the Scottish Inn and at the Sterling-Seward "Y".

Figure 7-1	Avalanche Area Warning Signs
Figure 7-2	Electronic Message Board

FIGURE 7-1

FIGURE 7-2

Type (Northbound)	Type (Southbound)	Milepost
2	3	17.8)
3	2	22.8)(5 Miles)
1	3	31.6
3	1	31.8
1	3	33.8
3	1	34.6
2	3	35.0)
3	2	38.5)(3-1/2 Miles)
2	3	43.9)
3	2	45.9)(2 Miles)
1	3	46.9
3	1	47.1
2	3	48.4)
3	2	49.4)(1 Mile)
2	3	59.0)
3	2	60.0)(1 Mile)
1	3	62.4
3	1	62.6
2	3	65.9)
3	2	66.9)(1 Mile)
1	3	71.1
3	1	71.7
1	3	83.2
3	1	84.0
1	3	85.4
3	1	85.7
1	3	86.6
3	1	87.1
2	3	90.6)
3	2	95.6)(5 Miles)
2	3	97.0)
3	2	99.0)'2 Miles)
1	3	104.9
3	1	105.1

Chapter VIII

ARTILLERY CONTROL

Control of avalanches by systematic firing of military and commercial artillery has become a standard practice in the United States and Canada. As early as 1945 this method was used by the Swiss, mostly with the employment of mortars.

In 1946 Monty Atwater, the snow ranger in Little Cottonwood Canyon, Utah, learned of the use of artillery in Europe, and decided to pursue its use here in the United States. He was able to reach an agreement with the U.S. Army to fire on the slopes overhanging the highway and town of Alta. Immediately following severe storms he would call upon the Army to assist in shelling potential avalanche areas. Realizing that this was somewhat inefficient, the next year he arranged to have the gun left up the canyon, leaving only the gun crew to be called out for the drive and subsequent shooting. By the third year Atwater was doing the firing. Thus was born Forest Service involvement in artillery avalanche control. (Cottonwood Canyons Highway Safety Plan, 1979).

Since that time the Forest Service has focused on artillery use for public safety by means of a cooperative agreement with the U.S. Army for procurement of artillery supplies. This has made these supplies available to permittees of the Forest Service for controlling avalanches, primarily in ski areas, but also in some locations on highways. In some areas the use of military artillery has become a prerequisite for the safe movement of large numbers of people.

Federal law presently dictates that military weapons be fired by federal employees or state employees who have a cooperative agreement with the U.S. Army. Several states, including Alaska, have pursued agreements on their own to procure equipment for highway control programs. State employees are then allowed to fire weapons after intensive training.

According to the latest information artillery control is now being used in 18 ski areas and 6 state highway departments in the U.S. to provide for safe travel in mountainous terrain. Approximately 13,300 rounds are fired per year nationwide. This is causing some depletion of surplus reserves; and, in some cases, parts have had to be remanufactured in order to use existing hardware (Anderson, 1975).

In 1975, as a result of an investigation into usage and supply by the National Ski Areas Association, Congress made $300,000 available to the Forest Service for purchase of ammunition, guns, and parts through a revolving account. This prepurchase procedure tied up a considerable number of rounds and all remaining surplus weaponry deemed suitable for avalanche control. It was found at the time that breeches and vent rings for 75mm and 105mm recoilless rifles were in short supply or non-existent. Money was appropriated from the revolving account for remanufacture of vent rings and breeches to match the supply of barrels and ammunition. Users of this supply are expected to pay the fund actual costs of procurement, thereby insuring a continuing flow of money for the purchase of equipment. This system could go on for years so long as supplies are available (Anderson, 1975).

It is possible that there will be other weapons systems made available in the future. Improved communications between the U.S. Army's Rock Island procurement division, the U.S. Forest Service, and interested state agencies would result in a more comprehensive view of the artillery hardware available for avalanche control. Of particular interest to this study would be the possibility of obtaining a 105mm Howitzer for Gun Position No. 2.

Artillery control has proven itself to be the most reliable and cost-effective method of controlling remote slopes. In spite of this, there are some drawbacks to artillery use. Safety is of primary interest. A single fatal accident would, in all probability, result in the abatement of all artillery avalanche control.

Recoilless rifles are based upon the principle of half the blast propelling the projectile out the front and half the blast being vented out the back to balance the forces. There is a large area adjacent to the rear of the gun that could cause a fatality should a round go off while a person is exposed. Two close calls with rounds that overshot their targets and landed near populated areas have occurred in Wyoming and Utah. Hearing losses occur regularly to gunners. Handling ammunition has a long-term possibility of accident exposure. Care must be taken and proper procedures set and practiced to avoid a serious accident.

There is not a commercial substitute for military artillery that can reliably fire long distances in high winds without visibility. A compressed air cannon called the avalancher has been developed but is severely restricted in range and adversely affected by winds because of its slow, lobbing trajectory. Helicopter bombing is limited to clear weather with little wind - a rare occurrence in coastal Alaska. Military artillery continues to be the only delivery system of explosives to remote locations that combines speed, safety, and cost-effectiveness.

Weapons Available and Characteristics

Weapons	Maximum Range	Useful Life (#rounds)	
75mm Recoilless	2,?00 yards	500/breech	2,000/barrel
105mm Recoilless	3,500 yards	500/breech	2,000/barrel
75mm Howitzer	5,000 yards	20,000	
105mm Howitzer	8,000 yards	20,000	

The above are maximums used in existing control programs and might disagree with official estimates of maximum range.

EXPLOSIVES FOR AVALANCHE CONTROL

Inventory of Weapons and Ammunition for Avalanche Control

Weapon Type	Weapons in Storage	x Tube Life =	Potential Rounds ÷	Vent Assembly Life =	Vent Assembly Needs /	Vent Assemblies in Storage x	Vent Assembly Life =	Adjusted Potential Rounds /	Rounds in Storage HE	HEP	Total
75 mm Howitzer	5	20,000	100,000	N/A	N/A	N/A	N/A	100,000	20,800	-----	= 20,800
75 mm Recoilless Rifle	31	2,000	62,000	500	124	61	500	30,500	27,500	55,000	= 82,500
105 mm Recoilless Rifel	18	2,000	36,000	500	72	28	500	14,000	30,500	35,000	= 65,500

Corrected figure of useable rounds based on available weapons, available vent assemblies, tube life and available ammunition.

75mm Howitzer - 20,800
75mm Recoilless Rifle - 30,500
105mm Recoilless Rifle - 14,000

Unserviceable Weapons
75mm Howitzer - 8
75mm Recoilless Rifle - 251
105mm Recoilless Rifle - 249

Plans call for re-vamping of unserviceable weapons to replace weapons that become inoperative due to expiration of tube life or malfunction after inventories on this chart are exhausted.

Figures - U.S. Army and U.S.F.S. 10/79

There are considerable differences in several letters obtained concerning quantities of ammunition. It is entirely possible that there is considerably more ammunition than indicated in the 1979 report. This is an area where further communications with the Army will help to obtain accurate reports. In recent communications with various people it seems there is a good possibility that the amount of 75mm Howitzer ammunition has been understated. A 1975 report showed considerably fewer 75 howitzer rounds than the 1979 report. There seems to be an absence of records reflecting the availability of 105mm Howitzers and ammunition.

Gunners' Qualifications and Training

Standards for the training and certification of gunners vary somewhat according to geographical location. It is not clear whether the U.S. Army requires a particular course of training.

There is an excellent publication by Region 6 of the U.S. Forest Service that can be used as a basis for training which is included in the related letters section of this report, an unpublished collection of information.

There are some guidelines that can be generalized as standards. All gunners should receive a formal training course (20 to 40 hours) every two years and refresher courses should occur every year (6 hours). There is a natural progression of involvement beginning with occasional exposure to artillery, then assuming the role of assistant gunner and eventually becoming a gunner. Normally this process takes two years or more, however, if this progression is intensified by virtue of considerable expenditure of ammunition, this familiarization period could be made shorter.

Of primary importance in the use of artillery is the application of common sense and caution. These weapons can be extremely dangerous if used in a casual manner. Diligence, adherence to strict procedure, and alertness in every firing mission should preclude the possibility of an accident.

Storage, Handling, and Transport

All of these operations must be done in adherence to federal and military rules and regulations. It is beyond the scope of this plan to outline all of these, as manuals are available, but several aspects of these procedures should be noted.

Storage requirements presently dictate that all recoilless rifle rounds be stored in separate compartments with a minimum of 4-1/2 inches of sand separating each round. In addition, the walls of the storage facility must be 12-inch reinforced concrete or cinder block poured with concrete, the roof 12-inch reinforced concrete, and the door 1/2-inch steel plate with a 2-inch hardwood backing. Doors must be double locked with safety shields to prohibit the locks from being cut off with a hack saw.

All handling and transportation should take place at a distance from public areas with vehicles in good repair and equipped with explosives warning signs. Care should be taken in handling and transport to avoid sudden stops or jarring of the ammunition.

Response Time

During critical periods of the winter avalanche conditions can develop in a very short period of time, particularly with the advent of wind increase. Most active control programs can respond to changing conditions with control work in an hour or less. At present, conditions here may not allow for such rapid response, but efforts should be made to reach this guideline in the future. There should be no problem with establishing a maximum two-hour response time for this coming season. Forecasting ahead of the hazard will be necessary considering this time requirement. A method of alerting the gun crews to standby status will help reduce response time. This might require some extra funds but will greatly increase the efficiency of the operation. Another consideration in terms of response time is the fact that instability can rectify itself almost as quickly as it occurs, therefore, timing of artillery control is very important to achieve the best results possible.

Continuity

Every effort should be made to utilize the same gun crews year after year. Many hours will be spent by each crew in initially identifying all of the target points from each gun position and becoming familiar enough with the terrain so that confusion over targets is eliminated. Thorough training in artillery procedure also takes considerable time. The combination of these factors makes continuity of the gun crew an important prerequisite to a smoothly functioning control program.

Helicopter Bombing

This method of avalanche control has been successfully used in many areas of the country. Since 1975 it has been used occasionally by the DOT/PF to control avalanches on the Seward Highway. It has been proven to be an accurate and cost-effective method, but there are certain limitations. Clear and calm weather is an important prerequisite. This means that helicopter bombing can be done only a few times each year. The use of a large helicopter can extend these weather limitations somewhat. There are considerable target points on the highway. Because the price of helicopter time is much greater than extra explosives, it could be considered more effective to carry a large number of bombs on each individual run. The helicopter bombing done during the avalanche cycle of March, 1979, could have used in excess of 100 charges had they been on board at that time. The number of charges necessary is another justification for using a large ship such as the Bell 212.

Safety of the crews is a difficult proposition when using two such potentially dangerous elements as helicopters and explosives. The use of a twin turbine Bell 212 will somewhat reduce the hazard presented by the helicopter. Adherence to strict procedures in handling the explosives while airborne will reduce the possibility of an accident from the powder. Nevertheless, there is always the possibility that the ship could go down with explosives on board, therefore the powder must always be contained in a wood box, enabling jettisoning the load should a mechanical problem develop.

The design of the avalanche control system is such that there is no necessity for helicopter bombing. This technique can be valuable at times, but must be used with much discretion.

Gun Positions

An inventory of gun positions is given below. Positions for visual fire are not given as they can remain flexible. Some of the gun positions listed were established in years past, and some were installed this year (fall, 1979) to provide a reasonable degree of control coverage until the full program comes on line. Related comments are provided.

* is an existing mount

\# is the recommended mounts for this control design

Gun Position	Target Points	Total no. of Targets	Type Weapon	Type Mount	Milepost	Comments
*IA	103-108	9	105RR	Fixed	99.2	Avalanche safe, protection shots to allow gun crew to 1B and 1.
1B	101-116		105RR	Mobile	98.15	Low probability of inundation.
#1	102-116	32	105RR	Fixed	97.1	Avalanche safe.
*2A	All P west of 201		105RR	Mobile	95.7	Protection shots for 2B.
*2B	201-208		105RR	Fixed	95.3	High probability of inundation.
*2C	209-219		105RR	Fixed	94.3	Low probability of inundation.

Chart (continued)

Gun Position	Target Points	Total no. of Targets	Type Weapon	Type Mount	Milepost	Comments
#2	201-219	50	75/105 Howitz.	Turntable	Bird Point	Avalanche safe if located properly. Could combine S.H.A. Forecast Office.
#3	301-313	26	105RR	Fixed	92.74	Low probability of inundation Earthworks defense required.
*3A	305-313,401-404		105RR	Fixed	92.05	Low probability of inundation High probability of skipped round into Girdwood.
#*4	401-409	21	105RR	Fixed	90.7	Avalanche safe, eliminates skipped round potential.
#5	501-510	10	105RR	Fixed	44	Avalanche safe.
#6	601-614	14	105RR	Fixed	37	Avalanche safe.
#7	701-708	8	105RR	Fixed	22.6	Avalanche safe, long range to shots 707 and 708.
#*8	801-811	14	105RR	Fixed	20.5	Avalanche safe.

Figure 8-1	105 mm recoilless rifle
Figure 8-2	75 mm Howitzer on turn-table mount
Figure 8-3	Ammunition storage for 75 Howitzer
Figure 8-4	Mt. Alyeska ammunition storage facility
Figure 8-5	Detail of ammunition storage facility
Figure 8-6	105 RR fixed gun mount
Figure 8-7	Snowshed at Rogers Pass with 105 mm turntable mount in foreground

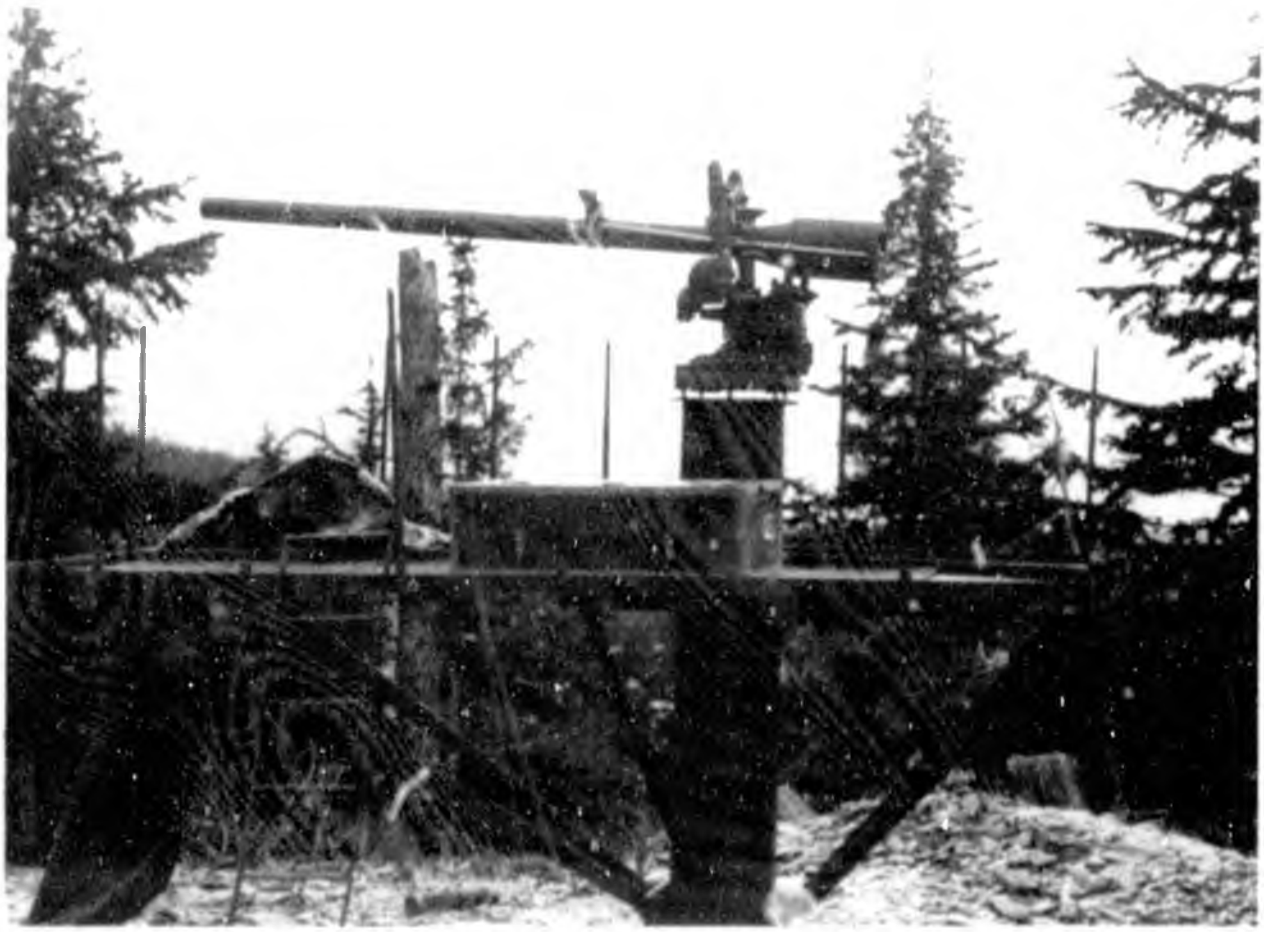


FIGURE 8-1

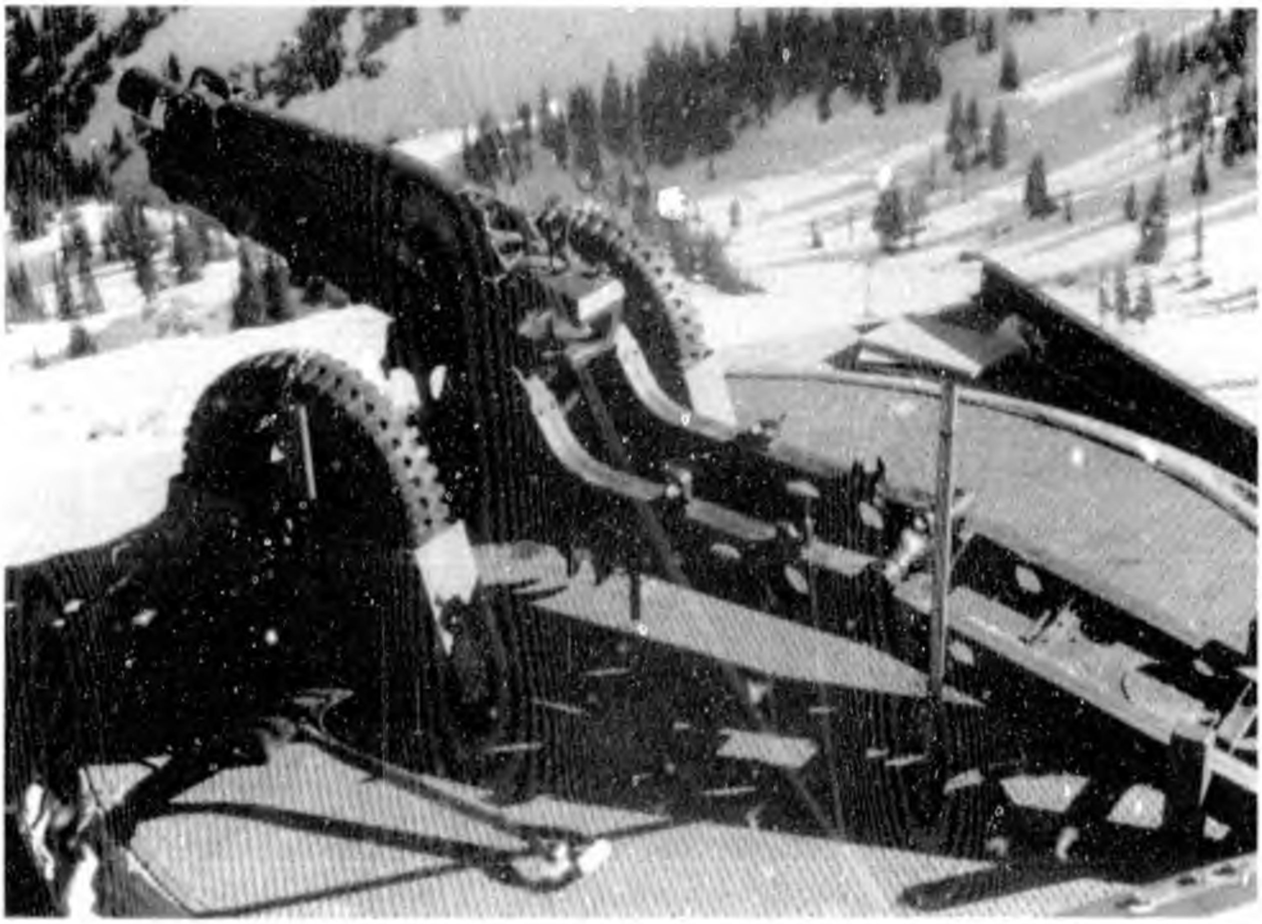


FIGURE 8-2

FIGURE 8-3

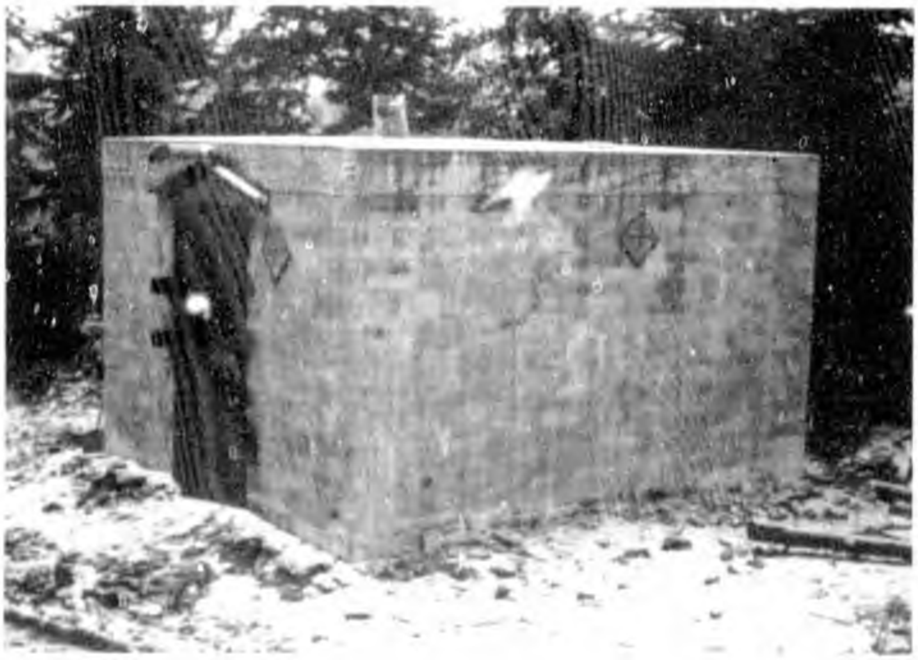


FIGURE 8-4

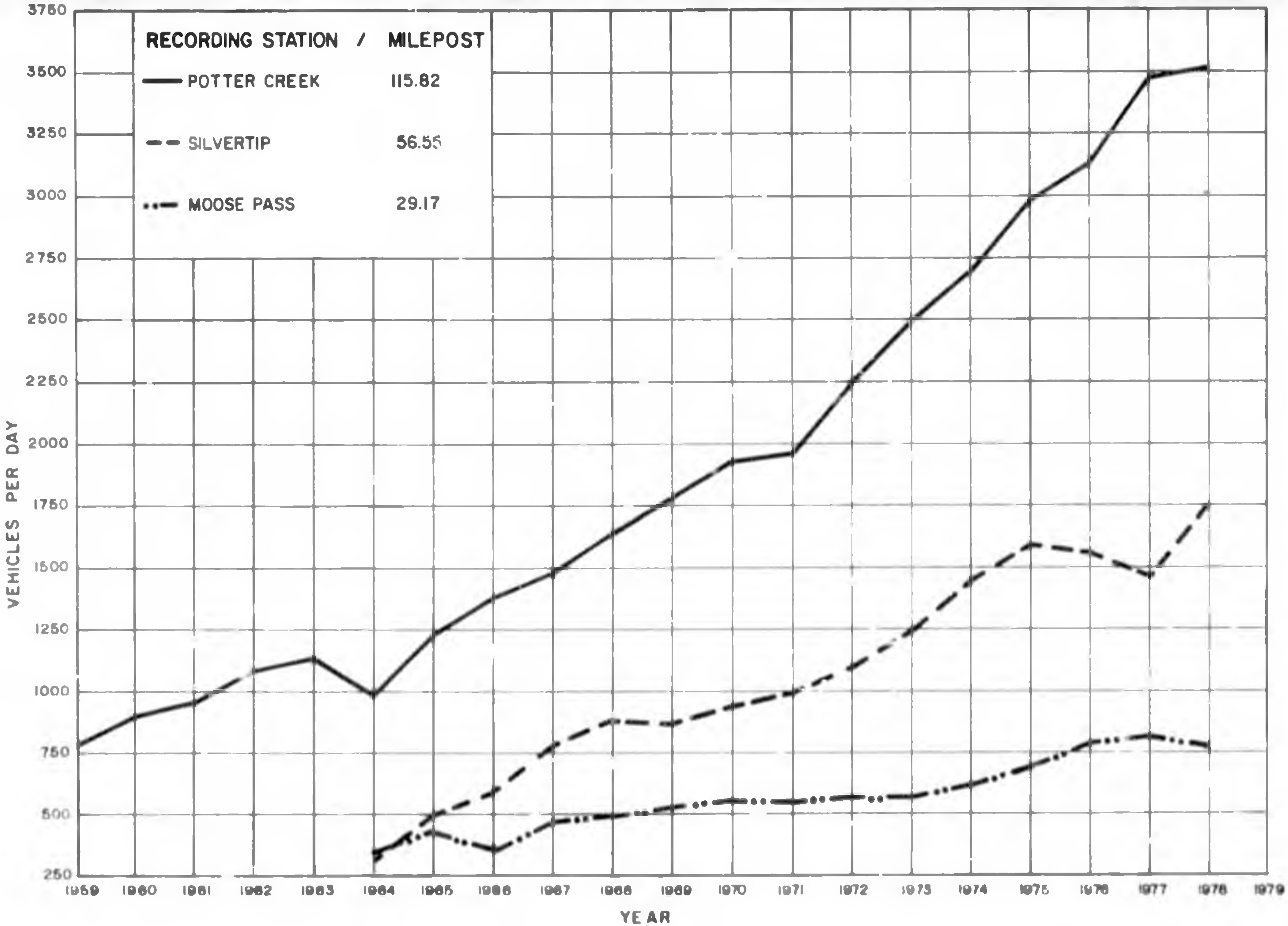
FIGURE 8-5

FIGURE 8-6

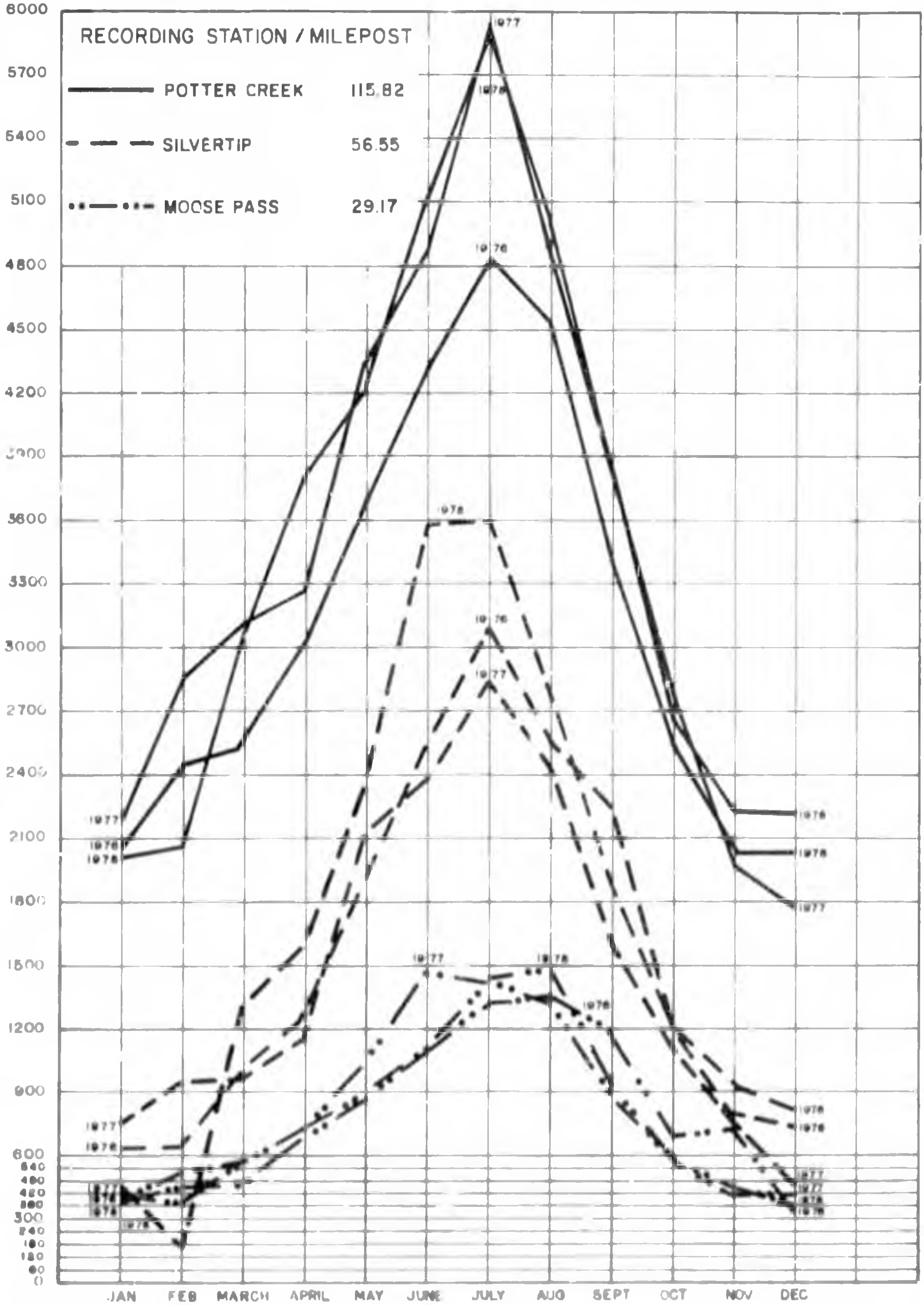
FIGURE 8-7

APPENDICES

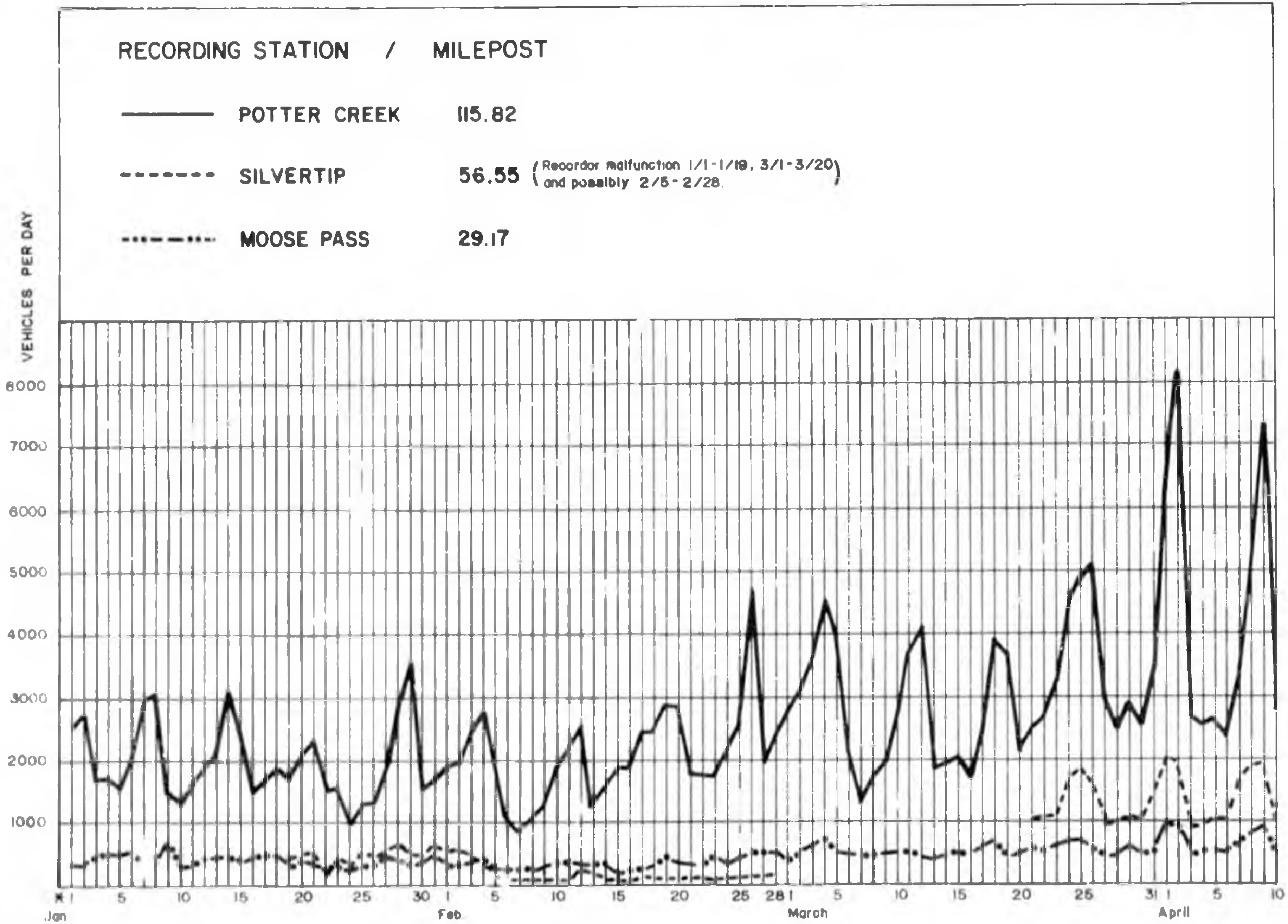
AVERAGE ANNUAL DAILY TRAFFIC

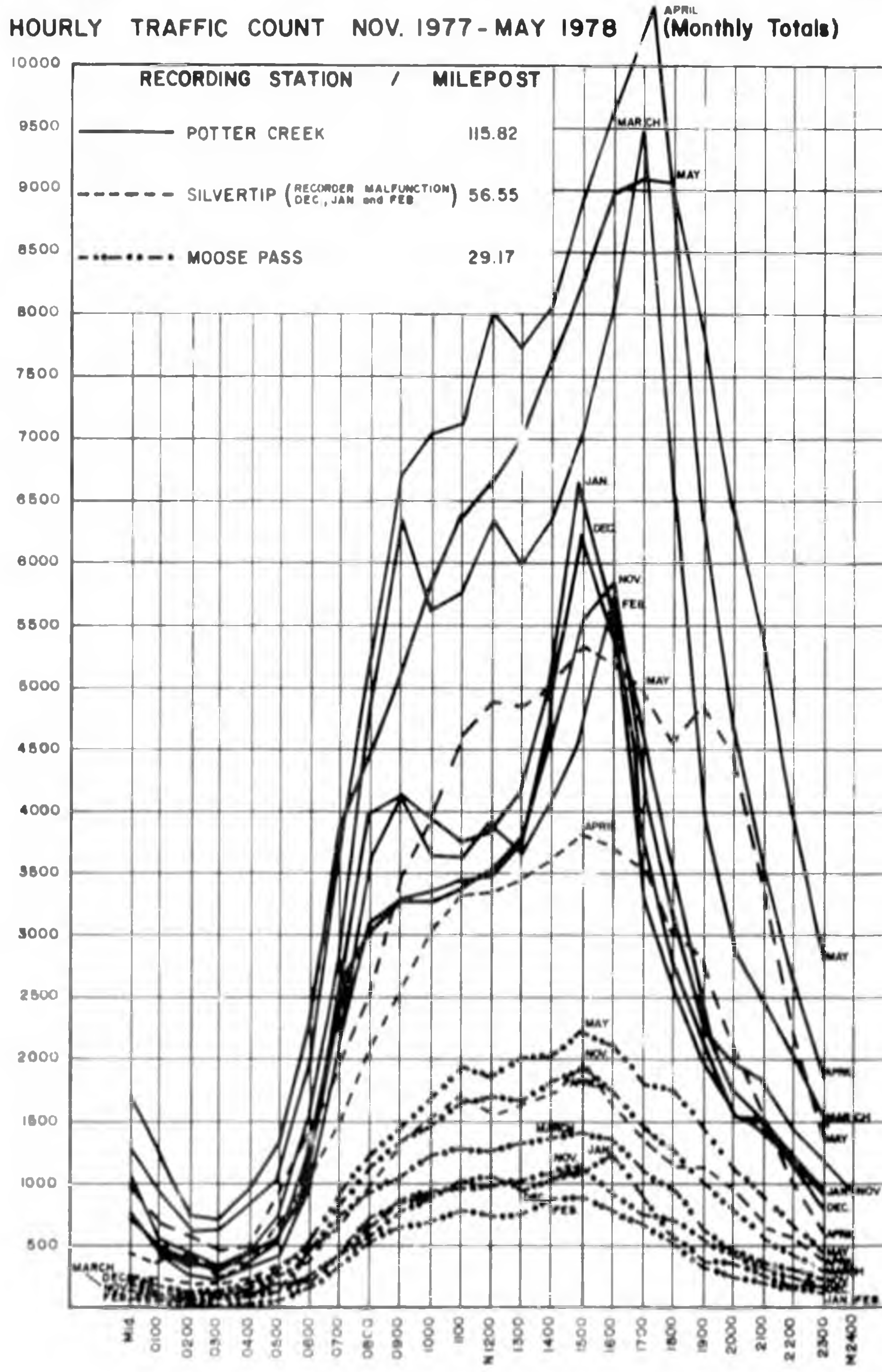


MONTHLY AVERAGE DAILY TRAFFIC 1976-1977-1978



DAILY TRAFFIC VOLUMES JAN. 1, 1978 - APRIL 9, 1978





HOURLY TRAFFIC COUNT NOV. 1977 - MAY 1978 (Monthly Totals)
RECORDING STATION / MILEPOST
POTTER CREEK 115.82
SILVERTIP (RECORDER MALFUNCTION DEC., JAN and FEB) 56.55
MOOSE PASS 29.17
APRIL
MARCH
MAY
JAN
DEC
NOV
FEB
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
MID
0100
0200
0300
0400
0500
0600
0700
0800
0900
1000
1100
N1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
M2400

Appendix II

HISTORICAL AVALANCHE ACTIVITY ON THE SEWARD HIGHWAY

This record was largely compiled from DOT/PF records. There are several intermediate years between 1968 and 1979 for which no avalanche activity reached the higway so these years have been deleted from the survey.

Slide Path #	68/69	70/71	74/75	75/76	76/77	77/78	78/79	Avg/Yrs
1					2	1		1/4
2						2	4	1/2
3				1		2	2	5/12
4				1	1	1	1	1/3
5						1	4	5/12
6						1	1	1/6
7						1	2	1/4
8						1	1	1/6
9						1	1	1/6
10						2	4	1/2
11			1	1		2	3	7/12
12	1					2	3	1/2
13						2	2	1/3
14				1		4	3	1/1-1/2
15						2	1	1/4
16	1				1	2	2	1/2
17						2	2	1/3
18						3	2	5/12
19	1			1		2	2	1/2
20						1	2	1/4
22						1	1	1/6
23						1		1/12

Chart (Continued)

HISTORICAL AVALANCHE ACTIVITY ON THE SEWARD HIGHWAY

Slide Path #	68/69	70/71	74/75	75/76	76/77	77/78	78/79	Avg/Yrs
24		1				1	1	1/4
25		1				1		1/6
26	1	1	1			2		5/12
27		1			1	1		1/4
28	1							1/12
41			1					1/12
42			1					1/12
43			1					1/12
45	1							1/12
49						1		1/12
50						1		1/12
51			1			1		1/6
52			1			1		1/6
53						1		1/12
70							1	1/12
73							2	1/6
74			1					1/12
75						1	3	1/3
76							3	1/4
77							3	1/4
78							2	1/6
79							2	1/6
92						1		1/12

HISTORICAL AVALANCHE ACTIVITY ON THE SEWARD HIGHWAY

Slide Path #	Years	Avg/Yrs
92	Nov. 11, 1976	1/12
93	May 11, 1974, 1978	1/6
94	1974, 1978	1/6

There has been a considerable number of avalanches reported the last two years, either as the result of unusually heavy winters or better reporting. While this section does give a good indication of the relative frequency of each path it was not used exclusively in establishing a frequency rating for these locations. It is possible that unreported or recorded avalanches did occur. The overall record spans too short a time to be used reliably in establishing frequency ratings. As a consequence the frequency ratings given in Appendix V are based loosely on historical information. Primary input was provided by field personnel that have been working with these avalanche paths for a number of years.

Appendix III

SUPPLEMENTAL WEATHER INFORMATION

The collection of weather data is essential to the formation of an avalanche hazard forecast. Recording all previous weather and avalanche occurrence data will take a considerable amount of time. This appendix is therefore limited to graphing two storm periods that induced large scale avalanching. Good records exist for these periods and were used to compile the graphed data.

For purposes of graphing the information was split into two geographical sections - north and south of Silvertip Maintenance Station. Seward weather observations were used for the section south and Mt. Alyeska for the northern section. Temperature graphs had to be adjusted to the wind graph for each location.

These graphs can be reproduced on a daily basis by the forecasting office for use as an aid to stability evaluations. Operationally, the graph works such that when the wind speed, increasing downward, crosses the minimum temperature line a favorable wind speed/ temperature for instability exists. When the precipitation rate crosses into the wind speed it can be presumed that leeslope loading is reaching a critical level.

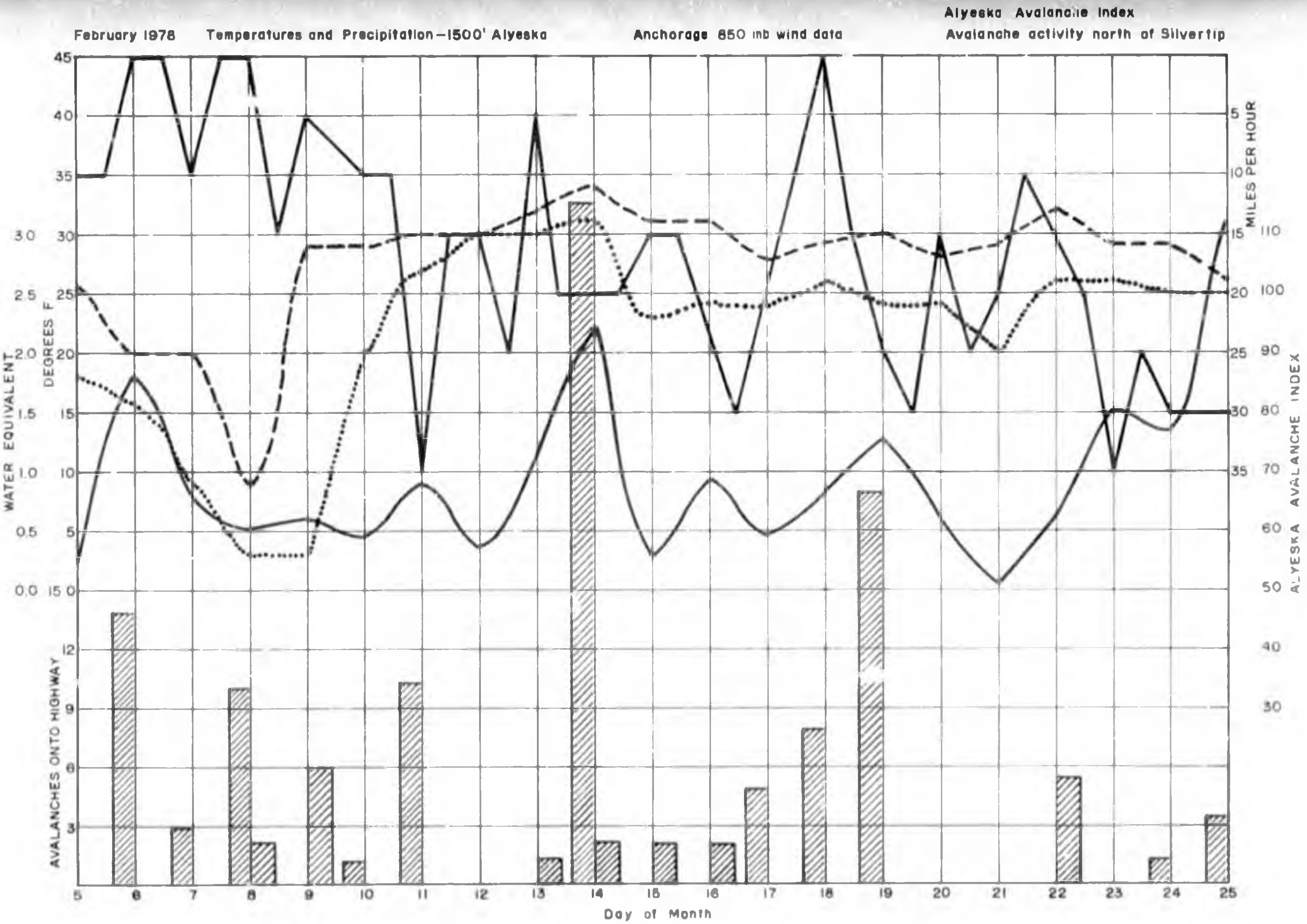
On the north section graphs it is interesting to compare avalanche activity at Alyeska to the Seward Highway. The difference is largely due to control being done during storms at Alyeska, and after storms on the highway.

The Alyeska Avalanche Index (AAI) was derived by multiplying the number of avalanches times a magnitude scale. The magnitude scale was derived on the basis of Class #2 and #3 avalanche runouts being on the perimeter of the area, Class #4 avalanches running well into the area, and Class #5 going completely through the area. Because of the hazard level to people a proportionately higher scale had to be applied to Class #4 and #5. A value of 6 was applied to Class #4 and

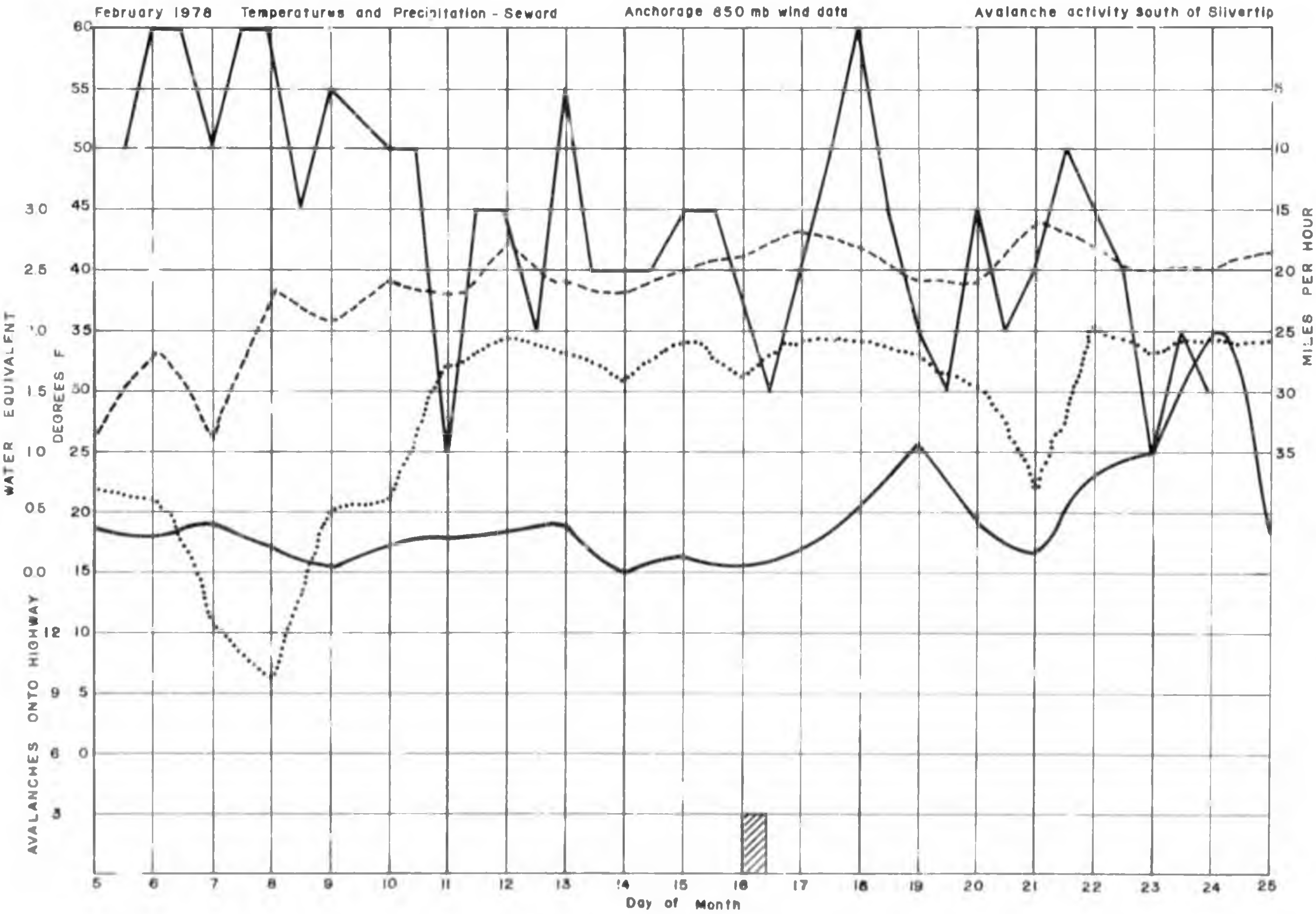
10 applied to Class #5. For a day that had 3 class #3, 1 Class #4, and 1 Class #5, the magnitude factor would be (3x3)+(1x6)+(1x10) = 25 ÷ 5 = 5 magnitude factor x 5 avalanches = 25 AAI.

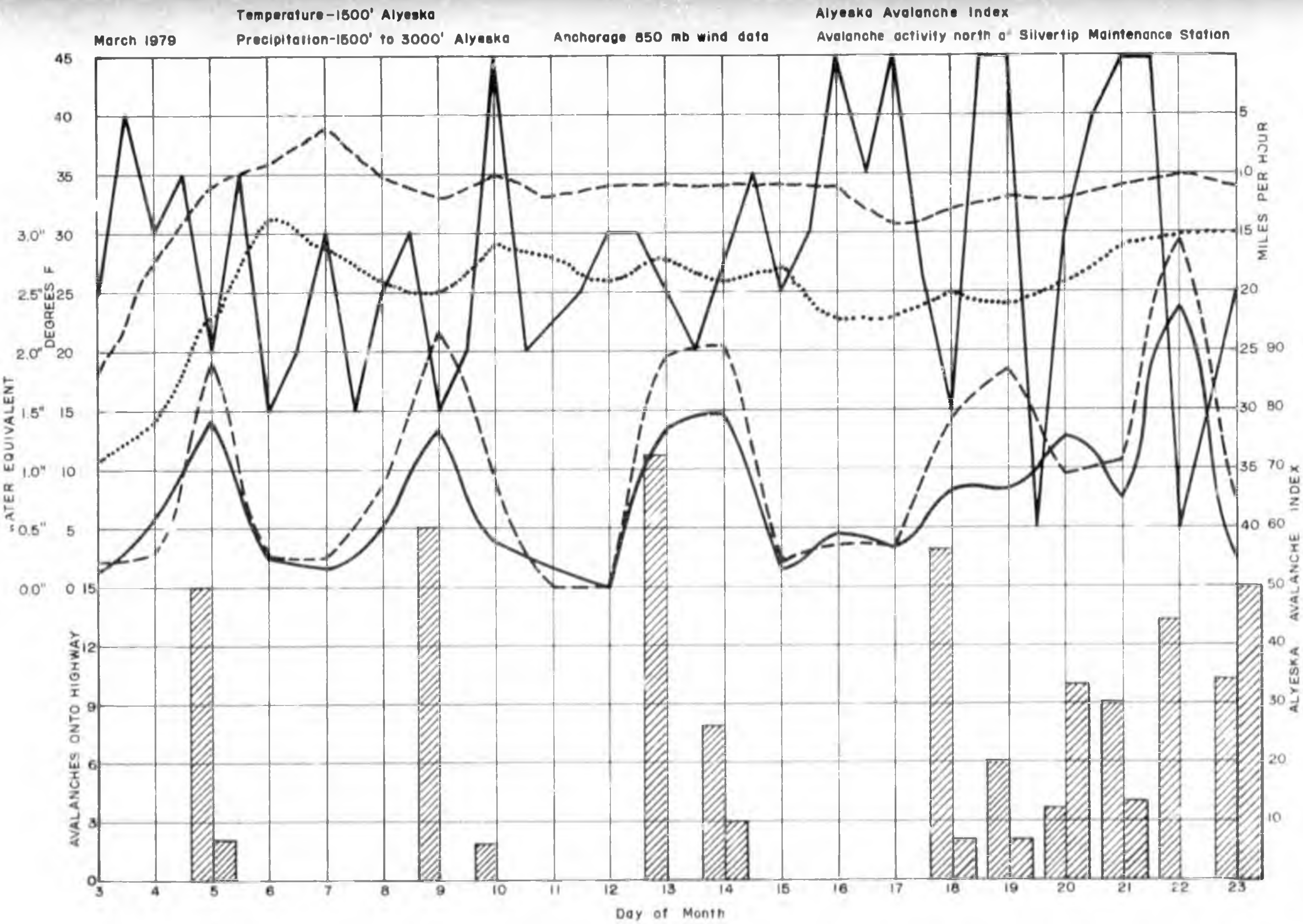
4 Class #3 and 1 Class #4 would produce a scale of (4x3)+(1x6) = 18 ÷ 5 = 3.6 magnitude factor x 5 avalanches = 18 AAI.

The final part of this appendix is a collection of 850 mb. wind flow patterns that produced differential precipitation between Seward and Alyeska. More work needs to be done on this phenomenon, however, it was possible during this report to isolate these cases to find if there was a similarity in flow patterns. Type 1 storms produced heavier precipitation in Girdwood, and Type 2 produced heavier precipitation in Seward. These are certainly limited examples but a cursory study does show a good correlation in pattern.

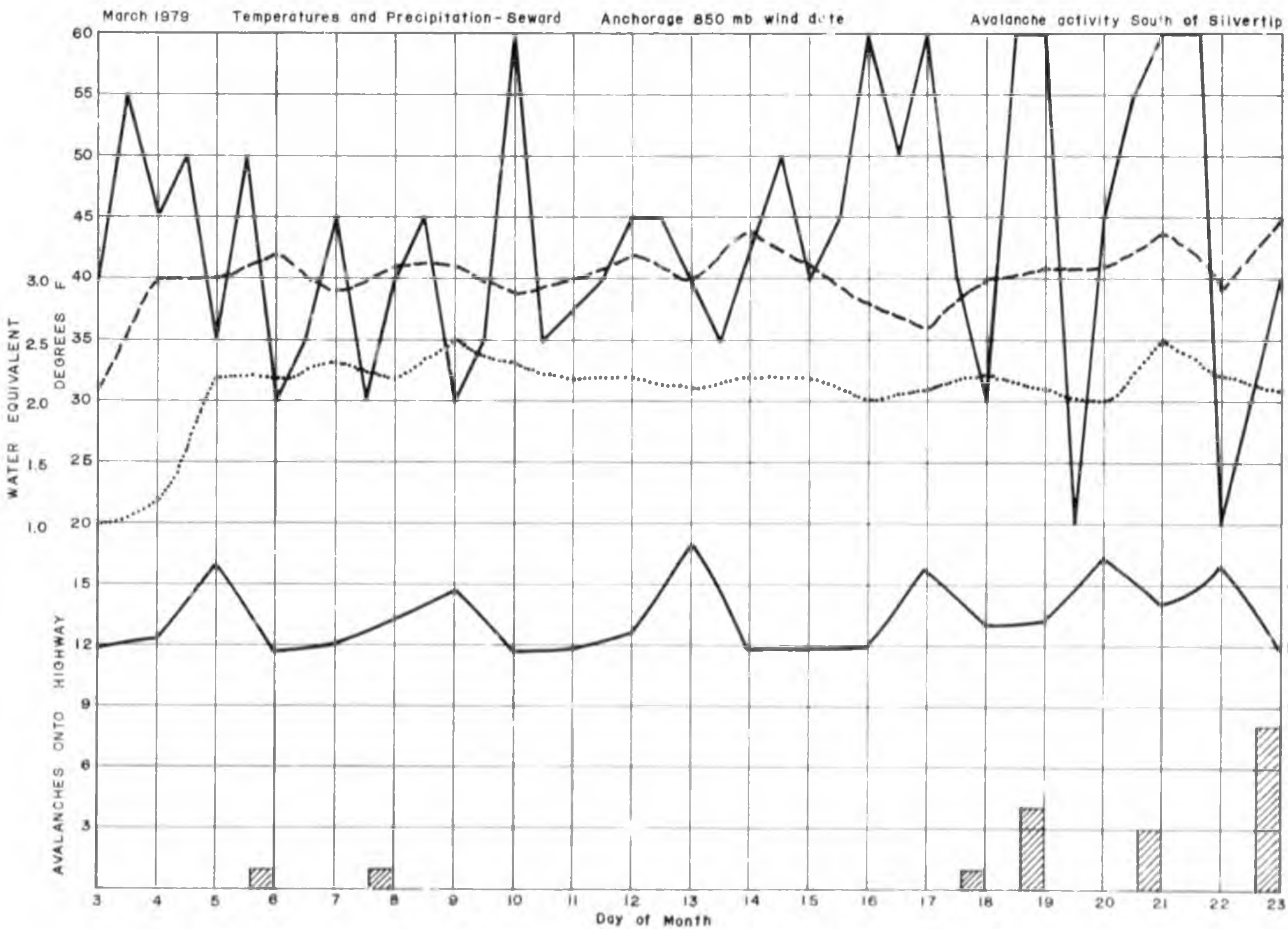


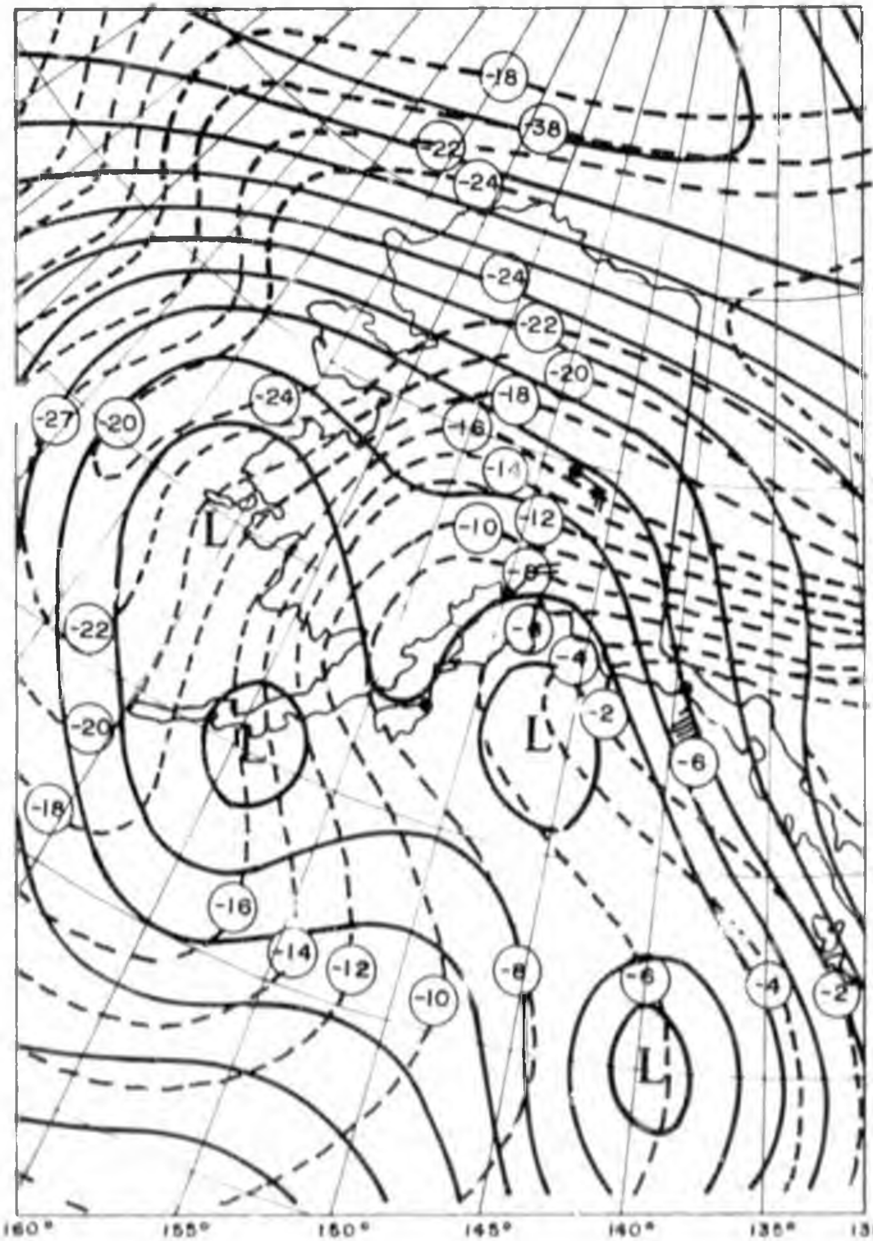
February 1978
Temperatures and Precipitation—1500' Alyeska
Anchorage 850 mb wind data
Alyeska Avalanche Index
Avalanche activity north of Silvertip
WATER EQUIVALENT
DEGREES F
MILES PER HOUR
ALYESKA AVALANCHE INDEX
AVALANCHES ONTO HIGHWAY
Day of Month


February 1978
Temperatures and Precipitation - Seward
Anchorage 850 mb wind data
Avalanche activity South of Silvertip
WATER EQUIVALENT
DEGREES F
AVALANCHES ONTO HIGHWAY
MILES PER HOUR
Day of Month

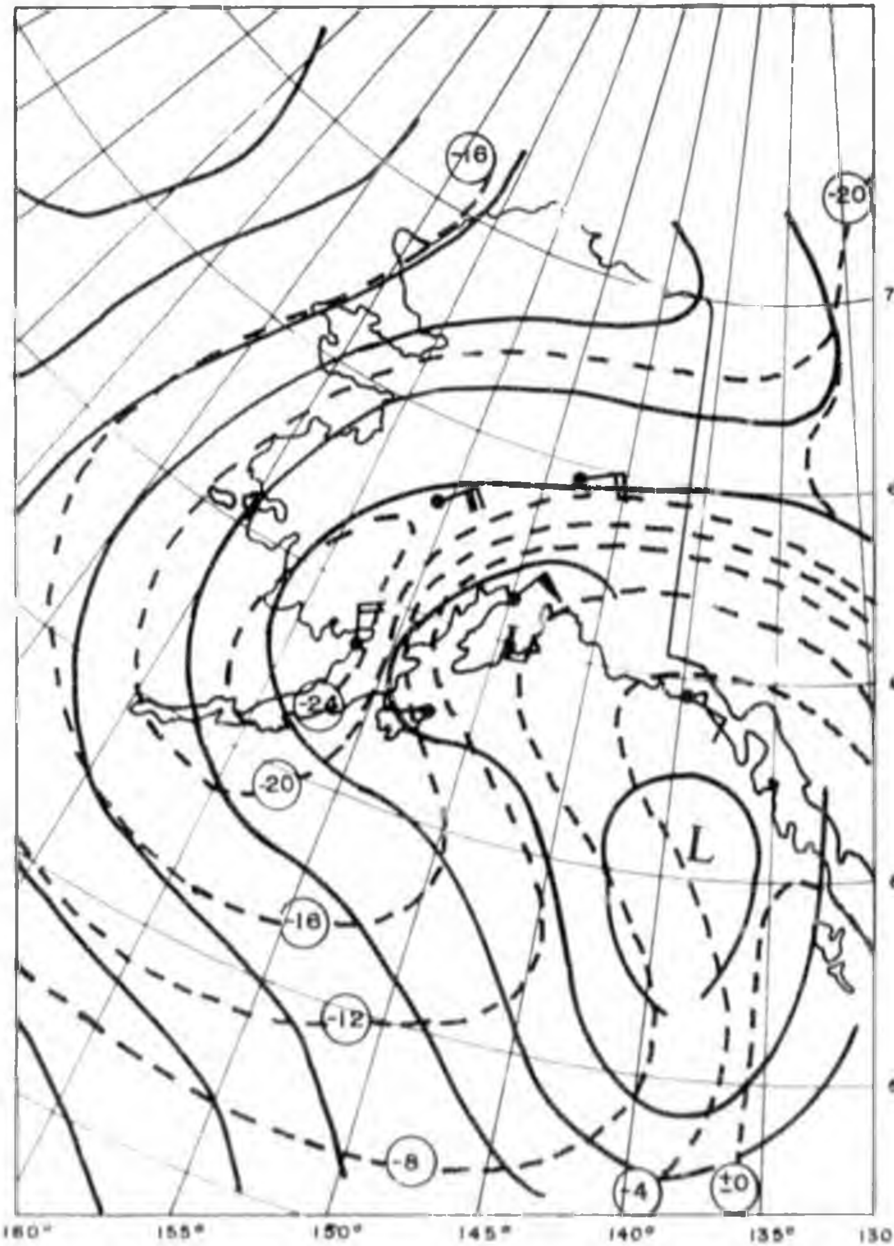


March 1979
Temperature-1500' Alyeska
Precipitation-1500' to 3000' Alyeska
Anchorage 850 mb wind data
Alyeska Avalanche Index
Avalanche activity north of Silvertip Maintenance Station
WATER EQUIVALENT
DEGREES F
MILES PER HOUR
ALYESKA AVALANCHE INDEX
AVALANCHES ONTO HIGHWAY
Day of Month

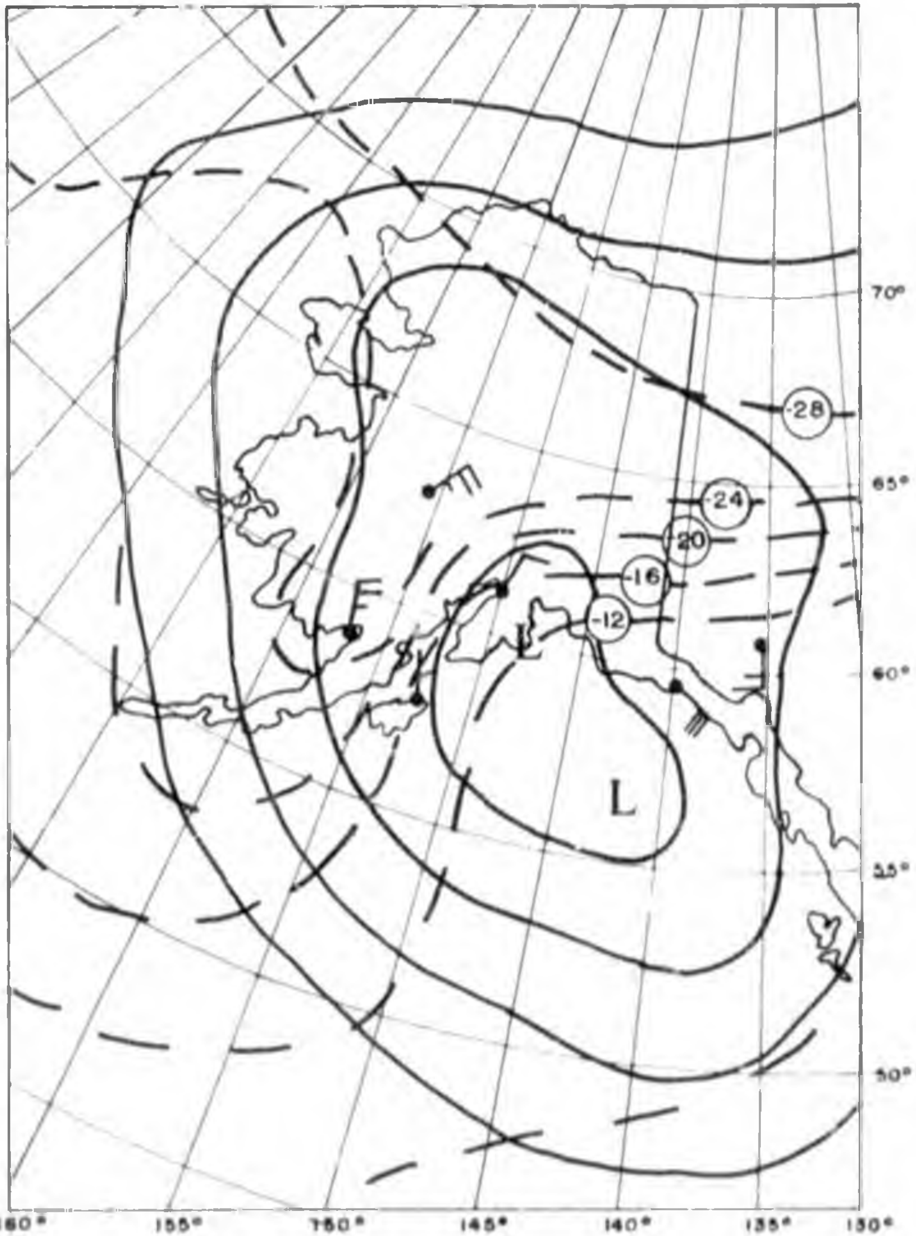

March 1979
Temperatures and Precipitation - Seward
Anchorage 850 mb wind data
Avalanche activity South of Silvertip
WATER EQUIVALENT
DEGREES F
MILES PER HOUR
AVALANCHES ONTO HIGHWAY
60
55
50
45
40
35
30
25
20
15
12
9
6
3
3.0
2.5
2.0
1.5
1.0
5
10
15
20
25
30
35
40
45
50
55
60
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Day of Month



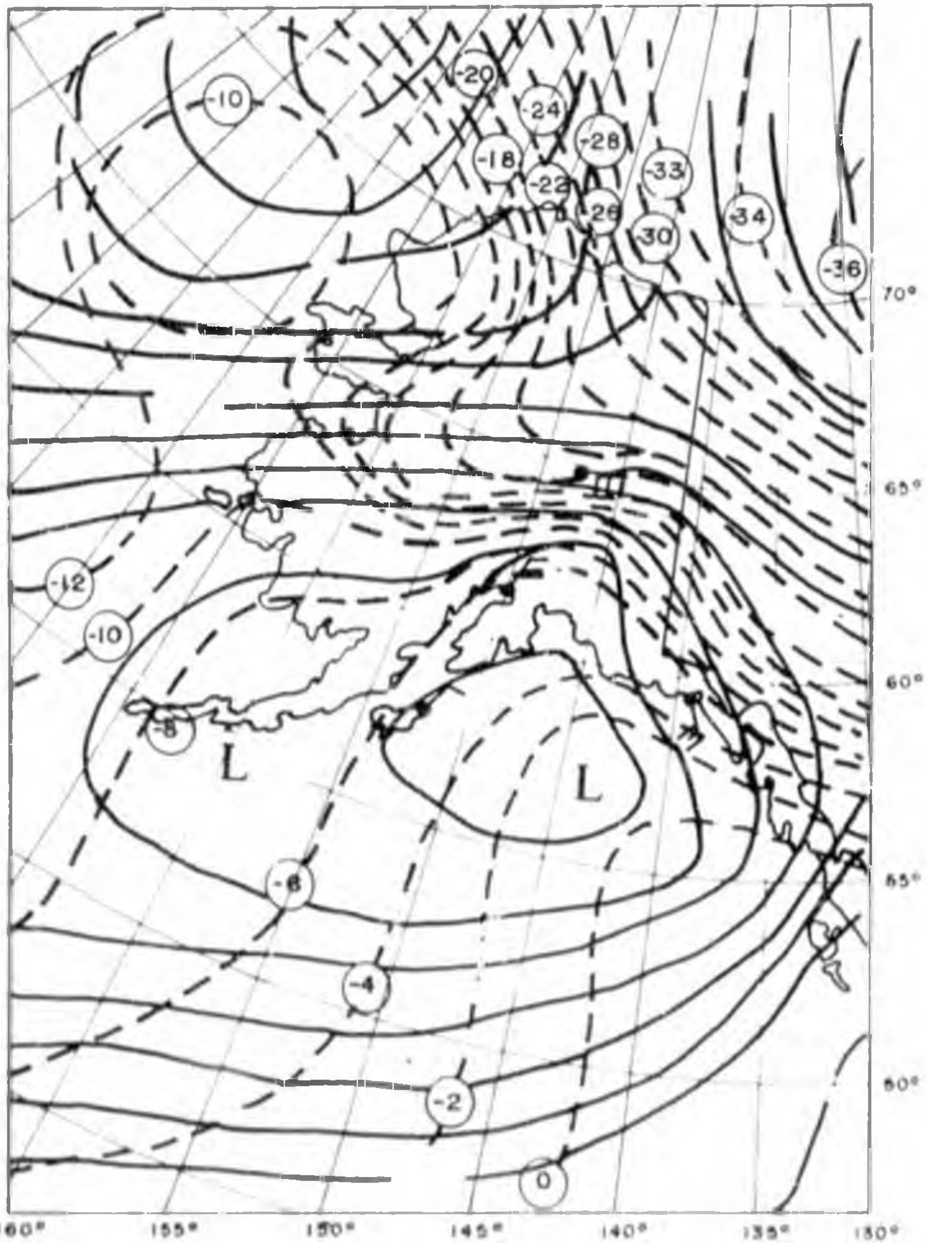
7 Mar 78 Type l



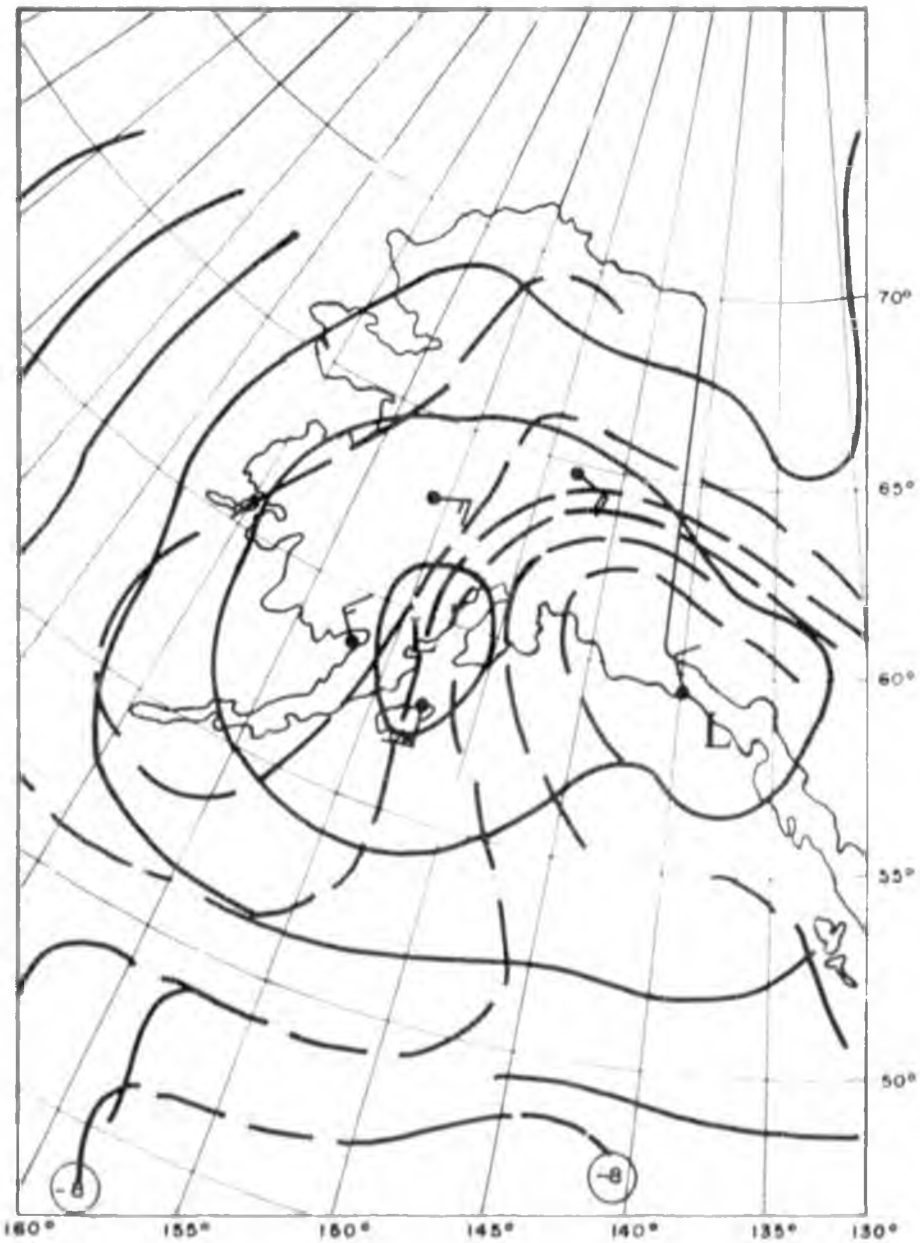
18 Mar 78 Type I



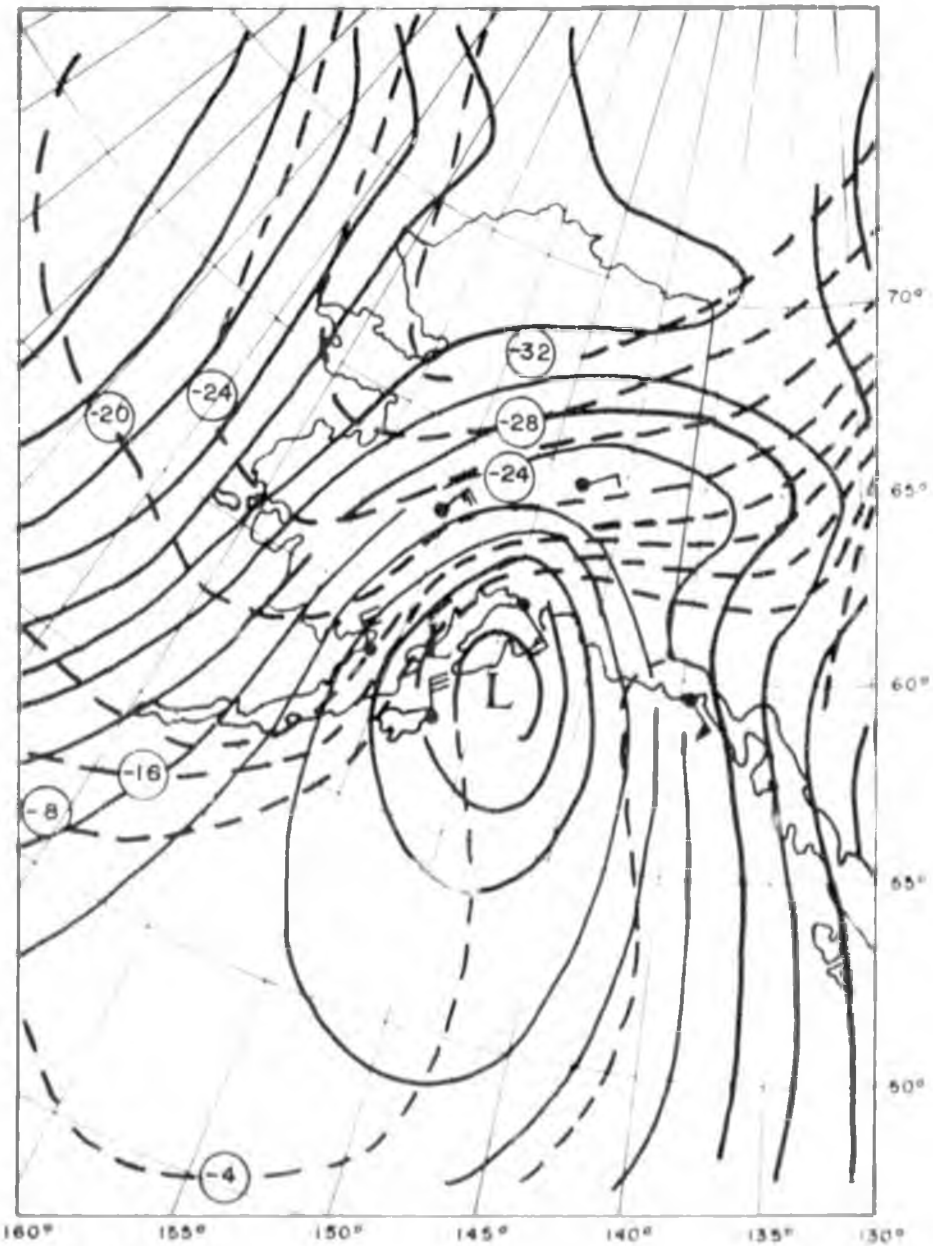
24 Feb 76 Type I



3 Mar 79 Type I



19 Mar 76 Type I



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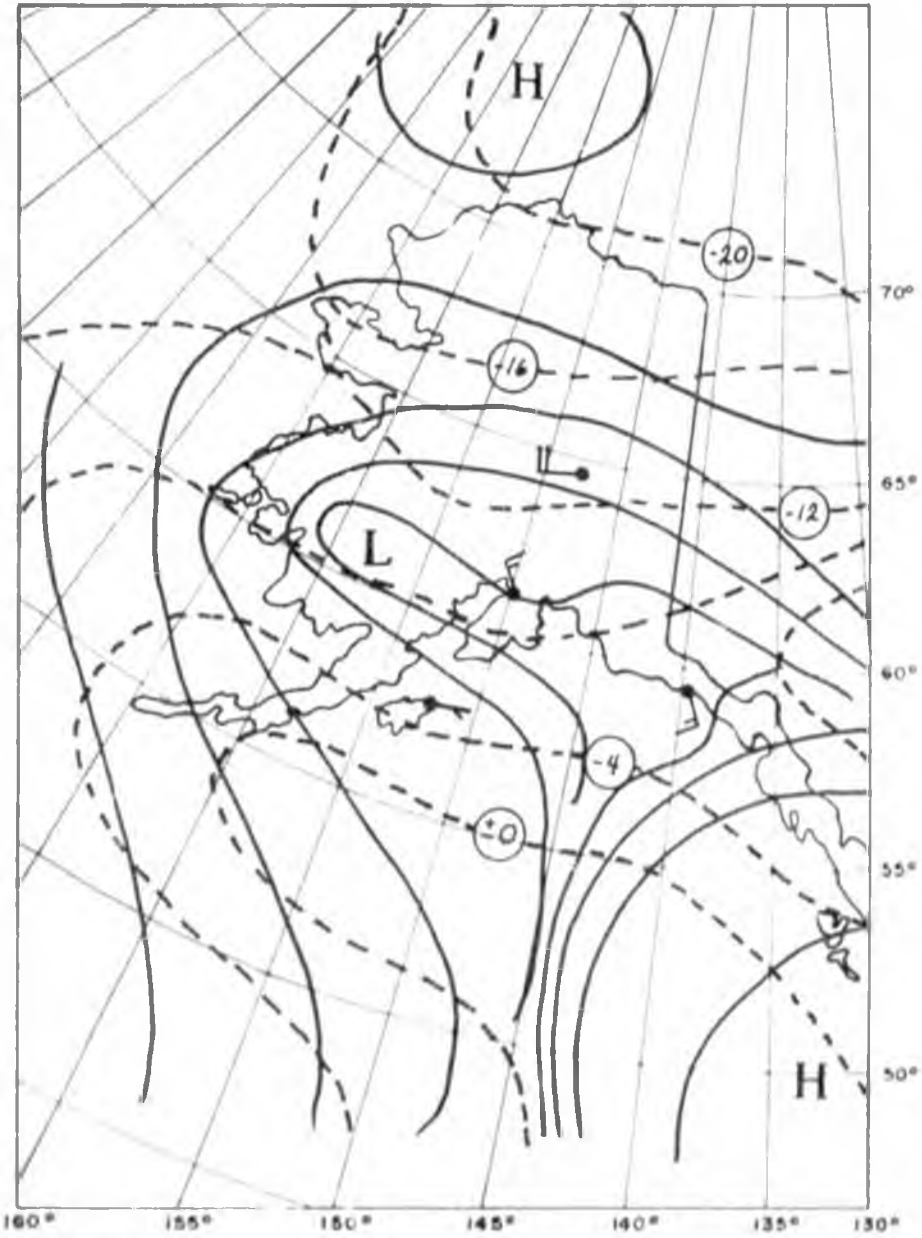

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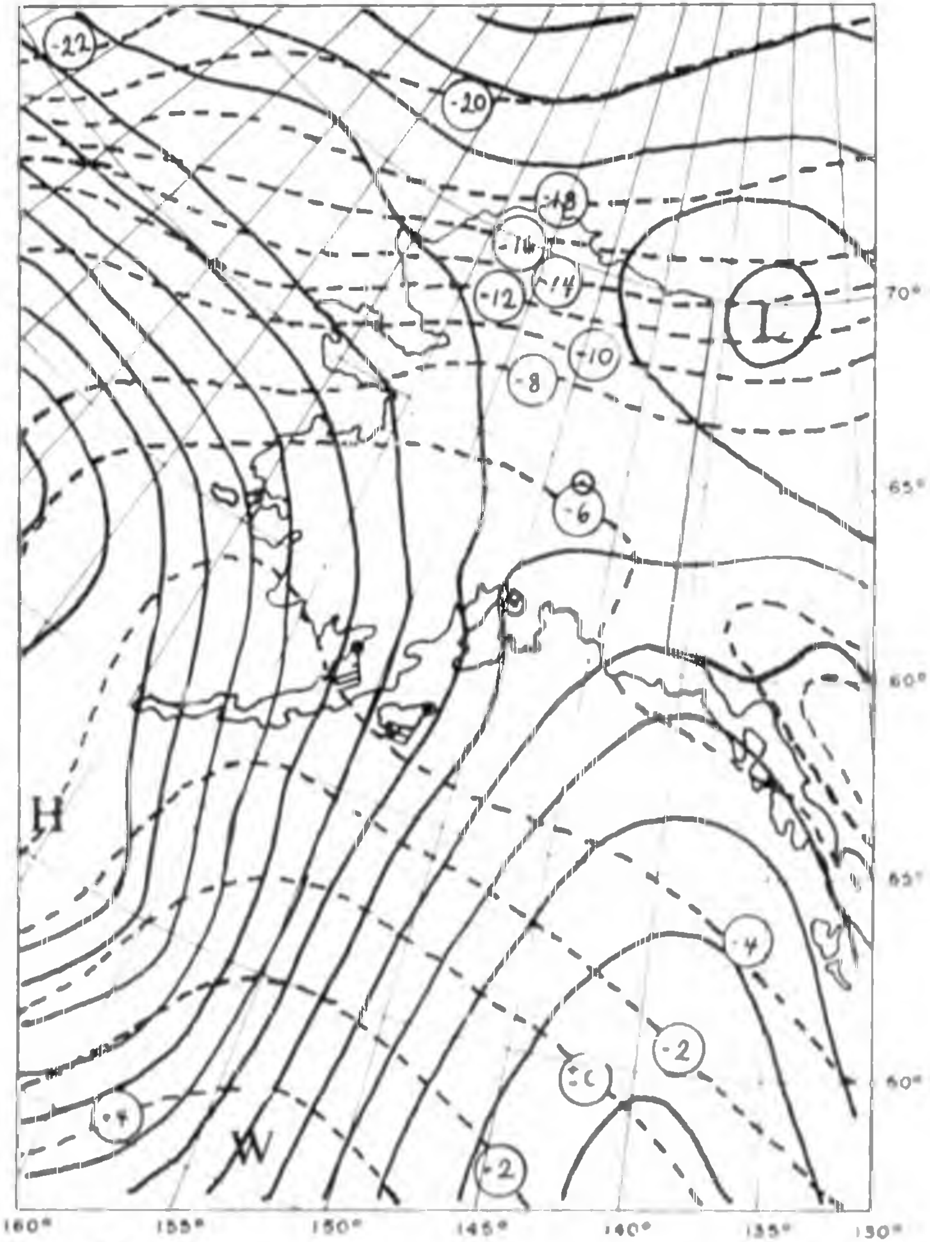

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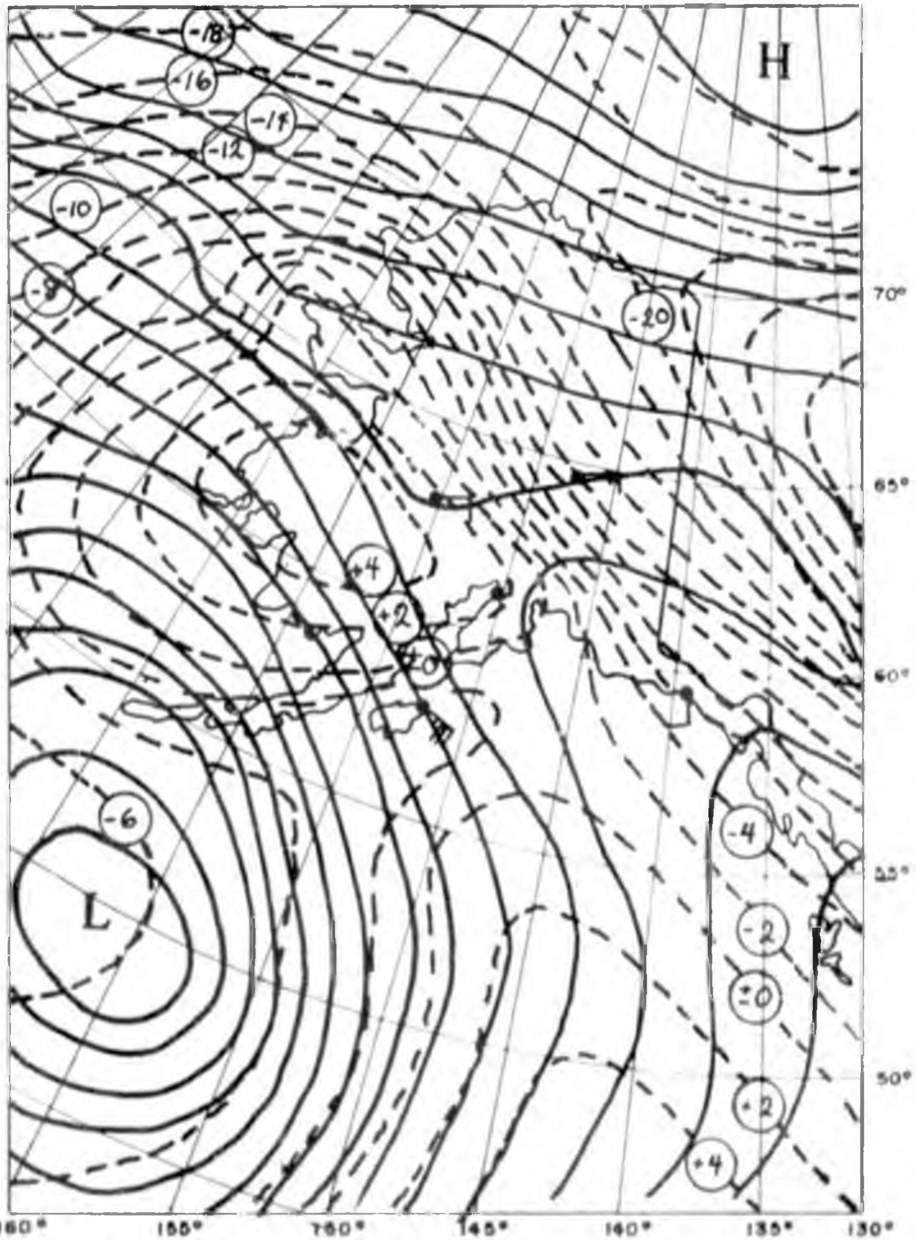

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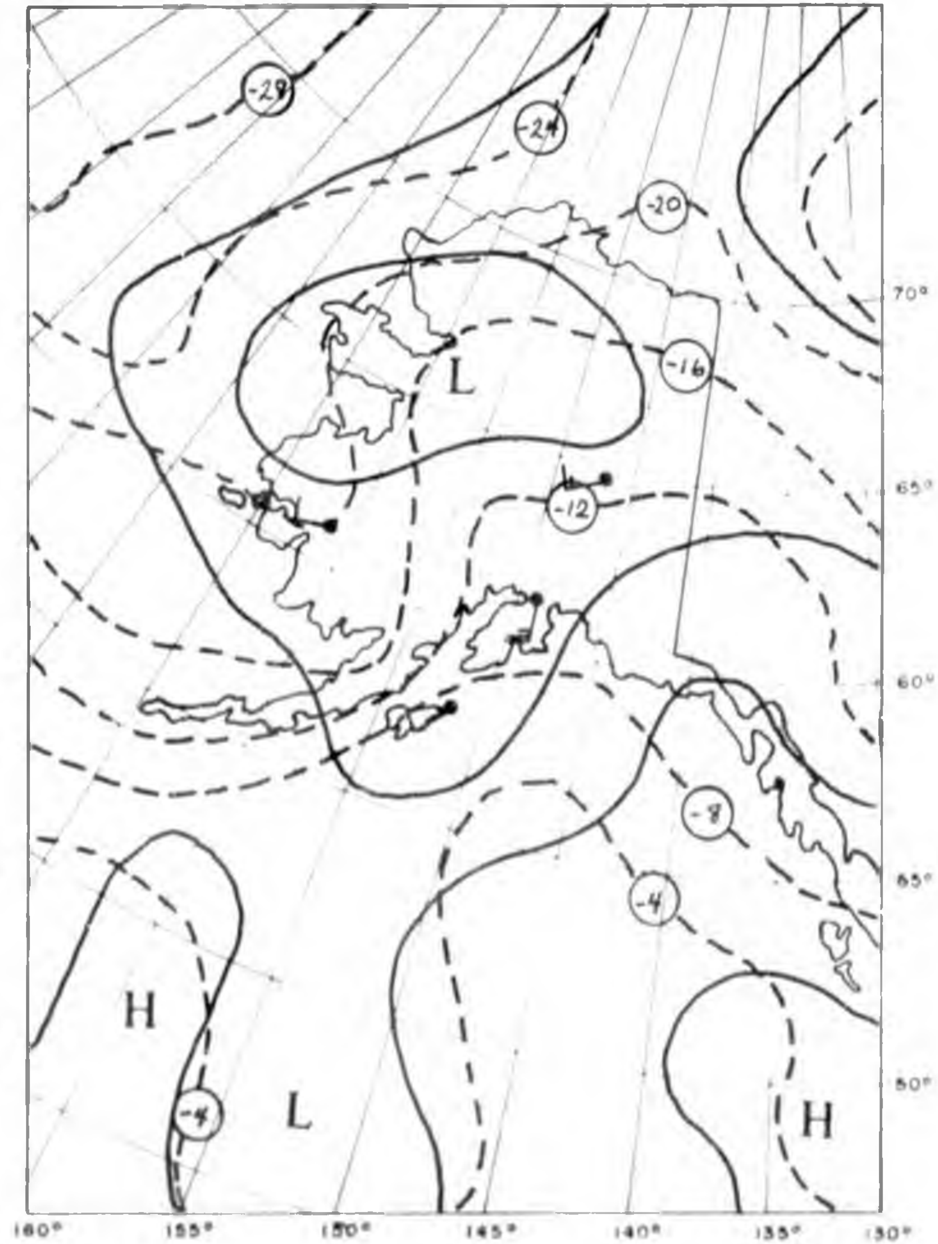

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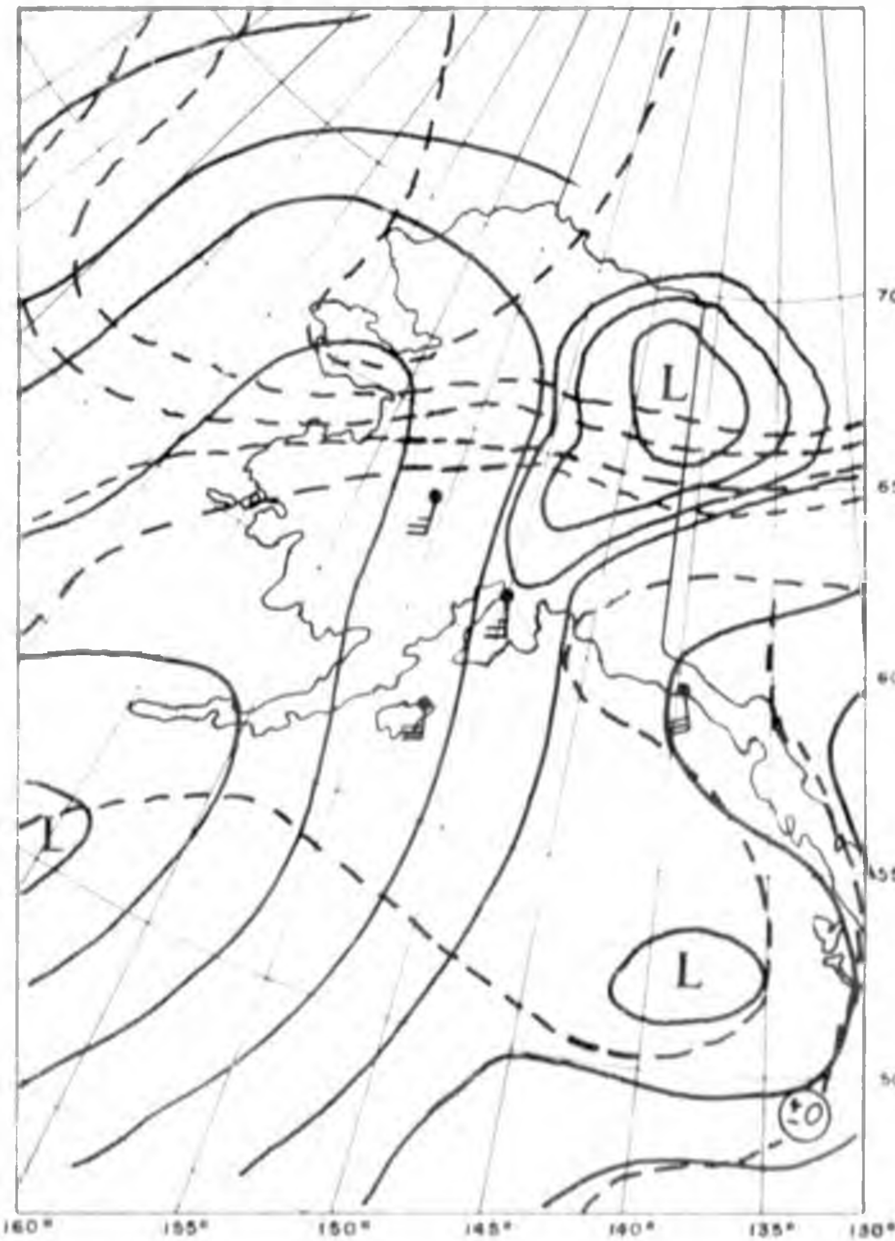

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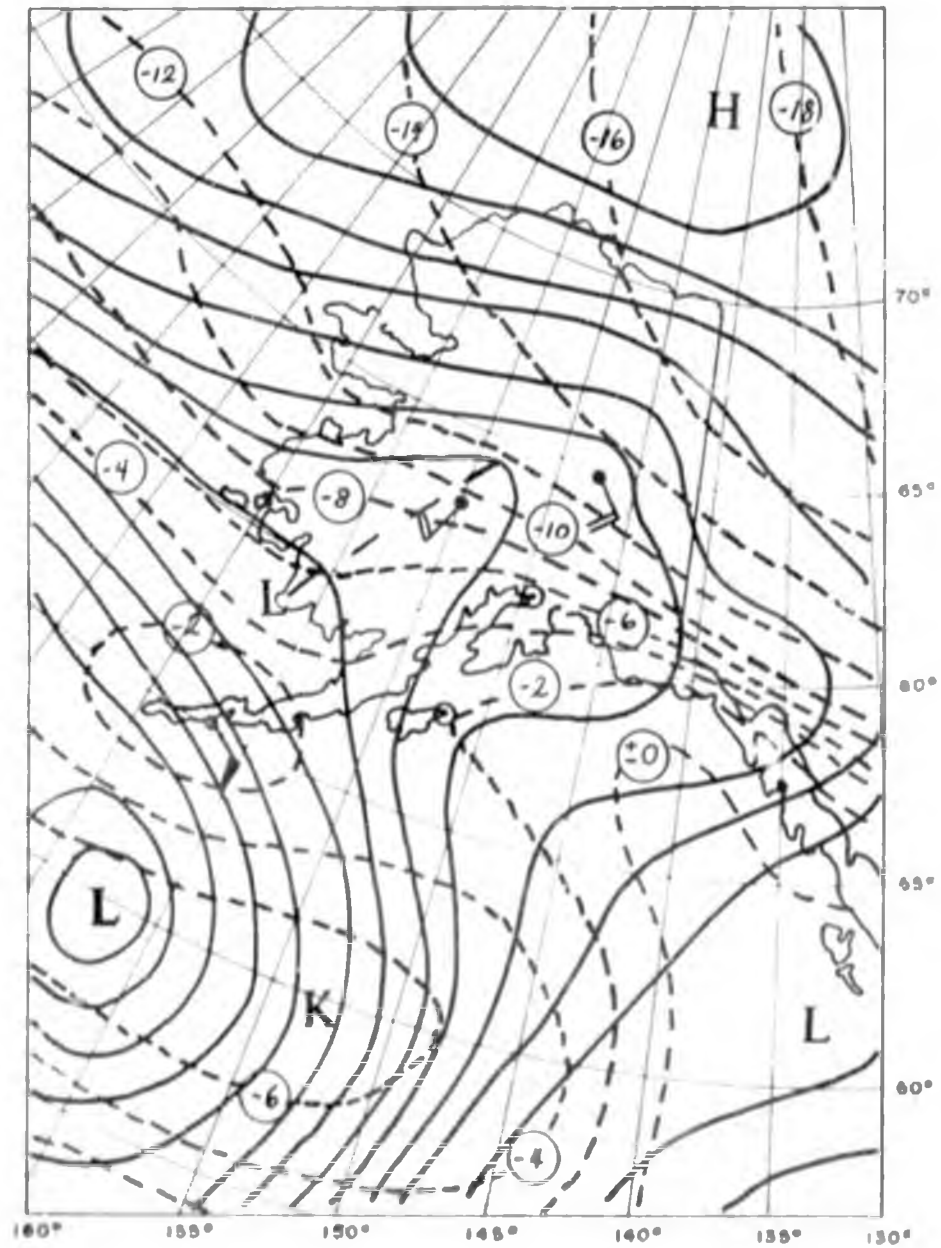

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Appendix IV

AVALANCHE PATH INVENTORY

Slide Path #	Width(ft)	Vertical(ft)	Frequency	Hazard Class	Milepost
1A	200	3800	Infreq.	High	104.9
1	520	3000	Infreq.	Low	98.8
2A	800	4300	Infreq.	Low	98.3-98.5
2B	720	4300	Freq.	High	98.2-98.3
3	850	3900	Freq.	High	97.9-98.1
4	480	4000	Freq.	Low	97.8-97.9
5	1050	4100	Infreq.	High	97.4-97.7
6	690	4100	Infreq.	Low	97.3-97.4
7	660	3800	Infreq.	High	95.1-95.2
8	600	3800	Infreq.	High	95.0-95.1
9	580	3500	Infreq.	High	94.9-95.0
10	575	3500	Infreq.	High	94.8-94.9
11	2000	3200	Freq.	High	94.3-94.8
12	2600	2900	Freq.	High	93.8-94.3
13	550	3400	Infreq.	High	93.6-93.8
14	800	3300	Freq.	High	93.4-93.6
15	825	3300	Infreq.	Low	92.8-93.0
15A	200	3300	Infreq.	Low	92.7
16	1080	3300	Infreq.	High	92.3-92.6
17	730	3500	Freq.	High	92.1-92.3
18A	860	3200	Infreq.	High	91.8-92.0
18B	1800	3200	Freq.	High	91.5-91.8
19	1580	3000	Freq.	High	91.3-91.5
20	1370	2700	Freq.	High	90.9-91.3
21	750	3300	Infreq.	Low	87.0-87.1
22	850	3200	Infreq.	Low	86.8-87.0
23	700	3200	Infreq.	Low	85.5-85.6
24	700	3800	Infreq.	Low	83.8-83.9
25	730	3800	Infreq.	Low	83.7-83.8
26	800	3800	Infreq.	Low	83.5-83.7
27	800	3800	Infreq.	Low	83.4-83.5
40	150	1600	Infreq.	Low	71.6
41	300	1600	Infreq.	Low	71.4
42	200	1600	Infreq.	Low	71.2
43	1700	2600	Infreq.	Low	66.5-66.8
44	400	2800	Infreq.	Low	66.2
45	200	2900	Infreq.	Low	65.9
46	200	2300	Infreq.	Low	65.2
47	200	3400	Infreq.	Low	62.5
51	300	3200	Infreq.	Low	59.7
52	250	3200	Infreq.	High	59.5
53	400	3200	Infreq.	High	59.1
54	350	2800	Infreq.	Low	49.3
55	560	2800	Infreq.	Low	49.1-49.2
56	1300	1600	Infreq.	Low	48.5-48.8
58	300	3500	Infreq.	Low	47
70	4040	2100	Freq.	High	44.7-45.5
71	1220	2400	Freq.	High	44.4-44.7
72	840	2500	Freq.	High	44.2-44.4

Chart (Continued)

AVALANCHE PATH INVENTORY

Slide Path #	Width(ft)	Vertical(ft)	Frequency	Hazard Class	Milepost
73	360	2700	Infreq.	Low	44.1-44.2
74	2300	2800	Infreq.	High	37.6-38.1
75A	300	2900	Infreq.	Low	37.4
75	550	2800	Freq.	Low	37.1-37.2
76	1300	2800	Infreq.	Low	36.8-37.1
77	1370	3400	Infreq.	Low	36.2-36.5
78	200	3400	Infreq.	Low	35.7
79	500	3400	Infreq.	Low	35.1-35.2
80	2600	3700	Infreq.	Low	34.0-34.5
82	200	4200	Infreq.	Low	31.7
83	200	4200	Infreq.	Low	30.6
90	200	3800	Infreq.	Low	22.4
91	1150	3800	Infreq.	High	22.0-22.2
92	1950	3800	Infreq.	High	21.6-21.9
93	770	4900	Freq.	High	20.9-21.1
94	1100	4400	Infreq.	High	20.7-20.9
95	570	4000	Infreq.	Low	18.5-18.7
96	470	4000	Infreq.	Low	18.3-18.4
97	700	4000	Infreq.	Low	18.1-18.3

In addition to these well recognized paths there are several areas that show evidence of damage to vegetation, probably as a result of large, infrequent avalanches. This study does not document all such areas, but several bear mention. These have been indicated in Chapter VI, Avalanche Mapping, with the use of a slide path marker, but not in this inventory.

LAWS

PASSED AT THE
SECOND REGULAR SESSION
OF THE

FORTY-NINTH GENERAL ASSEMBLY OF THE
STATE OF COLORADO
CONVENED AT DENVER
AT 10 O'CLOCK A.M.
WEDNESDAY, JANUARY 2, A.D. 1974
AND ADJOURNED SINE DIE ON
WEDNESDAY, MAY 22, 1974

Published by authority of
TED L. STRICKLAND
Acting President of the Senate
JOHN D. FUHR
Speaker of the House of Representatives

Legislation pertaining to "natural hazard areas" and snow avalanches. R 5/79

Bradford Printing Co.
Denver, Colorado
1974

CHAPTER 80

PLANNING COMMISSIONS — STATE AND COUNTY

AREAS AND ACTIVITIES OF STATE INTEREST

HOUSE BILL NO. 1041. BY REPRESENTATIVES Dittemore, Buechner, Herzberger, Miller, Pettie, Baker, Echelberry, Friedman, Gustafson, Hamlin, Koster, O'Brian, Ross, Sack, Sonnenberg, and Tempest; also SENATORS Allshouse, Darby, Johnson, Plock, H. Brown, DeBerard, L. Fowler, Garnsey, Jackson, Klein, McCormick, Schieffelin, Stockton, and Strickland.

AN ACT

CONCERNING LAND USE, AND PROVIDING FOR IDENTIFICATION, DESIGNATION, AND ADMINISTRATION OF AREAS AND ACTIVITIES OF STATE INTEREST, AND ASSIGNING ADDITIONAL DUTIES TO THE COLORADO LAND USE COMMISSION AND THE DEPARTMENT OF LOCAL AFFAIRS, AND MAKING APPROPRIATIONS THEREFOR.

Be it enacted by the General Assembly of the State of Colorado:

Section 1. Chapter 106, Colorado Revised Statutes 1963, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 7

Areas and Activities of State Interest

PART 1

GENERAL PROVISIONS

106-7-101. Legislative declaration. (1) In addition to the legislative declaration contained in section 106-4-1 (1), the general assembly further finds and declares that:

(a) The protection of the utility, value, and future of all lands within the state, including the public domain as well as privately owned land, is a matter of the public interest;

(b) Adequate information on land use and systematic methods of definition, classification, and utilization thereof are either lacking or not readily available to land use decision makers;

(c) It is the intent of the general assembly that land use, land use planning, and quality of development are matters in which the state has responsibility for the health, welfare, and safety of the people of the state and for the protection of the environment of the state.

(2) It is the purpose of this article that:

(a) The general assembly shall describe areas which may be of state interest

Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

Includes "natural hazard areas" and controls re. occupancy of snow avalanche paths

RF 5/79

and activities which may be of state interest and establish criteria for the administration of such areas and activities;

(b) Local governments shall be encouraged to designate areas and activities of state interest and, after such designation, shall administer such areas and activities of state interest and promulgate guidelines for the administration thereof; and

(c) Appropriate state agencies shall assist local governments to identify, designate, and adopt guidelines for administration of matters of state interest.

106-7-102. General definitions. As used in this article, unless the context otherwise requires:

(1) "Development" means any construction or activity which changes the basic characte. or the use of the land on which the construction or activity occurs.

(2) "Local government" means a municipality or county.

(3) "Local permit authority" means the governing body of a local government with which an application for development in an area of state interest or for conduct of an activity of state interest must be filed or the designee thereof.

(4) "Matter of state interest" means an area of state interest or an activity of state interest or both.

(5) "Municipality" means a home rule or statutory city, town, or city and county or a territorial charter city.

(6) "Person" means any individual, partnership, corporation, association, company, or other public or corporate body, including the federal government, and includes any political subdivision, agency, instrumentality, or corporation of the state.

106-7-103. Definitions pertaining to natural hazards. As used in this article, unless the context otherwise requires:

(1) "Aspect" means the cardinal direction the land surface faces, characterized by north-facing slopes generally having heavier vegetation cover.

(2) "Avalanche" means a mass of snow or ice and other material which may become incorporated therein as such mass moves rapidly down a mountain slope.

(3) "Corrosive soil" means soil which contains soluble salts which may produce serious detrimental effects in concrete, metal, or other substances that are in contact with such soil.

(4) "Debris-fan floodplain" means a floodplain which is located at the mouth of a mountain valley tributary stream as such stream enters the valley floor.

(5) "Dry wash channel and dry wash floodplain" means a small watershed with a very high percentage of runoff after torrential rainfall.

(6) "Expansive soil and rock" means soil and rock which contains clay and which expands to a significant degree upon wetting and shrinks upon drying.

(7) "Floodplain" means an area adjacent to a stream, which area is subject to flooding as the result of the occurrence of an intermediate regional flood and which area thus is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Mainstream floodplains;

(b) Debris-fan floodplains; and

(c) Dry wash channels and dry wash floodplains.

(8) "Geologic hazard" means a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Avalanches, landslides, rock falls, mudflows, and unstable or potentially unstable slopes;

(b) Seismic effects;

(c) Radioactivity; and

(d) Ground subsidence.

(9) "Geologic hazard area" means an area which contains or is directly affected by a geologic hazard.

(10) "Ground subsidence" means a process characterized by the downward displacement of surface material caused by natural phenomena such as removal of underground fluids, natural consolidation, or dissolution of underground minerals or by man-made phenomena such as underground mining.

(11) "Mainstream floodplain" means an area adjacent to a perennial stream that is subject to periodic flooding.

(12) "Mudflow" means the downward movement of mud in a mountain watershed because of peculiar characteristics of extremely high sediment yield and occasional high runoff.

(13) "Natural hazard" means a geologic hazard, a wildfire hazard, or a flood.

(14) "Natural hazard area" means an area containing or directly affected by a natural hazard.

(15) "Radioactivity" means a condition related to various types of radiation emitted by natural radioactive minerals that occur in natural deposits of rock, soil, and water.

(16) "Seismic effects" means direct and indirect effects caused by an earthquake or an underground nuclear detonation.

(17) "Siltation" means a process which results in an excessive rate of removal of soil and rock materials from one location and rapid deposit thereof in adjacent areas.

(18) "Slope" means the gradient of the ground surface which is definable by degree or percent.

(19) "Unstable or potentially unstable slope" means an area susceptible to a landslide, a mudflow, a rock fall, or accelerated creep of slope-forming materials.

(20) "Wildfire behavior" means the predictable action of a wildfire under given conditions of slope, aspect, and weather.

(21) "Wildfire hazard" means a wildfire phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Slope and aspect;

(b) Wildfire behavior characteristics; and

(c) Existing vegetation types.

(22) "Wildfire hazard area" means an area containing or directly affected by a wildfire hazard.

106-7-104. Definitions pertaining to other areas and activities of state interest. As used in this article, unless the context otherwise requires:

(1) "Airport" means any municipal or county airport or airport under the jurisdiction of an airport authority.

(2) "Area around a key facility" means an area immediately and directly affected by a key facility.

(3) "Arterial highway" means any limited-access highway which is part of the federal-aid interstate system or any limited-access highway constructed under the supervision of the state department of highways.

(4) "Collector highway" means a major thoroughfare serving as a corridor or link between municipalities, unincorporated population centers or recreation areas, or industrial centers and constructed under guidelines and standards established by, or under the supervision of, the state department of highways. Collector highway does not include a city street or local service road or a county road designed for local service and constructed under the supervision of local government.

(5) "Domestic water and sewage treatment system" means a wastewater treatment plant, water treatment plant, or water supply system, as defined in section 66-38-2 (6), (7), and (8), C.R.S. 1963, and any system of pipes, structures, and facilities through which wastewater is collected for treatment.

(6) "Historical or archaeological resources of statewide importance" means resources which have been officially included in the national register of historic places, designated by statute, or included in an established list of places compiled by the state historical society.

(7) "Key facilities" means:

(a) Airports;

(b) Major facilities of a public utility;

(c) Interchanges involving arterial highways;

(d) Rapid or mass transit terminals, stations, and fixed guideways.

(8) "Major facilities of a public utility" means:

(a) Central office buildings of telephone utiliti ;

(b) Transmission lines, power plants, and substations of electrical utilities; nd

(c) Pipelines and storage areas of utilities providing natural gas or other etroleum derivatives.

(9) "Mass transit" means a coordinated system of transit modes providing ansportation for use by the general public.

(10) "Mineral" means an inanimate constituent of the earth, in either olid, liquid, or gaseous state which, when extracted from the earth, is usable its natural form or is capable of conversion into usable form as a metal, metallic compound, a chemical, an energy source, a raw material for manucturing, or construction aterial. This definition doe not include surface ground water subject to appropriation for domestic, agricultural, or indusal purposes, nor does it include geothermal resources.

(11) "Mineral resource area" means an area in which minerals are located sufficient concentration in veins, deposits, bodies, beds, seams, fields, ols, or otherwise, as to be capable of economic recovery. The term cludes but is not limited to any area in which there has been significant ining activity in the past, there is significant mining activity in the present, ining development is planned or in progress, or mineral rights are held by ineral patent or valid mining claim with the intention of mining.

(12) "Natural resources of statewide importance" is limited to shorelands major publicly-owned reservoirs and significant wildlife habitats in which e wildlife species, as identified by the division of wildlife of the department natural resources, in a proposed area could be endangered.

(13) "New communities" means the major revitalization of existing unicipalities or the establishment of urbanized growth centers in unincororated areas.

(14) "Rapid transit" means the element of a mass transit system involving mechanical conveyance on an exclusive lane or guideway constructed solely r that purpose.

106-7-105. Effect of article — public utilities. (1) With regard to public tilities, nothing in this article shall be construed as enhancing or diminishing e power and authority of municipalities, counties, or the public utilities ommission. Any order, rule, or directive issued by any governmental agency ursuant to this article shall not be inconsistent with or in contravention of ny decision, order, or finding of the public utilities commission with respect public convenience and necessity. The public utilities commission and ublic utilities shall take into consideration and, when feasible, foster complice with adopted land use master plans of local governments, regions, and e state.

(2) Nothing in this article shall be construed as enhancing or diminishing e rights and procedures with respect to the power of a public utility to quire property and rights-of-way eminent domain to serve public need the most economical and expedient manner.

106-7-106. Effect of article — rights of property owners — water rights. (1) Nothing in this article shall be construed as:

(a) Enhancing or diminishing the rights of owners of property as provided by the state constitution or the constitution of the United States;

(b) Modifying or amending existing laws or court decrees with respect to the determination and administration of water rights.

106-7-107. Effect of article — developments in areas of state interest and activities of state interest meeting certain conditions. (1) This article shall not apply to any development in an area of state interest or any activity of state interest which meets any one of the following conditions as of the effective date of this article:

(a) The development or activity is covered by a current building permit issued by the appropriate local government; or

(b) The development or activity has been approved by the electorate; or

(c) The development or activity is to be on land:

(I) Which has been conditionally or finally approved by the appropriate local government for planned unit development or for a use substantially the same as planned unit development; or

(II) Which has been zoned by the appropriate local government for the use contemplated by such development or activity; or

(III) With respect to which a development plan has been conditionally or finally approved by the appropriate governmental authority.

106-7-108. Effect of article — state agency or commission responses. (1) Whenever any person desiring to carry out development as defined in section 106-7-102 (1) is required to obtain a permit, to be issued by any state agency or commission for the purpose of authorizing or allowing such development, pursuant to this or any other statute or regulation promulgated thereunder, such agency shall establish a reasonable time period, which shall not exceed sixty days following receipt of such permit application, within which such agency must respond in writing to the applicant, granting or denying said permit or specifying all reasonable additional information necessary for the agency or commission to respond. If additional information is required, said agency or commission shall set a reasonable time period for response following the receipt of such information.

(2) Whenever a state agency or commission denies a permit the denial must specify:

(a) The regulations, guidelines, and criteria or standards used in evaluating the application;

(b) The reasons for denial and the regulations, guidelines, and criteria or standards the application fails to satisfy; and

(c) The action that the applicant would have to take to satisfy the state agency's or commission's permit requirements.

(3) Whenever an application for a permit as provided under this section contains a statement describing the proposed nature, uses, and activities in

conceptual terms for the development intended to be accomplished and is not accompanied with all additional information, including, without limitation, engineering studies, detailed plans and specifications, zoning approval, or where a hearing is required by the statutes, regulations, rules, ordinances, or resolutions thereof prior to the issuance of the requested permit, the agency or commission shall, within the time provided in this section for response, indicate its acceptance or denial of the permit on the basis of the concept expressed in the statement of the proposed uses and activities contained in the application. Such conceptual approval shall be made subject to the applicant filing and completing all prerequisite detailed additional information in accordance with the usual filing requirements of the agency or commission within a reasonable period of time.

(4) All agencies or commissions authorized or required to issue permits for development shall adopt rules and regulations, or amend existing rules and regulations, so as to require that such agency or commission respond in the time and manner required in this section.

(5) Nothing in this section shall shorten the time allowed for responses provided by federal statute dealing with, or having a bearing on, the subject of any such application for permit.

(6) The provisions of this section shall not apply to applications approved, denied, or processed by a unit of local government.

PART 2

AREAS AND ACTIVITIES DESCRIBED

CRITERIA FOR ADMINISTRATION

106-7-201. Areas of state interest — as determined by local governments. (1) Subject to the procedures set forth in part 4 of this article, a local government may designate certain areas of state interest from among the following:

(a) Mineral resource areas;

(b) Natural hazard areas;

(c) Areas containing, or having a significant impact upon, historical, natural, or archaeological resources of statewide importance; and

(d) Areas around key facilities in which development may have a material effect upon the facility or the surrounding community.

106-7-202. Criteria for administration of areas of state interest. (1) (a) Mineral resource areas designated as areas of state interest shall be protected and administered in such a manner as to permit the extraction and exploration of minerals therefrom, unless extraction and exploration would cause significant danger to public health and safety. If the local government having jurisdiction, after weighing sufficient technical or other evidence, finds that the economic value of the minerals present therein is less than the value of another existing or requested use, such other use should be given preference; however, other uses which would not interfere with the extraction and exploration of minerals may be permitted in such areas of state interest.

(b) Areas containing only sand, gravel, quarry aggregate, or limestone used for construction purposes shall be administered as provided by article 6 of chapter 92, C.R.S. 1963.

accomplished in a manner which causes the least practicable environmental disturbance, and surface areas disturbed thereby shall be reclaimed in accordance with the provisions of article 13 or article 32 of chapter 92, C.R.S. 1963, whichever is applicable.

(d) Unless an activity of state interest has been designated or identified or unless it includes part or all of another area of state interest, an area of oil and gas or geothermal resource development shall not be designated as an area of state interest unless the state oil and gas conservation commission identifies such area for designation.

(2) (a) Natural hazard areas shall be administered as follows:

(I) Floodplains shall be administered so as to minimize significant hazards to public health and safety or to property. The Colorado water conservation board shall promulgate a model floodplain regulation no later than September 30, 1974. Open space activities such as agriculture, recreation, and mineral extraction shall be encouraged in the floodplains. Any combination of these activities shall be conducted in a mutually compatible manner. Building of structures in the floodplain shall be designed in terms of the availability of flood protection devices, proposed intensity of use, effects on the acceleration of floodwaters, potential significant hazards to public health and safety or to property, and other impact of such development on downstream communities such as the creation of obstructions during floods. Activities shall be discouraged which, in time of flooding, would create significant hazards to public health and safety or to property. Shallow wells, solid waste disposal sites, and septic tanks and sewage disposal systems shall be protected from inundation by floodwaters. Unless an activity of state interest is to be conducted therein, an area of corrosive soil, expansive soil and rock, or siltation shall not be designated as an area of state interest unless the Colorado soil conservation board, through the local soil conservation district, identifies such area for designation.

(II) Wildfire hazard areas in which residential activity is to take place shall be administered so as to minimize significant hazards to public health and safety or to property. The Colorado state forest service shall promulgate a model wildfire hazard area control regulation no later than September 30, 1974. If development is to take place, roads shall be adequate for service by fire trucks and other safety equipment. Firebreaks and other means of reducing conditions conducive to fire shall be required for wildfire hazard areas in which development is authorized.

(III) In geologic hazard areas all developments shall be engineered and administered in a manner that will minimize significant hazards to public health and safety or to property due to a geologic hazard. The Colorado geological survey shall promulgate a model geologic hazard area control regulation no later than September 30, 1974.

(b) After promulgation of guidelines for land use in natural hazard areas by the Colorado water conservation board, the Colorado soil conservation board through the soil conservation districts, the Colorado state forest service, and the Colorado geological survey, natural hazard areas shall be administered by local government in a manner which is consistent with the guidelines for land use in each of the natural hazard areas.

(3) Areas containing, or having a significant impact upon, historical, natural, or archaeological resources of statewide importance, as determined by the state historical society, the department of natural resources, and the appropriate local government, shall be administered by the appropriate state agency in conjunction with the appropriate local government in a manner that will allow man to function in harmony with, rather than be destructive to, these resources. Consideration is to be given to the protection of those areas essential for wildlife habitat. Development in areas containing historical, archaeological, or natural resource shall be conducted in a manner which will minimize damage to those resources for future use.

(4) The following criteria shall be applicable to areas around key facilities:

(a) If the operation of a key facility may cause a danger to public health and safety or to property, as determined by local government, the area around the key facility shall be designated and administered so as to minimize such danger; and

(b) Areas around key facilities shall be developed in a manner that will discourage traffic congestion, incompatible uses, and expansion of the demand for government services beyond the reasonable capacity of the community or region to provide such services as determined by local government. Compatibility with nonmotorized traffic shall be encouraged. A development that imposes burdens or deprivation on the communities of a region cannot be justified on the basis of local benefit alone.

(5) In addition to the criteria described in subsection (4) of this section, the following criteria shall be applicable to areas around particular key facilities:

(a) Areas around airports shall be administered so as to:

(I) Encourage land use patterns for housing and other local government needs that will separate uncontrollable noise sources from residential and other noise-sensitive areas; and

(II) Avoid danger to public safety and health or to property due to aircraft crashes.

(b) Areas around major facilities of a public utility shall be administered so as to:

(I) Minimize disruption of the service provided by the public utility; and

(II) Preserve desirable existing community patterns.

(c) Areas around interchanges involving arterial highways shall be administered so as to.

(I) Encourage the smooth flow of motorized and nonmotorized traffic;

(II) Foster the development of such areas in a manner calculated to preserve the smooth flow of such traffic; and

(III) Preserve desirable existing community patterns.

(d) Areas around rapid or mass transit terminals, stations, or guideways shall be developed in conformance with the applicable municipal master plan adopted pursuant to section 139-59-6, C.R.S. 1963, or any applicable master plan adopted pursuant to section 106-2-7. If no such master plan has been adopted, such areas shall be developed in a manner designed to minimize congestion in the streets; to secure safety from fire, flood waters, and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements. Such development in such areas shall be made with reasonable consideration, among other things, as to the character of the area and its peculiar suitability for particular uses, and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout the jurisdiction of the applicable local government.

106-7-203. Activities of state interest as determined by local governments. (1) Subject to the procedures set forth in part 4 of this article, a local government may designate certain activities of state interest from among the following:

(a) Site selection and construction of major new domestic water and sewage treatment systems and major extension of existing domestic water and sewage treatment systems;

(b) Site selection and development of solid waste disposal sites;

(c) Site selection of airports;

(d) Site selection of rapid or mass transit terminals, stations, and fixed guideways;

(e) Site selection of arterial highways and interchanges and collector highways;

(f) Site selection and construction of major facilities of a public utility;

(g) Site selection and development of new communities;

(h) Efficient utilization of municipal and industrial water projects; and

(i) Conduct of nuclear detonations.

106-7-204. Criteria for administration of activities of state interest. (1) (a) New domestic water and sewage treatment systems shall be constructed in areas which will result in the proper utilization of existing treatment plants and the orderly development of domestic water and sewage treatment systems of adjacent communities.

(b) Major extensions of domestic water and sewage treatment systems shall be permitted in those areas in which the anticipated growth and development that may occur as a result of such extension can be accommodated within the financial and environmental capacity of the area to sustain such growth and development.

(2) Major solid waste disposal sites shall be developed in accordance with sound conservation practices and shall emphasize, where feasible, the recycling of waste materials. Consideration shall be given to longevity and subsequent use of waste disposal sites, soil and wind conditions, the potential problems of pollution inherent in the proposed site, and the impact on adjacent property owners, compared with alternate locations.

(3) Airports shall be located or expanded in a manner which will minimize disruption to the environment of existing communities, will minimize the impact on existing community services, and will complement the economic and transportation needs of the state and the area.

(4) (a) Rapid or mass transit terminals, stations, or guideways shall be located in conformance with the applicable municipal master plan adopted pursuant to section 139-59-6, C.R.S. 1963, or any applicable master plan adopted pursuant to section 106-2-7. If no such master plan has been adopted, such areas shall be developed in a manner designed to minimize congestion in the streets; to secure safety from fire, flood waters, and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements. Activities shall be conducted with reasonable consideration, among other things, as to the character of the area and its peculiar suitability for particular uses, and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout the jurisdiction of the applicable local government.

(b) Proposed locations of rapid or mass transit terminals, stations, and fixed guideways which will not require the demolition of residences or businesses shall be given preferred consideration over competing alternatives.

(c) A proposed location of rapid or mass transit terminal, station, or fixed guideway that imposes a burden or deprivation on a local government cannot be justified on the basis of local benefit alone, nor shall a permit for such a location be denied solely because the location places a burden or deprivation on one local government.

(5) Arterial highways and interchanges and collector highways shall be located so that:

(a) Community traffic needs are met;

(b) Desirable community patterns are not disrupted; and

(c) Direct conflicts with adopted local government, regional, and state master plans are avoided.

(6) Where feasible, major facilities of public utilities shall be located so as to avoid direct conflict with adopted local government, regional, and state master plans.

(7) When applicable, or as may otherwise be provided by law, a new community design shall, at a minimum, provide for transportation, waste disposal, schools, and other governmental services in a manner that will not overload facilities of existing communities of the region. Priority shall be given to the development of total communities which provide for commercial and industrial activity, as well as residences, and for internal transportation and circulation patterns.

(8) Municipal and industrial water projects shall emphasize the most efficient use of water, including, to the extent permissible under existing law, the recycling and reuse of water. Urban development, population densities, and site layout and design of storm water and sanitation systems shall be accomplished in a manner that will prevent the pollution of aquifer recharge areas.

(9) Nuclear detonations shall be conducted so as to present no material danger to public health and safety. Any danger to property shall not be disproportionate to the benefits to be derived from a detonation.

PART 3

LEVELS OF GOVERNMENT INVOLVED AND THEIR FUNCTIONS

106-7-301. Functions of local government. (1) Pursuant to this article, it is the function of local government to:

(a) Designate matters of state interest after public hearing, taking into consideration:

(I) The intensity of current and foreseeable development pressures; and

(II) Applicable guidelines for designation issued by the applicable state agencies;

(b) Hold hearings on applications for permits for development in areas of state interest and for activities of state interest;

(c) Grant or deny applications for permits for development in areas of state interest and for activities of state interest;

(d) Receive recommendations from state agencies and other local governments relating to matters of state interest;

(e) Send recommendations to other local governments and the Colorado land use commission relating to matters of state interest; and

(f) Act, upon request of the Colorado land use commission, with regard to specific matters of state interest.

106-7-302. Functions of other state agencies. (1) Pursuant to this article, it is the function of other state agencies to:

(a) Send recommendations to local governments and the Colorado land use commission relating to designation of matters of state interest on the basis of current and developing information; and

(b) Provide technical assistance to local governments concerning designation of and guidelines for matters of state interest.

(2) Primary responsibility for the recommendation and provision of technical assistance functions described in subsection (1) of this section is upon:

(a) The Colorado water conservation board, acting in cooperation with the Colorado soil conservation board, with regard to floodplains;

(b) The Colorado state forest service, with regard to wildfire hazard areas;

(c) The Colorado geological survey, with regard to geologic hazard areas, geologic reports, and the identification of mineral resource areas;

(d) The Colorado division of mines, with regard to mineral extraction and the reclamation of land disturbed thereby;

(e) The Colorado soil conservation board and soil conservation districts, with regard to resource data inventories, soils, soil suitability, erosion and sedimentation, floodwater problems, and watershed protection; and

(f) The division of wildlife of the department of natural resources, with regard to significant wildlife habitats.

(3) Pursuant to section 106-7-202 (1) (d), the oil and gas conservation commission of the state of Colorado may identify an area of oil and gas development for designation by local government as an area of state interest.

PART 4

DESIGNATION OF MATTERS OF STATE INTEREST — GUIDELINES FOR ADMINISTRATION

106-7-401. Designation of matters of state interest. (1) After public hearing, a local government may designate matters of state interest within its jurisdiction, taking into consideration:

(a) The intensity of current and foreseeable development pressures; and

(b) Applicable guidelines for designation issued by the Colorado land use commission after recommendation from other state agencies, if appropriate. In adopting such guidelines, the Colorado land use commission shall be guided by the standards set forth in this article applicable to local governments.

(2) A designation shall:

(a) Specify the boundaries of the proposed area; and

(b) State reasons why the particular area or activity is of state interest, the dangers that would result from uncontrolled development of any such area or uncontrolled conduct of such activity, and the advantages of development of such area or conduct of such activity in a coordinated manner.

106-7-402. Guidelines — regulations. (1) The local government shall develop guidelines for administration of the designated matters of state interest. The content of such guidelines shall be such as to facilitate administration of matters of state interest consistent with sections 106-7-202 and 106-7-204.

(2) A local government may adopt regulations interpreting and applying its adopted guidelines in relation to specific developments in areas of state interest and to specific activities of state interest.

(3) No provision in this article shall be construed as prohibiting a local government from adopting guidelines or regulations containing requirements which are more stringent than the requirements of the criteria listed in sections 106-7-202 and 106-7-204.

106-7-403. Technical and financial assistance. (1) Appropriate state agencies shall provide technical assistance to local governments in order to assist local governments in designating matters of state interest and adopting guidelines for the administration thereof.

(2) (a) The department of local affairs shall oversee and coordinate the provision of technical assistance and provide financial assistance as may be authorized by law.

(b) The department of local affairs shall determine whether technical or financial assistance or both are to be given to a local government on the basis of the local government's:

(I) Showing that current or reasonably foreseeable development pressures exist within the local government's jurisdiction; and

(II) Plan describing the proposed use of technical assistance and expenditure of financial assistance.

106-7-404. **Public hearing — designation of an area or activity of state interest and adoption of guidelines by order of local government.** (1) The local government shall hold a public hearing before designating an area or activity of state interest and adopting guidelines for administration thereof.

(2) (a) Notice, stating the time and place of the hearing and the place at which materials relating to the matter to be designated and guidelines may be examined, shall be published once at least thirty and not more than sixty days before the public hearing in a newspaper of general circulation in the county. The local government shall send written notice to the Colorado land use commission of a public hearing to be held for the purpose of designation and adoption of guidelines at least thirty days and not more than sixty days before such hearing.

(b) Any person may request, in writing, that his name and address be placed on a mailing list to receive notice of all hearings held pursuant to this section. If the local government decides to maintain such a mailing list, it shall mail notices to each person paying an annual fee reasonably related to the cost of production, handling, and mailing such notice. In order to have his name and address retained on said mailing list, the person shall resubmit his name and address and pay such fee before January 31 of each year.

(3) Within thirty days after completion of the public hearing, the local government, by order, may adopt, adopt with modification, or reject the particular designation and guidelines; but the local government, in any case, shall have the duty to designate any matter which has been finally determined to be a matter of state interest and adopt guidelines for the administration thereof.

(4) After a matter of state interest is designated pursuant to this section, no person shall engage in development in such area and no such activity shall be conducted until the designation and guidelines for such area or activity are finally determined pursuant to this article.

(5) Upon adoption by order, all relevant materials relating to the designation and guidelines shall be forwarded to the Colorado land use commission for review.

106-7-405. **Report of local government's progress.** (1) Not later than one hundred eighty days after the effective date of this article, each local government shall report to the Colorado land use commission, on a form to be furnished by the Colorado land use commission, the progress made toward designation and adoption of guidelines for administration of matters of state interest.

(2) Upon the basis of the information contained in such reports and any information received pursuant to any other relevant provision of this article, the Colorado land use commission may take appropriate action pursuant to section 106-4-3 (2) (a).

106-7-406. Colorado land use commission review of local government order containing designation and guidelines. (1) Not later than thirty days after receipt of a local government order designating a matter of state interest and adopting guidelines for the administration thereof, the Colorado land use commission shall review the contents of such order on the basis of the relevant provisions of part 2 of this article and shall accept the designation and guidelines or recommend modification thereof.

(2) If the Colorado land use commission decides that modification of the designation or guidelines is required, the Colorado land use commission shall, within said thirty-day period, submit to the local government written notification of its recommendations and shall specify in writing the modifications which the Colorado land use commission deems necessary for compliance with the relevant provisions of part 2 of this article.

(3) Not later than thirty days after receipt of the modifications recommended by the Colorado land use commission, a local government shall:

(a) Modify the original order in a manner consistent with the recommendations of the Colorado land use commission and resubmit the order to the Colorado land use commission; or

(b) Notify the Colorado land use commission that the Colorado land use commission's recommendations are rejected.

106-7-407. Colorado land use commission may initiate identification, designation, and promulgation of guidelines for matters of state interest. (1) (a) The Colorado land use commission may submit a formal request to a local government to take action with regard to a specific matter which said commission considers to be of state interest within the local government's jurisdiction. Such request shall identify the specific matter and shall set forth the information required in section 106-7-401 (2) (a) and (2) (b). Not later than thirty days after receipt of such request, the local government shall publish notice and hold a hearing within sixty days pursuant to the provisions of section 106-7-404, and issue its order thereunder.

(b) After receipt by a local government of a request from the Colorado land use commission pursuant to paragraph (a) of this subsection (1), no person shall engage in development in the area or conduct the activity specifically described in said request until the local government has held its hearing and issued its order relating thereto.

(c) If the local government's order fails to designate such matter and adopt guidelines therefor, or, after designation, fails to adopt guidelines therefor pursuant to standards set forth in this article applicable to local governments, the Colorado land use commission may seek judicial review of such order or guidelines by a trial de novo in the district court for the judicial district in which the local government is located. During the pendency of such court proceedings, no person shall engage in development in the area or conduct the activity specifically described in said request except on such terms and conditions as authorized by the court.

PART 5
PERMITS FOR DEVELOPMENT IN AREAS OF STATE INTEREST AND FOR CONDUCT OF ACTIVITIES OF STATE INTEREST

106-7-501. Permit for development in area of state interest or for conduct of an activity of state interest required. (1) (a) Any person desiring to engage in development in an area of state interest or to conduct an activity of state interest shall file an application for a permit with the local government in which such development or activity is to take place. The application shall be filed on a form prescribed by the Colorado land use commission. A reasonable fee determined by the local government sufficient to cover the cost of processing the application, including the cost of holding the necessary hearings, shall be paid at the time of filing such application.

(b) The requirement of paragraph (a) of this subsection (1) that a public utility obtain a permit shall not be deemed to waive the requirements of article 5 of chapter 115, C.R.S. 1963, that a public utility obtain a certificate of public convenience and necessity.

(2) (a) Not later than thirty days after receipt of an application for a permit, the local government shall publish notice of a hearing on said application. Such notice shall be published once in a newspaper of general circulation in the county, not less than thirty nor more than sixty days before the date set for hearing, and shall be given to the Colorado land use commission. The Colorado land use commission may give notice to such other persons as it determines not later than fourteen days before such hearing.

(b) If a person proposes to engage in development in an area of state interest or for conduct of an activity of state interest not previously designated and for which guidelines have not been adopted, the local government may hold one hearing for determination of designation and guidelines and granting or denying the permit.

(c) The local government may maintain a mailing list and send notice of hearings relating to permits in a manner similar to that described in section 106-7-404 (2) (b).

(3) The local government may approve an application for a permit to engage in development in an area of state interest if the proposed development complies with the local government's guidelines and regulations governing such area. If the proposed development does not comply with the guidelines and regulations, the permit shall be denied.

(4) The local government may approve an application for a permit for conduct of an activity of state interest if the proposed activity complies with the local government's regulations and guidelines for conduct of such activity. If the proposed activity does not comply with the guidelines and regulations, the permit shall be denied.

(5) The local government conducting a hearing pursuant to this section shall:

(a) State, in writing, reasons for its decision, and its findings and conclusions; and

(b) Preserve a record of such proceedings.

(6) After the effective date of this article, any person desiring to engage a development in a designated area of state interest or to conduct a desig-ted activity of state interest who does not obtain a permit pursuant to this ction may be enjoined by the Colorado land use commission or the appro-iate local government from engaging in such development or conducting ch activity.

106-7-502. **Judicial review.** The denial of a permit by a local government ency shall be subject to judicial review in the district court for the judicial strict in which the major development or activity is to occur.

Section 2. Article 3 of chapter 106, Colorado Revised Statutes 1963, as nended, is amended BY THE ADDITION OF A NEW SECTION to read:

106-3-9. Statewide program for identification of matters of state interest as art of local land use planning. (1) The department of local affairs shall onduct a statewide program encouraging counties and municipalities to pre-re, as a part of the comprehensive plan provided for in section 106-2-5 nd article 59 of chapter 139, C.R.S. 1963, a complete and detailed identifi-ation and designation of all matters of state interest within each county by une 30, 1976. The general assembly shall appropriate funds for this purpose the department of local affairs for distribution to participating counties. ach county desiring to participate in the identification and designation of natters of state interest program established by this section shall be allocated n equal amount by the department of local affairs from the funds so appro-priated, to be expended by each county separately or through an organized roup of counties or counties and municipalities. The department of local ffairs, in cooperation with applicable state agencies, shall establish reason-able standards relative to the scope, detail, and accuracy of the program and shall insure that all information is comparable for each county. Each county shall, after consultation with the municipality, prepare such identification and designation for territory located within these municipalities which request such preparation and in any municipality which fails to undertake an identifi-cation and designation program. Each county shall, upon request of the municipality, assist the municipality in its identification and designation pro-gram.

(2) The general assembly shall appropriate to the department of local affairs funds to assist counties and municipalities participating in the identifi-cation and designation of matters of state interes program, where additional assistance is deemed by the department of local affairs to be necessary. The department of local affairs shall also allocate such funds upon request of any county participating in the identification and designation of matters of state interest program under subsection (1) of this section for implementation of supplemental planning in that county, or to any municipality, based upon priorities established by the department of local affairs and on the need and capabilities of each county and municipality.

Section 3. 106-4-3 (2) (a), Colorado Revised Statutes 1963 (1971 Supp.), is amended to read:

106-4-3. Duties of the commission — temporary emergency power. (2) (a) Whenever in the normal course of its duties as set forth in this article the commission determines that there is in progress or proposed a land develop-ment activity which constitutes a danger of irreparable injury, loss, or damage of serious and major proportions to the public health, welfare, or safety, the commission shall immediately give written notice to the board of county commissioners of each county involved of the pertinent facts and dangers with respect to such activity. If the said board of county commissioners does not remedy the situation within a reasonable time, the commission may request the governor to review such facts and dangers with respect to such activity. If the governor grants such request, such review shall be conducted by the governor at a meeting with the commission and the boards of county commissioners of the counties involved. If, after such review, the governor shall determine that such activity does constitute such a danger, the governor may direct the commission to issue its written cease and desist order to the person in control of such activity. Such order shall require that such person immediately discontinue such activity. If such activity, notwithstanding such order, is continued, the commission may apply to any district court of this state in which such activity is located for a temporary restraining order, preliminary injunction, or permanent injunction, as provided for in the Colorado rules of civil procedure. Any such action shall be given precedence over all other matters pending in such district court. The institution of such action shall confer upon said district court exclusive jurisdiction to determine finally the subject matter thereof.

Section 4. Article 4 of chapter 106, Colorado Revised Statutes 1963, as amended, is amended BY THE ADDITION OF A NEW SECTION to read:

106-4-5. Commission staff to assist counties and municipalities. The commission, within available appropriations, shall assign full-time professional staff members to assist counties and municipalities in the program established under article 7 of this chapter and to monitor progress in the same. No later than February 1, 1975, the commission shall issue its report to the general assembly as to progress being made in such program and shall include in its report those items required by section 106-4-4 (4) (b) and (4) (c).

Section 5. **Appropriation.** (1) There is hereby appropriated to the department of local affairs, out of any moneys in the state treasury not otherwise appropriated, the sum of two million seventy-five thousand dollars ($2,075,000), or so much thereof as may be necessary, to implement the provisions of section 106-3-9, C.R.S. 1963, which moneys shall become available upon passage of this act and remain available until June 30, 1975, to be allocated as follows: Identification and designation of matters of state interest program — one million five hundred seventy-five thousand dollars ($1,575,000); supplemental planning — five hundred thousand dollars ($500,000).

(2) There is hereby appropriated out of any moneys in the state treasury not otherwise appropriated, to the Colorado land use commission, for the fiscal year beginning July 1, 1974, the sum of three hundred thousand dollars ($300,000), or so much thereof as may be necessary, to provide assistance to counties and muncipalities pursuant to section 106-4-5, C.R.S. 1963 (10.0 FTE, five of which shall be full-time professional staff pursuant to said section 106-4-5).

Section 6. **Safety clause.** The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

Approved: May 17, 1974

STATE OF ALASKA
THE LEGISLATURE

LEGISLATIVE AFFAIRS AGENCY

POUCH Y - STATE CAPITOL
JUNEAU, ALASKA 99811
907 465-3800

M E M O R A N D U M   July 25, 1979

SUBJECT: Appropriation to Department of Public Safety for state participation in the Alaska Avalanche Warning System (Work Order 7292)

TO: Representative Mike Miller

FROM: John B. Chenoweth
Legislative Counsel

After speaking with Bob Janes, I am suggesting that the appropriation requested be increased to $135,000, combining the requests for FY 80 and 81. Assuming the bills pass during the 1980 legislative session, the first $53,000 would be available immediately to meet the state share of costs of implementation in the 1979 - 1980 season, as the program funding estimate indicates, with the remaining $82,000 available for payment as the state's share during the 1980 - 81 season. In subsequent years, this would have the effect of providing a state appropriation the amount of which is known by participants in the program in advance of the winter avalanche season. If, by legislative or executive action, the full amount of the state's share were not provided, other federal or local government participants might be able to compensate.

The fiscal note on this would appear:

FY 80	$ 53,000)	
	)	135,000
FY 81	82,000)	
FY 82 (based on figures provided)		112,000
FY 83 (based on figures provided)		112,000

If this approach does not comply with your wishes, please advise me.

JBC:sl

THE FOLLOWING PAGES WERE TREATED AS A UNIT IN THE ORIGINAL FILE.

A PROPOSAL

FOR AN

ALASKA AVALANCHE WARNING SYSTEM

PREPARED BY

USDA - FOREST SERVICE, DIVISION OF STATE AND

PRIVATE FORESTRY

5-10-79

Alaska Avalanche Warning System

1. Situation: The combination of the permanent ice and snow fields in the mountain terrains of Alaska with the associated heavy snow fall during the winter creates a potential avalanche danger on a year around basis. Because of these conditions, during the period 1970-78, Alaska has had more fatalities due to snow avalanches than any of the other eleven Western States of the United States. Out of 109 deaths, 29 has occurred in Alaska, or 27% of the total. Colorado is second with 24 fatalities and Washington third with 21. The number of persons caught in a snow avalanche in Alaska and survived are unknown. A good estimate would be over 100 victims since 1970.

   In reviewing Art Judson's (Snow Management Specialist from the USDA - Forest Service Mountain Snow and Avalanche Research Center in Fort Collins, Colorado) report on the Alaska Avalanche situation, there are 500+ structure directly exposed to avalanches with the City of Juneau posing the greatest potential for catastrophic avalanching in North America. In addition there are approximately 180 identified avalanche paths crossing public highways and railroads that compose a constant hidden danger to the limited land transportation corridors in the state. The public is forced to use these avalanche prime routes since there are no alternative safe roads to use.

   The report also points out there are thousands of avalanche paths, both in developed and non developed recreation areas, with significant potential for avalanche fatalities to skiers, snowmobilers, mountain climbers and hikers on a year round basis.

   With a young outdoor minded population in the State, a prolonged winter condition, and the nucleus of the population living within minutes of the mountains, they are constantly using the snow covered mountain terrain for recreation activities with little or no knowledge of how the unseen changing snow pack structure and what can cause an avalanche could turn a pleasant outdoor outing into a catastrophic phenomenon within seconds.

Alaskans with a desire of rural type of living along with a desire to obtain a vast view of the country side are pushing higher into the apline reaches of the mountains seeking a place of residency. A high number of these persons are not aware or concerned of the lurking snow avalanche danger that may exist high above them when selecting and constructing their home. Their interest lies mainly in the unobstructive view they are seeking. This creates not only an avalanche hazard situation to the owners but a demand for public access thus creating more risk exposure in high ~~prime~~ avalanche country to ~~risk~~ the public and work maintenance crews.

2. Need: Three geogrpahic areas have been identified in Alaska that have a high snow avalanche danger associated with a high concentration of outdoor users. They are the Chugach-Kenai-Talkeetna Mountains, Mt. McKinley and the Coastal Range of Southeastern Alaska in the vicinity of Juneau and Sitka. A fourth potential area has been identified in the Haines-Skagway area. There are numerous smaller isolated areas where human activity is relative small.

In the Chugach-Kenai-Talkeetna Mountains the outdoor visits are increasing tremendously between population growth and more people seeking the outdoor experience with no awareness of the snow hazard situation involved in mountainous terrain. Housing is expanding into the avalanche zones of Eagle River Drainage, Indian Creek and Rainbow Creek and in other areas of the State which is lacking both municipalities and Statewide avalanche zoning regulations.

In the Juneau area, Behrends Ave. and the immediate vicinity poses the greatest risk in North America for a catastrophic avalanche to happen. Thirty-three homes, a motel, a high school auditorium and 453 boats located in the harbor along with the numerous cars passing by the area are exposed to a 3,000 foot vertical avalanche path that has a record of causing severe damage to the home in the area. This condition also exist in several other areas around Juneau which effects five other homes and several electrical transmission lines and towers.

More people are seeking the winter outdoor experience in Juneau with the opening of Eaglecrest Ski Area in 1975, thus increasing the avalanche risk exposure and the need for a more intense avalanche awareness program.

Whereas on Mt. McKinley, the mountain climbers are knowledgeable on avalanche phenonemon and are aware of the extreme avalanche danger and adverse weather elements found on the mountain. What their lacking is advance notice on predicted weather changes that could change the climb from a pleasant expedition to a disaster ~~holocast~~ within hours. The proposed establishment of a summer-winter visitor center in the Petersville area on the south side of McKinley National Monument will open up a whole new area of avalanche exposure to the public.

The Haines-Skagway area which includes Klondike Gold Rush Historical Park extends into Canada which encompasses both the Providence of British Columbia and Yukon Territory. The Park, because of its historical volume, has and will attract more people to hike over the historical trails during the winter time which are noted for their avalanche hazards. In order to fully provide an avalanche warning service to this area, weather stations will have to be installed in Canada which would involve obtaining an international agreement with the Canadians. Once the AAWS becomes operational, negotations with the Canadian Government will be made to otain their cooperation on the project.

With the few vital avalanche prone transportation corridors in Alaska, there exist a potential for all unaware travelers being caught in a snow slide along with maintenance crews clearing the blockage. The unsuspected closure of the road by the slides can also cause short term economical losses to both the public and business in addition to the high cost of opening up the roads to traffic. Travelers and maintenance crews should be aware of the existing hazards in advance in order to plan accordingly to cope with the situation.

The high avalanche problems in Alaska points to a need in developing a reliable and systematic state wide avalanche warning system along with a well organized public awareness and educational program.

3. Proposal: That an interagency Alaska Avalanche Warning System (AAWS) be established on a state wide basis for the purpose of:

   a. Forecasting snow avalanche conditions through out the State with main emphasis in Southcentral and Southeastern Alaska.

   b. Coordinate a public awareness program on avalanche.

c. Coordinate an annual Alaska Avalanche School.

d. Identify and catalog a comprehensive atlas of avalanche paths and slide occurrences.

e. Assist state and local governments in developing snow avalanche zoning regulations and identificaton of avalanche zones.

f. Providing a historical depository for avalanche snow data collected in Alaska.

With the main thrust of the AAWS being ~~similar~~ winter orinated, the slack summer montns can be devoted to providing:

a. Statewide fire weather forecasting

b. Special mountain weather forecasting for Mt. McKinley

c. Flood forecasting in areas covered by the orographic percipitation model

4. Organization: The USDA-Forest Service, the most noted historical government agency in snow management research and applied science is the most logical choice as being the lead agency in operating the AAWS. The AAWS-FS Division of State and Private Forestry who has the responsibility of providing forestry and related technical assistance to State and private land owners.

The AAWS organization structure comprises of three component parts - The Alaska Avalanche Warning System Center, (AAWSC) Primary field stations and supplemental field stations. Their structures and functions are:

AAWSC: The center will be located in Anchorage and housed in the National Weather Service Forecasting Office. It will be staffed with three Forest Service permanent professional employees - a project leader who has administrative and snow management experience, a mountain meterologist specialist who will be in charge of the forecasting and one mountain meterologist specialist assistant.

Their primary duty will be to provide a seven day service on avalanche forecasting during the period October 1 - May 15 and fire weather forecasting along with mountain weather and flood forecasting within the areas covered by the orographic precipitation model during the summer period. Secondary duties will be to assist in training and supervising the field personnel, assist in developing and carrying out an avalanche awareness program, conduct formal training sessions on mountain and fire weather meterology, catalog avalanche paths and record their activity, and provide technical assistance in developing avalanche zone regulations and zoning identification.

Primary Field Stations: Six field stations, have been identified to date which will be staffed with a temporary snow management technician between the period October 1 - May 15. The position could be a Forest Service or a cooperating agency employee who would either be detailed or assigned the primary duty of assisting the AAWSC.

The stations and where they will be housed at are:

Station	Housed at
Juneau	National Weather Service Office
Girdwood	Forest Service Office at Alyeski Ski Resort
Moose Pass	Forest Service Kenai Lake Work Center
McKinley	McKinley National Park Headquarters - McKinley
Valdez	Dept. of Transportation State Highway Office
Chugach State Park	Handled by the Park Rangers in Anchorage

The primary duties of the snow management technician are to provide on the ground weather conditions, snow pack conditions and avalanche activity to the AAWSC; carry out a public awareness program in the area; identify and catalog avalanche paths in their area of responsibility; read and record supplemental weather stations located in the immediate vicinity of their duty station.

Supplemental Field Stations: Twenty five supplemental field stations have been identified to furnish weather data to the AAWSC. Additional ones will be added as the need arises to assist in increasing the accuracy of the forecasting or expand the operation into new areas. There will be weather instrument stations located in an area where either a resident cooperator on a contractual arrangement or an employee from a cooperating agency who is assigned the task as part of his regular assignment can collect and forward the data to the AAWSC. The resident cooperator will also be requested to submit reports on any avalanche activity observed or investigated to the AAWSC.

In selected areas, remote sites will be established in high altitude locations to monitor the snow pack and weather conditions near the avalanche starting zones using the Meteor Burst System of Telemetry for recording and transmitting the data to the AAWSC.

The location of the site and type are:

Regional Area ~~Type~~	Site	Type
Southcentral	Tazlina Lodge	Resident Cooperator
	Thompson Pass	Cooperating Agency
	Isabelle Pass	Cooperating Agency
	Hatcher Pass	Resident cooperator
	Granview	Cooperating agency
	Alyeska Ski Resort	" "
	Max's Mt. (Alyeska Ski Resort)	Remote site
	Arctic Valley	Resident Cooperator
	Bird Creek	Cooperating Agency
	Turnagain Pass	" "
	Summit Lake	Resident Cooperator
	Six Mile Cr.(Sunrise)	" "
	Chugach State Park	Cooperating Agency
	Cambpell Cr	
	Indian Cr.	
	Ship Cr.	
	Eagle Cr.	
	Rabbit Cr.	
	Eagle River	Remote site

McKinley	Kahiltna Glacier(7000')	Resident cooperator (Summer only)
	Mt. McKinley	Remote site
	McKinley National Park Hdq.	Cooperating agency
Southeastern	Eaglecrest Ski Area	Cooperating agency
	Salmon Cr. Reservoir	Resident cooperator
	Mt. Juneau	Remote site
	Klukwan	Resident cooperator
	White Pass	Resident cooperator
	Sitka	Cooperating agency
	Hyder	Resident cooperator
	Mt. Troy	Remote site

5. AAWS Project Cost

The following is an estimated cost of setting up and operating the AAWS on an annual basis.

a. AAWSC operating cost

1)	Staffing	
	Project leader GS-23	35,000
	Meterologist in charge CS-12	35,000
	Assist. meterologist	28,000
2)	Travel for training and supervison by staff	15,000
3)	Staff office space, office equipment, clerical, data transmission and meterologist support	18,000
4)	Commercial Communications	10,000
	Subtotal	141,000

b. AAWS field station operating cost

1)	Staffing	
	6 Snow Management Tech. CS-9 7/9 @ $12,000	72,000
2)	Project travel for field personnel	10,000
3)	Station Mtc. and Supplies	5,000
4)	Supplemental Station Cost	24,000
5)	Equipment Replacement	15,000
6)	Cooperative agreements on remote site mtc.	3,000
	Subtotal	129,000
	Overhead cost	$42,000
	Total operating cost	$ 312,000

The USDA-Forest Service, Regional Office will provide the administrative support for the AAWS.

The above operating costs are based upon the AAWS being totally financed as a seperate identity without any cooperative support. The overall package can be reduced by the cooperating agencies absorbing part of the cost by intergesting various items into their regular on-going programs such as assigning certain individuals additional duties to perform a required task. Example - a state highway empoloyee was assigned the duty of reading the supplemental weather station at Thompson Pass.

The National Weather Service has stated they will furnish the office space, office equipment, clerical staff, data transmission of the forecasting and meterological support for the AAWSC.

c. Capital Investment
The following is a breakdown of the estimated capital investment cost needed to make the AAWS fully operable

1.	Weather instruments for the supplemental field stations	25,000
2.	UHFM radio for field personnel	5,000
3.	Remote instruments and installation cost 5@ 15,000	75,000
4.	Orographic Precipitation models * for Southcentral, Mt. McKinley and Southeaster	100,000
5.	Overhead cost	28,000
	Total	$233,000

* A computor program designed for Hydrometeorological use to determine the ability to diagnose the effect of topography on winter ~~written~~ precipitation over various time periods for differing wind regimes, employing upper air data and a fine-mesh topographic grid. Attached in the appendix is a summary report on the orographic precipitation model.

6. Action Plan

Phase I - Fiscal year 1979 & 1980

FY 79
- a. Install remote weather instrumentation on Max's Mt.
- b. Contract orographic precipitation model for Southcentral and Southeastern.

FY 80
- a. Hire one meterologist GS-11/12
- b. Activate primary stations at Girdwood, Juneau and Chugach State Park.

c. Activate supplemental stations at: Thompson Pass, Isabelle Pass, Bird Cr, Turnagain Pass, 6 Mile Cr, Grandview, Tazlina Lodge, Summit Lake, Hatcher Pass, Chugach State Park, Alyeska Ski Resort, Eaglecrest Ski Area, Salmon Cr. Reservoir.

d. Project leader duties will be carried out by present USDA-FS, Division of State and Private Forestry Staff.

Phase II - Fiscal Year 1981

a. Hire project leader GS-12

b. Hire one Meterologist GS-11/12 *

c. Activate Primary Station at McKinley National Park

d. Activate supplemental Stations at Arctic Valley Ski Area, Kluckwan, White Pass, Kahiltna Glacier, McKinley National Park Hdq.

e. Contract Orographic Precipitation Model for Mt. McKinley.

f. Install remote weather instrumentation on Mt. Juneau.

Phase III Fiscal year 1982

a. Activate primary station at Moose Pass and Valdez.

b. Activate supplemental stations at Sitka and Hyder.

c. Install remote weather instrumentations on Mt. McKinley, Mt. Troy near Juneau, and one other site to be selected in Southcentral area.

Phase IV - Fiscal year 1983 and on - AAWS in full operation.

a. Activate supplemental stations as needed.

* Will be hired during third quarter of FY 80 if BLM enters into a cooperative agreement with AAWS to perform fire weather forecasting.

7. FINANCIAL PLAN:

Suggested financial plan by agencies based upon beneficial Cooperators.

AGENCY	By Fiscal Year in "M" Dollars 79	80	81	82	83
USDA - FS	50	90	115	115	100
RMF	25	-	10	-	-
SCS	9	1	2	2	2
USDC - WS	3	10	25	35	30
USDI - BLM**	-	25 **	25 **	25 **	25 **
NPS	-	-	20	25	20
USDOT -AR	-	5	6	11	10
State of Ak.	-	53	82	112	112
DNR SP (25%)	-	-	-	-	-
CS (10%)	-	-	-	-	-
FL&W (10%)	-	-	-	-	-
DOT (50%)	-	-	-	-	-
DPS (5%)	-	-	-	-	-
BOROUGHS - Juneau	-	2	6	6	6
Anchorage	-	-	-	10	7
Private - Alyeska Ski Resort	2	1	1	1	1
TOTAL	89	187	297	342	312

** For Fire Weather forecasting only. Cost estimated at $25,000 per year which is based upon the meterologist salaries for 4 months.

Appendix

1. Memorandum from John A. Sandor, Regional Forester to David E. Herrick, Director, Rocky Mountain Station dated 2-1-79.

2. Letter from J.E. DiFalco, Chief, Operations Division, National Weather Service - Anchorage to Bob Janes, Deputy Director State and Private Forestry dated 3-14-79.

3. Alaska Avalanche Report by Art Judson, Researcher, USDA-FS Mountain Snow and Avalanche Project, Fort Collins, Colorado dated 3-20-79.

4. Orographic Precipitation Model for hydrometeorology use by J. Owen Rhea, excerpts from Atmospheric Science Paper No. 287, March 1978.

5. U.S. Ski Association - Alaska Division. Resolution supporting AAWS, adopted May 12, 1979.

6. Anchorage Times newsclipping of 5-12-79 re a Mount Hunter Avalanche fatality.

National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE - ALASKA REGION
701 C Street, Box 23, Anchorage, AK 99513

March 14, 1979

OA/WFA11/ALC:
(1304-55)

Mr. Robert C. Janes
Deputy Director
State and Private Forestry
U. S. Department of Agriculture
Box 1628
Juneau, Alaska 99801

Dear Mr. Janes:

We agree with the proposal that a Statewide Avalanche Warning System (SAWS) should be developed and implemented. Statistics indicate that use of State and Federal land will steadily increase.

It is logical that the Avalanche Warning Center (AWC) be colocated with WSFO Anchorage. We assume that one of the people manning the AWC would also be designated as the SAWS coordinator. This is necessary for two reasons: (1) Considerable time and talent will be needed to coordinate, implement, and maintain the system, and (2) the coordination function will enable management to justify a grade of at least GS-12 at the AWC. At any lower grade we would get very few applicants for the job, most would be young and relatively inexperienced -- not only in avalanche work but in meteorology as well, and finally they wouldn't stay around long enough to acquire the expertise needed to do a good job.

The coodinator will have to work with federal, state, municipal, and private groups. He/she should have a strong physical science background. He/she should be able to communicate well from middle management levels to recreation groups. He/she will have a supervisory function and should be knowledgeable about communications and instrumentation. It's been our experience that we can get fairly good talent and some longevity at the GS-12 level, and good to excellent talent and good longevity at the GS-13 level.

As to the financial plan, we cannot at this time provide any support other than to provide space, office equipment, and secretarial support. If there is general agreement to go ahead, and if additional resources are required, we'll have to request funds through the normal budget process, or develop a reimbursable from the Forest Service to the NWS.

Sincerely yours,

James E. DiFalco
Chief, Operations Division

cc: OA/W1
WSFO Anchorage

REPLY TO: 3210 Cooperative Programs
2300 Recreation

FEB 1 1979

SUBJECT: Snow Avalanche Assistance

TO: David E. Herrick
Director, Rocky Mountain Station

We appreciate Dr. Pete Martinelli and Art Judson's recent assistance trip in helping to conduct the Alaska Avalanche School in Anchorage, January 12-14, 1979.

The attendance of 250 participants, and many more being turned away because of size limitations, testifies to the interest and importance of the subject in this State. The school was a good example of effective interagency cooperation, and I am pleased we could play a rather lead role.

Following the session, Pete and Art stopped by Juneau for a day and I was able to have a brief chat with them. Their number one recommendation, regarding Alaska's needs, was to develop and implement a Statewide Avalanche Warning System at the earliest possible time. I intend to followup on this with the Alaska Land Managers Cooperative Task Force, a group of Federal-State and private entities that may be able to get such a project underway.

Another of their recommendations pertained to Juneau's extreme avalanche problems. Here, there is a need to strengthen and improve the local warning system. In this respect, and because of Art Judson's previous work on Colorado's system that could be applicable, we hope to further utilize his expertise. Our goal would be to get a local system developed and operable by next winter.

Because of the interagency coordination that could be involved in the overall effort, I am asking Bob Janes, Deputy Director of our Division of State and Private Forestry, to serve as our liaison. Bob also has personal qualifications and interest that should be useful. If agreeable with you, Bob will set up and maintain direct contact with Dr. Martinelli regarding further plans.

JOHN A. SANDOR

JOHN A. SANDOR
Regional Forester

cc: Marv Meier, Dr. Martinelli
Ray Clark, Art Judson

RJ:ds

S&PF

RSW

1/30

FOREST SERVICE
ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
240 West Prospect Street
Fort Collins, Colorado 80526

March 20, 1979

Robert C. Janes
Deputy Director
State & Private Forestry, R-10
Juneau, Alaska

RE: Alaskan Avalanche Report

Dear Bob:

Alaska's widespread and varied avalanche problems are summarized in Tables 1-4. Approximately 500 structures are directly exposed to avalanches, not to mention the ones I did not see on my last two trips. The Juneau area avalanches alone, pose the greatest potential for catastrophic avalanching in North America. Strong positive action is needed to alleviate this problem in Alaska. The fatality count from 1970 to date ranks first in the nation with 29 deaths. Eighty percent of these were mountain climbers but the records are much too short to indicate any definitive trend. The number of people exposed to avalanches along highways, in permanent structures, and at recreation areas justifies a warning program now. The Forest Service should:

--1. Establish a statewide avalanche warning service.

--2. Obtain orographic precipitation models for two sections of Alaska.

--3. Publish a comprehensive atlas of avalanches along Alaskan highways, recreation areas, and railroads.

--4. Continue annual avalanche schools.

--5. Institute public awareness programs.

--6. Initiate a vigorous research program to provide instrumentation needed for effective operation of the warning network.

--7. Start zoning avalanche areas on a contractual basis.

Development in the Eagle River drainages is rapidly increasing avalanche encounter probabilities there. Avalanche zoning is needed at that site now. This requires highly specialized personnel. The RM Station has the necessary contacts for such work, and we would be pleased to recommend qualified personnel for this work.

The Division of State and Private Forestry is best suited to coordinate the entire avalanche program in Alaska, because of the numerous interactions with Federal, state and private landowners affected. We support your efforts, and will be glad to help in any way possible.

Central warning systems have proven effective in Colorado, Washington, and Oregon. The mechanics of running such systems have been solved over the past 10 years by the Forest Service with good results. Existing programs in Colorado and Washington have wide public acceptance, and afford unusual opportunities for Federal, state and local governments to give the general public immediate returns for their tax dollars. The primary thrust is to save lives. Because these programs have been successful, I strongly recommend immediate action. It takes years to establish a complete program, but you will find it a gratifying and worthwhile venture.

Precedence

Authorization for an avalanche warning program is covered in the March 4, 1974 Memorandum of Understanding signed by the Chief of the Forest Service and the Director of the National Weather Service (NWS), enclosed. Specific application is authorized by local memorandums of understanding between the Forest Service (FS) and Weather Service Forecast Offices (WSFO's). The memorandum for Colorado is enclosed. Operations are detailed in the NWS Operations Manual Letter 1-75, also enclosed.

Some minor changes for your proposal of 1/25/79

Primary Station No. 4, Chugach State Park, could be more stratigically located at Moose Pass. Proposed additional supplemental stations include: Chugach State Park sites to be selected, DOT maintenance stations at Thompson Pass and Isabelle Pass, Grandview (railroad stop), Tsaina Lodge near Thompson Pass, Klukwan, Sitka, White Pass, Hyder and Salmon Creek Reservoir. Other supplemental stations are needed,but these can be gradually brought on stream when the warning system becomes operational. Both Meteor Burst Telemetry Systems - NWS and SCS should be incorporated in the data acquisition scheme. A standard "Westwide" wind system could be located at Arctic Valley, preferably at the Army Radar Site. Thorough and complete records on weather, snow, and avalanches will be essential. Alaskan avalanche records are nearly non-existent at the moment. This was the weak point of the early studies conducted by the Bureau of Public Roads near Girdwood in the 1950's. I have studied their data in detail and am sorry to say that the avalanche data are sadly lacking in documentation.

Research needs

The number one research priority relative to the warning system is to develop a heated, non-moving part anemometer. I am working with the Chief of NOAA's Laboratory Support Branch on this problem. A prototype model has been developed, but needs additional work, and a full winter of testing at a manned severe weather site--possibly Mt. Washington, N.H. Our project has already committed $10,000 toward this program and more will be needed. With luck we may have a working unit available for use in R-10 by 1981. Standard systems and heavy reliance on upper air data will be necessary for the present.

FM - CW Unit

We are working with the National Bureau of Standards Electromagnetics Division to develop a snow and water equivalent monitor which has great potential for measuring snow accumulation rates, loading rates, and avalanche occurrence in remote starting zones. The system uses frequency modulated continuous waves which penetrate the snow cover from an emitter buried in the ground. Present results show a one on one correlation with snow depth and water equivalent for snowpacks in the central Colorado mountains. Further testing is underway in deep snowpacks on the west coast. If we are lucky, the system will provide a major breakthrough in avalanche forecasting and warnings. I can foresee employment of several of these units in the starting zone areas of Behrends Avenue avalanche and at other critical locations.

Other Research

The Station's Mountain Snow and Avalanche Project has numerous studies underway which include quantitative measurements on blowing snow, acoustic emissions from stressed snow, avalanche dynamics, numerical models for simulating avalanche danger, wind flow in mountain terrain, passive seismic monitoring of mountain snowpacks, and analyses of seismic signals associated with avalanche slopes to mention a few. Many additional studies are underway, and all of these are pertinent to avalanche problems in Alaska and elsewhere. I know the Director is very interested in helping you solve some of Alaska's many avalanche problems, and our project knows the avalanche situation in R-10 requires action. We will do everything possible to help make Alaskan winters safer from an avalanche standpoint.

Thank you for inviting us to Alaska for a first-hand look at your avalanche problems. Our recent trips have been extremely interesting, and thanks to your unusual dedication, interest and hospitality; a great deal has been accomplished in record time.

Sincerely,

ARTHUR JUDSON
Mountain Snow & Avalanche Research

Table 1

Developments with homes or other structures in avalanche zones as of March 1979

TECHNICAL STUDY BY A QUALIFIED AVALANCHE DYNAMICS MAN RECOMMENDED AT AREAS OTHER THAN BEHRENDS AVENUE

Location	Number and Type of Structures	Return Interval	Encounter Probability	Severity of problem	Danger Trend
Juneau Area					
Behrends Avenue	33 homes 1/ 453 boats	13 years	very high	extreme	constant
	1 motel 2/ 1 high school auditorium	unknown	high	high	constant
White Subdivision	3 homes	unknown	high	high	constant
3/ North of Gold Creek	1 home	unknown	unknown	moderate	constant
Norway Point	1 home	unknown	high	high	constant
Snettisham Project	several power lines	unknown	unknown	unknown	constant
Power Line-Thane Road	3 power towers	unknown	unknown	unknown	constant
Anchorage-Seward					
Eagle River	several homes	unknown	high	moderate	increasing
Rainbow Creek	few homes	unknown	high	moderate	constant
Alyeska	1 lodge	unknown	high	high	unknown
	several other structures	unknown	high	high	constant
Indian Creek	few homes	unknown	unknown	low	unknown
Moose Pass Mile 35	unknown, homes	unknown	unknown	unknown	unknown
W. of Cooper Landing	few homes	unknown	unknown	unknown	unknown
Valdez	4/ 1 high school	unknown	low	low	constant
	1 home	unknown	high	moderate	constant

1/ Estimate of the number of boats occupied is 10 percent.

2/ Northwest section most exposed.

3/ At entrance to Evergreen bowl toward cemetary.

4/ Structural damage to north wall possible, but unlikely--parking lot to east is highly exposed to infrequent avalanches.

Table 2

Avalanches affecting state highways and other roads as of March 1979

Note: Avalanche advisories and/or warnings recommended all areas

Location	No. of Avalanche Paths	No. of Miles	No. of Paths with Frequency ≥ one/yr.	Present Control	Control Intensity	Recommendations
Seward Highway	90	90	~15	artillery	light	intensify control
1/ Thompson Pass	30	47	7	none	---	periodic closure
Juneau Area	18	10	2	artillery	light	intensify control and training
Isabelle Pass	10	4	unknown	none	---	none
Hatcher Pass	several	~10	unknown	none	---	periodic closure
Six Mile Creek	several	>5	unknown	unknown	---	periodic closure
Glenn Highway	several	>100	unknown	none	---	periodic closure
Eagle River	several	unknown	unknown	none	---	none
Chitna	several	~3	unknown	none	---	none
Nenana Canyon	several	1	unknown	none	---	none
Arctic Valley	1	---	0	none	---	none
Areas Not Visited						
Eyak-Cordova	2	---	unknown	none	---	none
Hyder Area	few	unknown	unknown	none	---	periodic closure
Haynes-Klukwan	few	unknown	unknown	none	---	none
Iliamna Bay to Pile Bay	several	unknown	3	none	unknown	plan spring opening during stable condition
Skagway to White Pass	numerous--severe problem when highway is opened to winter travel in 1979-80.					
Aleutian Islands	several--control not yet warranted.					

1/ Thompson Pass has large destructive avalanches at infrequent intervals in addition to avalanches from 7 frequent paths. At least one of two newly planned bridges circumventing the tunnel at the upper end of Keystone Canyon will be directly exposed to a very large avalanche (4500 feet vertical fall to bridge). ALASKA D.O.T. DESIGN PERSONNEL SHOULD CONTACT A QUALIFIED ENGINEER SPECIALIZING IN AVALANCHE DEFENSE STRUCTURES FOR THIS BRIDGE, PETER SCHAERER, NATIONAL RESEARCH COUNCIL OF CANADA, VANCOUVER, CANADA, OR HANS FRUTIGER, SWISS FEDERAL INSTITUTE FOR SNOW AND AVALANCHE RESEARCH, DAVOS, SWITZERLAND, PREFERRED.

Table 3

Recreational areas with significant potential for avalanche fatalities

Location	Avalanche Paths - No.	Primary Use	No. of Fatalities 1970-1979	Degree of Hazard	Comment
McKinley National Park	thousands	climbing	8	extreme	Constant danger, no viable means of hazard reduction. Mt. McKinley is an international drawing card.
Chugach State Park	thousands	all winter uses	5	very high	Public warnings and avalanche awareness training most effective.
Turnagain Pass	>100	skiing, snowmobiling	4	high	Same as above.
Independence Mine	~100	skiing	0	high	Same as above.
Alyeska	>30	skiing	0	moderate	Excellent control program.
Eaglecrest	numerous small paths	skiing	0	low	Good control program.
Juneau Region	>100	all uses	0	high	Public warnings.
Dyea to Lake Bennett	numerous	skiing	0	high	Warnings and avalanche awareness training most effective.
Sitka-Silver Bay to Blue Lake	numerous	skiing, snowmobiling	0	high	Same as above.
Seward Region	numerous	skiing, climbing	1	high	Same as above.
Thompson Pass	numerous	skiing	0	high	Same as above.
Mt. St. Elias	thousands	climbing	4	extreme	Same as Mt. McKinley

Table 4

Avalanches affecting Alaskan railroads

Location	No. of Paths	Severity of Problem	Present Control	Control Intensity	Recommendation
Spencer to Hunter	11	high	artillery	light	Heavier control, avalanche warnings.
Moraine to Whittier	unknown	low	none	---	Avalanche warnings.
Skagway to White Pass	unknown	very high	none	---	On ground evaluation, avalanche advisories and warnings.

THE FOLLOWING DOCUMENT(S) MAY NOT FILM LEGIBLY BECAUSE OF POOR QUALITY OF THE ORIGINAL.

OROGRAPHIC PRECIPITATION MODEL FOR HYDROMETEOROLOGICAL USE

by

J. Owen Rhea

Research report supported by the

Rocky Mountain Forest and Range Experiment Station
Forest Service
U.S. Department of Agriculture
Under Cooperative Agreements
16-[illegible]-CA and 16-5[illegible]-CA

Department of Atmospheric Science

Colorado State University

Fort Collins, Colorado

March, 1978

Atmospheric Science Paper No. 287

ABSTRACT

OROGRAPHIC PRECIPITATION MODEL FOR HYDROMETEOROLOGICAL USE

Research was performed to determine the ability to diagnose the effect of topography on winter precipitation for western Colorado over various time periods for differing wind regimes, employing upper air data and a fine-mesh topographic grid.

To accomplish the objectives, a simple, operationally oriented orographic precipitation model was developed. The model is two-dimensional, steady state, and multi-layer. It follows parcels at layer mid-points through topographically-induced moist adiabatic ascents and descents. Layer budgets of water substance are calculated by (a) allowing precipitation of a constant fraction of total cloud water (i.e., local condensation plus imported cloud water), (b) carrying the remainder downstream where it and additional condensate can partially precipitate, and (c) permitting evaporation of cloud water upon descent and of precipitation falling into subsaturated layers. A key feature of the approach is its representation of precipitation shadowing by upstream barriers (when used with a different topographic grid for each wind direction).

Airflow is constrained to two dimensions and the complications of topographic effects on the flow are approximated by using a set of stability-dependent damping factors to adjust the vertical displacement of layers. Effects of large-scale vertical motion are added to those of topography.

The model was tested for western Colorado using 12 winter seasons of twice daily upper air measurements as input. Results were summed

and compared to observed spring and summer runoff from watersheds of varying size. Correlation coefficients between seasonally-summed model watershed precipitation and observed runoff range mainly between 0.75 and 0.94. On a daily basis large discrepancies between model and observation sometimes exist, but model frequency distribution of daily precipitation totals appears realistic.

A 13 year model mean precipitation map was found to agree quite well in mountainous areas with an isohyetal map constructed by ESSA of the U.S. Department of Commerce using precipitation and snow-course data with empirical correlation to topographic features. The model underestimated broad valley precipitation in most cases.

Test quantitative precipitation forecasts (QPF's) were made (and communicated daily to the U. S. Forest Service) from November, 1975, to March, 1976, using wind direction-dependent model pattern maps as objective aids. Isohyets on these pattern maps were calibrated using forecast wind speed, moisture depth, duration, areal coverage, and cloud temperature. Skill scores for 24 hour QPF's ranged from 0.56 to 0.67.

The derived method has utility (a) in assessing the average magnitude and the inter-season variation of topographic effects on winter precipitation in western Colorado and (b) as an objective aid for quantitative precipitation forecasting. It has substantial potential utility as input to hydrologic process models for streamflow forecasting. The basic approach should be transferable to other topographically complex areas which are dominated by stratiform precipitation.

John Owen Rhea
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523
Summer, 1977

using wind direction-dependent pattern maps from the model as objective aids. Isohyets on these pattern maps were calibrated using forecast values of wind speed, moisture depth, duration and areal coverage, and cloud temperature. Skill scores for [illegible] hour quantitative precipitation amounts ranged from [illegible] to [illegible].

8.2 Conclusions

From this study a number of conclusions can be drawn and these are listed below.

1. It has been demonstrated that it is feasible to assess the average magnitude and the inter-season variation of topographic effects on winter season precipitation in the mountainous section of Colorado using only routinely available upper air information, a fine mesh topographic grid, and a simple orographic precipitation model.

2. Computations of model volume precipitation over various watersheds in the study area show strong positive correlation to observed spring and summer runoff. Thus the model has substantial potential for providing input to hydrologic process models for streamflow forecasting, especially for watersheds of greater than [illegible] square miles. This input could consist of computed areal and temporal distributions of winter precipitation using only routinely available upper air data as soon as it is collected.

3. The employment of model wind-direction dependent pattern maps of precipitation as objective aids to quantitative precipitation forecasting in mountainous areas is quite useful and should be continued.

and compared to observed spring and summer runoff from watersheds of varying size. Correlation coefficients between seasonally-summed model watershed precipitation and observed runoff range mainly between 0.75 and 0.94. On a daily basis large discrepancies between model and observation sometimes exist, but model frequency distribution of daily precipitation totals appears realistic.

A 13 year model mean precipitation map was found to agree quite well in mountainous areas with an isohyetal map constructed by ESSA of the U.S. Department of Commerce using precipitation and snow-course data with empirical correlation to topographic features. The model underestimated broad valley precipitation in most cases.

Test quantitative precipitation forecasts (QPF's) were made (and communicated daily to the U. S. Forest Service) from November, 1975, to March, 1976, using wind direction-dependent model pattern maps as objective aids. Isohyets on these pattern maps were calibrated using forecast wind speed, moisture depth, duration, areal coverage, and cloud temperature. Skill scores for 24 hour QPF's ranged from 0.15 to 0.67.

The derived method has utility (a) in assessing the average magnitude and the inter-season variation of topographic effects on winter precipitation in western Colorado and (b) as an objective aid for quantitative precipitation forecasting. It has substantial potential utility as input to hydrologic process models for streamflow forecasting. The basic approach should be transferable to other topographically complex areas which are dominated by stratiform precipitation.

John Owen Rhea
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523
Summer, 1977

4. The basic model should be transferable to other mountainous areas which are not dominated by convective precipitation. Parameter re-calibration would be required depending on such things as latitude, altitude, terrain scale-size and micro-physical characteristics of the moist air masses.

5. Historical orographic precipitation computations using real upper air information as model input require corrections for humidity sensor lag if meaningful model results are to be obtained.

8.3 Model Utilization Suggestions

Model patterns of precipitation are sufficiently realistic to suggest several immediately useful applications. Some of these are briefly discussed below.

First of all, the skill scores attained from the 1975-76 winter of test quantitative precipitation forecasting (QPF) are sufficiently high to warrant the construction and use of model pattern maps for QPF aids in other topographically complex areas as well as the continued use of the method for Colorado.

A second endeavor which would likely yield useful results would involve the interfacing of this orographic precipitation model to models of hydrologic processes and blowing snow to obtain runoff estimates. Snowcourses and precipitation gauge data for adjusting the model volume watershed precipitation should be incorporated in the method, while then using the adjusted precipitation model output to define the areal relative distribution of precipitation over the watershed. Adaptation of the blowing snow model by Schmidt ([illegible]) for use with interpolated winds aloft data is recommended as a technique for estimating sublimative water losses from blowing snow in the alpine zone.

The combined usage of the orographic precipitation model and a blowing snow model naturally suggests the incorporation of the resulting output into an avalanche dynamics model currently being developed by the U.S. Forest Service. Related to this, but more empirical in nature would be a climatological study of the model-indicated frequency of conditions conducive to avalanche occurrence utilizing model precipitation and upper air wind information.

Historical upper air information attending previous record point snowfalls could be input to the model for the construction of maps of "project snowstorms", an exercise which should be useful for structural planning purposes.

The gridded arrays of model output for each wind direction would be immediately useful for identifying widely separated points having a high degree of correlation between their precipitation values over a wide range of wind directions. Such information could be utilized for selection of precipitation measurement sites for use as weather modification target and control areas. The technique could also be employed to strategically locate gauges in a hydrometeorological network to maximize the information gained from a minimum number of gauges.

With adequate spatial and temporal resolution of upper air soundings, model output would be a quite useful data set for direct use as a covariate (equivalent to a control area precipitation station) for reducing the unexplained variance in weather modification target area precipitation and thus minimizing the required duration of the experiment for obtaining meaningful results.

Finally, the rather dramatic visual and quantitative depiction of terrain shadowing effects in model output suggests that qualitative insight into the possible downwind effects of weather modification might be gained from a series of model sensitivity tests employing spatially variable precipitation efficiency values.

While results from this simple approach to the orographic precipitation problem are encouraging and point to its immediate utility for certain purposes, limitations inherent in both the model simplicity and in the input data should be kept in mind. Based on this study and those of several other investigators referenced herein, accuracy limits even with adequate input data for computing precipitation over periods of 6 hours or less should be near a value of 0.7 for the correlation coefficient between model and measurement. Summation of these short period computations over 24 hour periods might attain a correlation coefficient of approximately 0.8. Seasonal summations can be expected to attain peak correlation of near or just slightly above [illegible].

Accuracy beyond that stated above will likely require (1) consideration of three-dimensional effects on airflow, (2) markedly improved knowledge of precipitation efficiency, (3) improved parameterization of meso-scale banded precipitation phenomena, and (4) better temporal and spatial resolution of upper air moisture profiles.

[illegible] Recommendations for Further Research

Continued pursuit of the problem of seasonal orographic precipitation estimation is recommended along the lines discussed in this study. In particular the implications from Section [illegible] suggest an attempt to quantify effects from (a) terrain funneling, (b) ridges aligned with the wind, or (c) isolated peaks might be profitable. Objective precipitation corrections for these effects might logically be sought by comparing the fields of either horizontal perturbation velocity or vertical motion obtained from a three-dimensional flow model to those from the current computation scheme.

The regression relationships obtained between model precipitation and observed runoff should be tested for stability for several subsequent years. In particular tests should be made using data from any available extremely dry or wet years.

Also, it would be instructive to test the approach for other areas including topographically complex regions dominated by stratiform rain.

Much more effort should be expended to understand the nature of and quantify precipitation efficiency.

An attempt should be made to fine tune the model to even finer resolution topography. This should include [illegible] nested topographic grids with resolution of the order of 1.5 km. The crystal trajectory subroutine of the model should be refined for this research. Empirical fine-tuning solutions could also be sought by developing correction factors for current model output by comparing model and actual station elevations and precipitation. These correction factors might then be useful over a limited area to estimate precipitation on the sub-grid scale.

Finally, the model should be combined with an atmospheric water balance box model such that the box model [illegible] the box volume quantify precipitation amounts [illegible] while the orographic model is utilized to spatially distribute the precipitation. Extensive usage of interpolated upper air temperature, wind, and humidity data should be made in this study not only for model corrections but also to test the utility of these interpolated data for developing relations to indicate periods of high mountain evaporation through both blowing snow sublimation and from the stationary snow cover. Insight into the areal and temporal distribution of evaporation should be one outcome of this research.

The extreme short period variability of relative humidity profiles observed in this study suggests the need for additional research into the causes for such with end goals of (a) arriving at improved ways of considering the effects of mesoscale banded structures (including convection bands) and (b) a determination of the minimum sampling frequency of upper air moisture fields required to significantly improve precipitation estimates.

THE PRECEDING DOCUMENT(S) MAY NOT FILM LEGIBLY BECAUSE OF POOR QUALITY OF THE ORIGINAL.

U. S. SKI ASSOCIATION - ALASKA DIVISION

RESOLUTION

STATE-WIDE AVALANCHE WARNING SERVICE IN ALASKA

WHERE AS:

The U. S. Ski Association-Alaska Division, a non-profit organization for the promotion and development of Alpine and Nordic skiing and comprising of 750 members, is vitally concerned for the safety of both their members and non-members participating in these sports, and

WHERE AS:

Snow avalanche hazards in Alaska have resulted in the highest number of avalanche fatalities in the Nation since 1970, and

WHERE AS:

More than 500 human habitable structures are directly exposed to avalanches in addition to 180 avalanche paths crossing public highways and railroads and thousands of avalanche paths within heavily used developed and undeveloped public recreation areas, and

WHERE AS:

the establishment of a State-wide avalanche network is needed in order to alert our State citizens to changing snow conditions and to inform outdoor use of related avalanche danger, and

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WHERE AS:

the establishment of a State wide avalanche network is needed in order to alert our State citizens to changing snow conditions and to inform outdoor use of related avalanche danger, and

WHERE AS:

such a network could provide important supplemental benefits for flooding and fire weather forecasting, and mountain weather forecasting for mountain climbers, and thus resulting in a year-round life and property saving service to all our citizens.

THEREFORE BE IT RESOLVED:

the U. S. Ski Association - Alaska Division urges the State of Alaska Legislature to provide financing for a cooperative State-wide Avalanche Warning Service in Alaska, and

BE IT FURTHER RESOLVED

that such a service should involve State and Federal Agencies, Municipalities ar private enterprises for the purposes of a jointly financed and operated Alaska Avalanche Warning Service.

ADOPTED BY, the U. S. Ski Association - Alaska Division at their annual meeting on 12 May 1979.

SAM HAYES
President - USSA - Alaska Division

Climber Killed By Avalanche In Alaska Range

A Japanese mountain climber was the victim Wednesday of the first climbing fatality of the season in the Alaska Range, but his death was not reported until Friday when his partner reached a landing strip on the southeast fork of the Kahiltna Glacier.

Dead is Masamitsu Urayama, 29.

Yutaka Shinohara, 40, is the partner who survived. He was taken to Providence Hospital and has been released.

Both were members of Shizuoka Climbing Club of Japan.

McKinley Park rangers said today they did not know what city in Japan the men are from.

An avalanche caught the climbers as they were descending the west ridge of Mount Hunter, which is just south of Mount McKinley in Denali National Monument.

The two had just completed a difficult route on the north face of the 14,573-foot peak, said Bob Gerhard, spokesman for the National Park Service.

"This is probably the first fatality ever on Mount Hunter," Gerhard said.

Shinohara was flown to Talkeetna and then to Anchorage Friday for medical attention. He had an apparent knee injury, lacerations and bruises, Gerhard said.

The victim's family, the surviving climber and National Park Service personnel "will have to make the decision on retrieving the victim and then decide whether it will be possible, practical or desirable," Gerhard said.

Park Service personnel are not sure of the exact location of the body, he said.

THE PRECEDING PAGES WERE TREATED AS A UNIT IN THE ORIGINAL FILE.

THE FOLLOWING PAGES WERE TREATED AS
A UNIT IN THE ORIGINAL FILE.

Alyeska
RESORT

P.O. BOX 249 GIRDWOOD, ALASKA 99587

January 27, 1980

The Honorable Mike Miller, Chairman
House State Affairs Committee
Alaska State House of Representatives
Pouch V
Juneau, Alaska 99811

Dear Mike:

Bob Janes of the U. S. Forest Service in Juneau recently briefed me on the legislation pending before your committee regarding avalanche forecasting and control program funding. I certainly appreciate your active participation in getting such a program run on a professional basis statewide.

I had planned to testify last Monday via telecon before your committee from the Anchorage legislative office; however, the Seward Highway was closed due to avalanches, and I was unable to get through. As you have probably heard, the Highway was closed from Thursday, January 17 through Wednesday, January 23. Several cars were hit and a train derailed when it could not stop in time to avoid hitting one of the slides.

I have enclosed a letter and picture which I sent Commissioner Ward regarding the avalanches on the Seward Highway last spring. This slide cost the Highway Department over $60,000 to clean up. I am sure the cost of regular control work which would have brought down the snow before it had a chance to build up would have been far less costly.

Alyeska Resort is willing to participate in such a program to help in the scientific evaluation of avalanche hazards in this region. The resort itself has had an extensive control program for many years for the ski slopes and in recent years has spent approximately $75,000 per year to keep the slopes safe for skiers. Because the Department of Highways is not fully funded or prepared to undertake a regular control program, we have loaned them two of our four 105mm rifles.

Naturally, I feel this program is absolutely essential. It would be desirable for funding to be retroactive to this winter season and go through

1981; although, I feel the amount recommended is conservative especially if the program is to be successful on a statewide basis.

Bob Janes and I both agree that the agency of the State that would best be suited to be responsible for the program is the Department of Public Safety.

Mike, I appreciate your getting this going in the House. Although I do not know who will spearhead this program in the Senate, I have sent a copy of this letter to Senator Colletta who represents this district. He has been very helpful in getting a control program going and is well versed on the subject as it pertains to this area.

If I can be of further help, please let me know. I would be willing to come to Juneau and do whatever necessary to get the funding for this program approved.

Best regards,

Chris von Imhof
Vice President and General Manager

CVI/bbp
Attachments 2

Copy to Senator Mike Colletta
Mr. Bob Janes

GIRDWOOD
BOARD OF SUPERVISORS

P.O. BOX 249
GIRDWOOD, ALASKA 99587

PAT ABSHER
DANA BROCKWAY
HAROLD CASEY
SEWELL FAULKNER
CHRIS VON IMHOF, CHAIRMAN

MUNICIPALITY OF ANCHORAGE
GEORGE M. SULLIVAN, MAYOR

April 13, 1979

Mr. Robert Ward, Commissioner
Department of Transportation and
Public Facilities
Juneau, Alaska 99811

Mr. Robert Dorsey General Manager
Alaska Railroad
Pouch 7-2111
Anchorage, Alaska 99510

Gentlemen:

As a result of the recent major natural (uncontrolled) avalanches over the Seward Highway between March 23 and March 25, the Board of Supervisors felt an inquiry should be made into why it happened and what was done or not done to prevent the occurence.

We solicited reports from three avalanche experts who were directly involved in the follow up avalanche control. The experts are Tom Miller and Jim Hackett, Snow Rangers for the U. S. Forest Service; David Hamre, Avalanche Technician for Alyeska, the third most avalanche prone ski area in the country; and Doug Fessler, Chief Ranger, Chugach State Park. Their findings and recommendations are enclosed.

For decades the tremendous avalanche hazard between Bird and Girdwood has been acknowledged. Various experts over the years such as Norm Wilson of California and Art Judson of the U. S. Forest Service in Colorado, have been consistent in their recommendations that the area be controlled regularly.

Last year several natural avalanches covered the Seward Highway and concern was expressed at that time about safety of the highway given the sporadic control work done by the Department of Transportation. A meeting was held last February, and I felt the outcome would result in a coordinated preventative avalanche control program between the DOT and the Alaska Railroad. Apparently this did not happen.

Speaking as the General Manager of Alyeska Resort, we have been forced to become well-versed in all aspects of avalanche control techniques and consequently I feel qualified to recommend such a program be undertaken in earnest by the DOT and the Railroad before there is loss of life and property.

It is common opinion that it was only a matter of luck that no one was injured or killed in one of these natural releases. I know that three people narrowly escaped death - two from the Department of Highways in Girdwood and a Municipal inspector. It is providential that the highway was closed for construction (Potter South Project); however, the releases occurred within an hour of the road reopening.

Systematic preventative control work would have gotten the snow down as it accumulated before the accumulation was so heavy that the resulting slides covered the highway and railroad tracks. Besides alleviating the danger to life and property, a control program would have saved the considerable cost of clearing the snow off the highway. In addition, the huge climax slides cause heavy damage to the soil and therefore increase the likelihood of mud slides during rainy seasons which are also expensive to clean up.

The DOT does have a few dedicated employees with the basic knowledge of avalanches; however, either because of budget restrictions or other duties or lack of authority, they are not able to monitor the avalanche conditions on the highway consistently enough to provide reliable control. We are also concerned that the DOT does not have the necessary rifles, equipment, blind firing data, or commitment to do helicopter control work or whatever is necessary to keep the slides from reaching the highway.

Should a fatality occur as a result of an avalanche across the highway or railroad tracks, the DOT most certainly would be held responsible. Given the information already compiled on avalanche conditions, under most circumstances, it could not be considered an "Act of God."

We feel the taxpayers would not object to spending extra money to keep the Seward Highway safe for travel in the winter. We hope you will study these reports and are persuaded to budget for a more comprehensive avalanche control program for this coming year.

Speaking again as the General Manager of Alyeska Reosrt, one business that lost an estimated $70,000 over that weekend in March, the Resort stands ready to assist the DOT and the Railroad with manpower and artillery on a contractual basis.

The Board of Supervisors would like to ask the DOT and the Railroad how they intend to handle the avalanche problem on the Seward Highway for the 1979-80 winter season. By copy of this letter we would also like to request our State and Federal representatives to support the DOT with the necessary budgetary authorizations.

Sincerely yours,

Chris von Imhof
Chairman

CVI/bbp

Copy to Governor Jay Hammond
Mr. Mike Colletta, State Senator, District I
Mr. Ray H. Metcalf, State Representative, District 11
Ms. Joyce Munson, State Representative, District 11
Mr. Ted Stevens, U. S. Senator, Alaska
Mr. Mike Gravel, U. S. Senator, Alaska
Girdwood Board of Supervisors

INTER-OFFICE CORRESPONDENCE

Alaska Airlines

DATE 4/3/79

SUBJECT Avalanche problems on the Seward Highway

TO Chris Von Imhof

FROM David Hamre
Avalanche Technician

In response to your recent request to document the recent avalanche activity on the highway, and provide some recommendations for improving the control program, I have written a summary of weather and avalanche occurence here for the past month, a chronology of events on Bird Hill and other selected areas, a short summary of the methods used in two other transporation corridors, and a list of what I feel to be the most important areas that need attention in the D.O.T. control program. The list of recommendations could include numerous less important suggestions, but I have left these out in order to emphasize the importance of the six suggestions I made.

It is an unfortunate fact of life that problems are not often recognized until a major disaster occurs, hopefully my efforts here will help to persuade a far-sighted individual or group to act now, rather than react later when the effects of the current program become catastrophic, as they surely will.

Every year the amount of traffic on the Seward Highway increases, raising the chances of an accident. As has been the case in every other avalanche-threatened transporation corridor, economics will some day dictate that the avalanche problem here be dealt with on a far more active basis.

In spite of the lack of traffic on March 23rd, I still think we were very lucky that no one was caught in the avalanche activity. Let us both hope we don't have to rely on luck any more.

Alyeska Resort Inc.

4/3/79

WEATHER AND AVALANCHE SUMMARY ON MT. ALYESKA
prior to avalanche cycle of March 20-23 on Seward Highway

Weather - Late January- moderate depth and temperature snowpack
February 2- 5 inches of light new snow followed by 4 hrs of freezing drizzle.
February 3- Temperatures had been running in the high teens for lows and high twenties for highs for all of January making the snowpack somewhat uniform in temperature at 26-28°F. Then on Feb.3 a cold front came in dropping the temperature below 0°F. for several days, moderating to highs in the 4-7°F. and lows below 0°F. till mid-February.
February 4- Strong surface hoar formation above and depth hoar formation below the ice lens caused by the freezing drizzle on Feb. 2. Very steep temperature gradient between snowpack and air would normally form surface hoar, but ice on the surface of the snowpack is prohibiting necessary vapor transfer above, so vapor transfer is occuring just below ice lens.
February 6- Snow below ice lens now looking like begginning T.G., poorly sintered
February 9- T.G./ice lens layer of snowpack has now developed to the point that a notation is made in daily weather and snowpack summary that this layer could produce large avalanches when given a rapid load of new snow.
Mid-February- Highs moderating to mid-teens, lows around 5°F.
Late February- Highs moderating to mid-twentys, lows around 10°F.

There was no precipitation from February 3 to March 3, then four storms followed in March as follows:
March 3- March 6 Storm#1 onto the T.G./ice layer
March 7- March11 Storm#2
March 13- March 17 Storm#3
March 18- March 23 Storm#4

Storm #	1500' elevation snowfall/Water equiv.	2,200' winds	3,000' snowfall/water equiv.
1	23"-2.25"	130@15m.p.h.	22"-2.68"
2	24"-2.55"	130@20m.p.h.	23"-3.85"
3	42"-3.64"	240@5m.p.h.	42"-4.73"
4	62"-6.22"	130@10m.p.h.	74"-8.85"
Totals	151"-14.66"		161"-20.11"

Avalanche- March 5-Significant avalanching starts at Alyeska with some natural releases and many paths reacting to control work- up to 2' fractures.
March 9- More loading causes slightly larger avalanching with average fracture depth around 2' and one fracture 3' deep. Inspection of the three foot fracture reveals that the snow had run on the T.G. crystals just below the ice lens caused by freezing drizzle.
March 13- Larger fractures appeared with good releases on almost all shots. Many areas of instability were cleaned out and most run-outs were far short of what they would have been had we allowed the snow to stay put for the next storm.
March 15-18 Lucas (D.O.T.) informed that there could be a serious instability on Bird Hill. Fracture size at Alyeska is dropping off in general, indicating that many places have avalanched off the T.G./ ice layer. Occasional large fractures to 5' are still

occuring indicating there is a probability that the unstable T.G./ice layer still exists in large pockets.
March 20-21 Many new snow avalanches but only occasional large releases from control.
March 22- Extreme loading from last storm has brought many remaining T.G./ice pockets to critical levels causing large natural releases in the backcountry, and onto the highway during the past 48 hrs. Several large releases occured on the 22nd on Alyeska, one of these went 2' below the T.G./ice layer into old T.G. 2 feet above ground. Fracture profile from North Face reveals 60"-86" depth with 13.75" of water content.

As early as February 9 we felt that we would see large avalanches on the T.G./ice layer so that when the precipitation arrived we made an attempt to do continuous control work in an effort to bring down the accumulating snow in small quantities. These efforts were reasonably succesful in keeping the size of the avalanches smaller than could have been expected had we allowed the hazard to build.

David Hamre, Avalanche Technician

4/3/79

Alyeska Resort Inc.

CHRONOLOGY OF AVALANCHE EVENTS ON BIRD HILL MARCH 20-28
and other selected areas

March 20 Natural avalanche at SP 15½ closes road all night. Road buried 300'x20'

March 21 Visual fire on SP19 and 20 produce one avalanche that crosses road in the morning burying road 80'x20'. Road crew cleans debris from avalanche of night before and control work, opening road approx. 10 A.M.
4 P.M. Intense storm causes natural release at 106 mile, first time since earthquake of 1964 that this avalanche had reached the road.
7 P.M. Natural release at 93 Mile closes road for night, two other natural releases occur shortly after.

March 22 6 A.M. Road crew goes to work clearing debris from avalanches of night before. Storm abating somewhat. Road open at noon. Blind fire on Whiskey in afternoon produces another avalanche that crosses highway. By evening the storm has let up considerably.

March 23 6 A.M Cloudy weather in early morning, D.O.T. gun crew decides to go to Hatcher Pass for control work.
8 A.M. Rapid clearup followed by warm breeze and sunshine.
1:15 P.M. First large natural release onto highway reported at Alyeska by skiers on hill. This avalanche was probably Bird Hill Left (SP9-12) burying road approx. 2,000'x20'. Triangulation of debris shows that the snow ran 550 yards into the inlet, giving an indication of the velocity involved.
1:17 P.M. Another major release goes well out into the inlet, this one probably Bird Hill Right (SP13 and 14)
1:18 Large natural avalanche hits highway near Whiskey
1:19 Tom Miller blocks traffic at Girdwood end.
1:20 Phone call from Alyeska to Bird catches Doug Fessler who stops traffic in Bird. Quick action in blocking the highway at both ends could well have saved some lives as several more large avalanches occured until approx. 2:30 P.M. Miller and Hamre had immediately suggested an aerial reconnaissance to determine if anyone had been in the avalanches. It is still not clear to them whether this was ever done.
3:00 P.M. Larry Daniels gets approval from Lucas or Morrow, D.O.T., to get a helicopter bombing mission together in an effort to make the road safe for highway crews to go to work clearing debris.
5:00 P.M. Helicopter bombing crew flies out to highway observing for people, cars, etc. before starting bombing mission. Observations show that approx. 40% of the release zones had avalanched naturally, leaving a tremendous amount of snow still to come down. Natural activity had already buried the road in about ten places, with about 1½ miles of debris averaging 10 ft. in depth. Control work is mandatory to insure safe conditions for road clearing operation. Helicopter lands on highway about ½mile beyond Bird Hill where D.O.T. control team has set up for firing. D.O.T. crew fires one round bringing a major avalanche out of SP8 and 9 that covers road approx. 400'x20'. The velocity of the avalanche when it hit the road was about 100 m.p.h. with a throw out of debris to 50 ft. high and a dust cloud to 200 ft. Several mature cottonwoods were seen flying through the air, with the debris coming to within 100 yards of the gun position. Lucas joins bombing team in helicopter while gun crew pulls back to safe position on Bird Point. Helicopter bombing commences at Girdwood end of Bird Ridge, and proceeds west to SP 6. The first mission uses 40 hand charges, placing approx. 32 effectively, and releasing another 4 major avalanches that went into the inlet and 10 that reached the road in addition to some smaller ones that did no reach the road. Aerial recon indicates that many of the chutes on the ridge had not released, particularly on the Girdwood end. Lucas decides to make up remaining explosives and make another pass. The second mission takes off at 6:30 and uses 6 charges, releasing one more

major avalanche and 5 smaller ones that stop just short of the road. Operations are suspended because of darkness.

March 24 6 A.M. Road crews go to work clearing avalanche debris from highway. Approx. 80% of the release zones had run yesterday leaving only a moderate hazard on Bird Ridge. Decision made by Lucas to shoot avalanche paths above Peterson Creek with Alyeska 75mm and use these observations to determine if more helicopter bombing is necessary on Bird Ridge. Bird Ridge has S.E. aspect and Peterson Cr. S.W. No results from test firing. Road crews work all day to clear avalanche debris. Helicopter bombing late in afternoon of ski slopes used by Far North Ski Guides Inc. releases a slab avalanche in Glacier Cr. with an 8 ft. fracture, and another in Winner Cr. with a 12 ft. fracure, both on southerly aspects.

March 25 6 A.M. Road crews again at work clearing debris from highway. By 2 P.M. using 16 pieces of machinery they have cleaned the road up to allow for a normal flow of traffic, and the road is once again opened. At 1 P.M. test firing is done on slopes adjacent to Bird Ridge with several large releases occuring. On the basis of these results Lucas decides to once agin helicopter bomb Bird Ridge in an effort to clean out all the remaining unstable pockets. Helicopter takes off at 3:30 P.M. to place 30 charges on the ridge. 29 charges are placed effectively producing one more large avalanche that crosses the highway, and several that stop just short. Road is closed from 3 P.M. to 6 P.M. for bombing and clearing debris.

By the end of the last Helicopter bombing mission approx. 90% of the hazard area that overhangs the 3.8 miles of highway from the west end of Bird Hill to the railroad crossing in Girdwood had released. The few chutes that did not release could well have been the ones that ran naturally early in the storm. Avalanche debris averaged 10 ft. in depth with a maximum of 40 ft. for a length of 2.2 miles of the 3.8 miles of highway in this section. SP 6 also released onto Bird Flats, bring down several 400 yr. old trees. There was a total of 35 avalanches on Bird Hill and 7 others on Bird Flat.

March 27 An earthquake measuring 2.9 on the Richter scale occured at 8:39 A.M. with an epicenter 12 miles S.E. of Girdwood. Numerous avalanches occured in California Cr. and Virgin Cr., one of which the fracture line was estimated to be two miles in length involving slopes of north, west, and south aspect, indicating that an unstable condition still exists in the snowpack.

March 28 Helicopter bombing for powerline problem areas releases another large avalanche with fracture depth of 6-8 ft.

March 29 Helicopter bombing for Railroad gets no results/

Alyeska RESORT INC.

4/3/79

AVALANCHES ---
MODEL FORECASTING AND CONTROL

Historically speaking, transportation corridors that are threatened by avalanches and show an increase in traffic every year find it economically necessary to establish a comprehensive control program to avoid property damage and loss of life. With the present control program on the Seward Highway, it is just a matter of time before there are severe losses of life and property. The problem is complex because of the interaction between politics and a natural phenomena, but there are several possible solutions that would greatly reduce the chances of an accident happening, and increase the reliability of the transportation corridor. For any solution to work, however, there must be a cooperative venture between the railroad and highway.

There are two transportation corridor control plans that we can look to as models for establishing a comprehensive solution to the problems here. The first and probably foremost is Rogers Pass in central British Columbia. There is no other pass available to transcontinental traffic for 400 miles north or south, so economics have fostered an awareness of the avalanche problem from the start. During construction numerous snowsheds were built in areas that frequently avalanche along both the highway and railroad. Weather data is fed to a main center from several mountaintop remotes and two other manned stations. Forecasting is done by a conventional method; when a storm reaches a critical level so that avalanches are expected on the road or rail, a gun crew is called in to fire on the places that are felt to be a problem. Blind fire data is kept and used when necessary on all shots. Crews are on call 24-hours a day, and shooting is done during the critical periods of instability, with temporary closures of an hour or so for control work to be done. Every attempt is made to control the avalanches while they are small, with the realization that the manpower and money for this is, in the long run, cheaper than large clean-up efforts after major avalanches and loss of the use of the transportation corridor. Natural avalanche occurances onto the highway or railroad is a very rare occurrence, as the intent of any control program is to reduce the odds of a natural avalanche occurring that will cause loss of life or property damage.

Another example of a highway control program is in Little Cottonwood Canyon, Utah. There are two major ski areas at the end of the nine mile road, with an average of 4,000 cars per day crossing underneath the 21 major avalanche paths. One hundred and ten avalanches cross the highway on an average year. As in Rogers Pass, storms are allowed to build up to an unstable condition short of naturally releasing, then the road is closed temporarily for firing from fixed mounts at three different locations. Firing is commonly done from all three mounts simultaneously. The intent again is to release the snow under controlled circumstances, with small enough avalanches to hopefully stop short of the road. Occasionally a large storm will occur with an instability deep in the pack that necessitates closing the road for a longer period of time. Forecasting is done utilizing conventional methods, with two mountaintop weather stations; and control work is done in the ski areas on similar slopes and aspects, providing basic input.

(continued)

Briefly, these are the methods used in two highly regarded transportation corridor control programs. Perhaps an examination of these compared to the Department of Transportation's program here could bring a revision in procedures to reduce the hazard to life and property.

Comparison Chart
Avalanche Control

Description	Rogers Pass	L.C. Canyon	Department of Transportation
Fixed Mounts for Gun Positions	Yes	Yes	Some
Blind Fire Data on all Shots	Yes	Yes	Blind Fire on SOME Shots
Capability to Shoot at Night	Yes	Yes	Onl w/Existing Blind Fire .ata
Instrumentation	Yes	Yes	Fui Is Pending
Qualified Forecaster w/only Responsibility Hwy. Control	Yes	Yes	Not Sole Responsibility
Study of Snow & Snow Pack in Release Zones	Yes	Yes	No
Emergency Rescue Procedures for Crew & Public	Yes	Yes	Speed of Rescue in Doubt
Closures before Natural Activity	Yes	Yes	Rarely

* * *

Dave Hamre, Avalanche Technician

DH:bjb

Alyeska Resort Inc.

4/3/79

RECOMMENDATIONS FOR D.O.T. AVALANCHE CONTROL PROGRAM

For any meaningful improvementsto occur in the avalanche control program there must be a recognition amongst a wide diversity of people that there is a problem that could be solved before there is a serious accident. Had conditions of Friday, March 23rd been slightly later in reaching thier peak, there could have been a school bus full of children under the paths, or a truck with people and cargo, or a train with equipment bound for the north. The results would obviously be far more catastrophic. Following is a list of recommendations:

1. Appropriations specifically earmarked to deal with the avalanche problem on the Seward Highway and Alaska Railroad.

2. Hire a qualified avalanche technician with transportation experience to set up and run a comprehensive control program utilizing the funds hopefully appropriated for this purpose.

3. Fixed mounts installed to have the capability of blind firing all shots at any time of day or in any weather.

4. Instrumentation for weather monitoring at starting zone locations.

5. Rescue plans should be drafted and practiced.

6. Economics demand a unified approach by the D.O.T. and Alaska Railroad in the funding and operation of a control program. Cost of the original installation could be appropriated by the state, with operational costs to be split between the two agencys.

A very rough estimate of the amount of money necessary to set up a comprehensive control program, including the purchase of two howitzers, installation of two gun platforms, signing systems, manpower, and one more weather station would be around $100,000.

To run a comprehensive program with two people to do the forecasting and control plus 600 rounds of artillery per year and two full scale helicopter bombing missions when conditions warranted, will cost approx. $50,000/yr.

STATE OF ALASKA

JAY S. HAMMOND, GOVERNOR

Terry A. McWilliams, Director

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

2601 Commercial Drive
Anchorage, Alaska 99501

April 2, 1979

RECEIVED

APR 4

ALYESKA RESORT, INC.

Chris Von Imhof, Chairman
Girdwood Board of Supervisors
P.O. Box 249
Girdwood, Ak 99587

Dear Chris,

Pursuant to your request for recommendations for increasing public safety in Avalanche Zones along the Seward Highway, I offer the following comments:

- A public safety problem does exist along the Bird Hill section of the Seward Hwy and elsewhere due to avalanches. (This is evident in the number of close calls to passerbys, destruction of power lines, guard rails, motor vehicles and railroad tracks, road closures and loss of business revenue. However, only one fatality and 5 injuries are known to have occured since 1952.
- It is not anticipated that this problem will disappear without initiation of a bonafide program of avalanche control in conjunction with snow pit studies and meterological data collection.
- The purpose of an avalanche control program is to trigger small avalanches on a regular basis under controlled situations in order to protect public safety, transportation and business interests.
- It is generally less expensive - and far safer - to deal with an avalanche problem through a comprehensive avalanche control program then to respond to road clean-up as a result of fate.
- DOT's present activity of periodically shooting down avalanches is not an avalanche program in the real sense of the meaning and it would seem that the State is leaving itself open to a significant amount of liability should someone be killed or injured along the Highway as a result of an avalanche in an area that is supposedly "controlled".

Perhaps those agencies delegated with joint management responsibilities for areas identified as being avalanche hazard areas should form a joint Task Force whose responsibility it would be to draw up and implement a comprehensive snow safety plan which would address the how, who, what, when and where of avalanche control, snow pit and meterological data collection, and road closure/rescue contingency plan.

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Additionally, it would be wise for the DOT to hire an avalanche "expert" who's full time responsibility would be to implement and coordinate the program. Much of the actual control work could be done on a contractual basis for less than present costs. Public safety would be greatly enhanced and State liability would be greatly reduced. I hope these comments are of some use in helping to solve the problem. The problem is enormous but not out of reach.

Sincerely,

Doug Fesler, Chief Ranger
Chugach State Park

DSF:lmk

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
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4 APR 1979

2340

Chris von Imhof
Board of Supervisors
Community of Girdwood
Girdwood, Ak. 99587

The following is an analysis of the Seward Highway Avalanche activity March 23-25, 1979 and recommendations to Department of Transportation, State of Alaska (DOT) pertaining to public safety, the avalanche phenomenon, and control procedures along the Seward Highway.

ANALYSIS

1. March 23, sunny, clear snowplumes observed on Bird Ridge. Approximately 1:00 p.m. Snow Ranger Miller received report from Alyeska Resort's Pro-patrol that two avalanches had just been observed crossing the highway below Bird Ridge.

2. Miller and Alyeska's Avalanche Technician Dave Hamre act to close the highway. (Miller on south end, and Hamre by phone to Park Ranger D. Fesler on north end)

3. Miller finds one barricade and sign already established on south end so proceded to first avalanche where he finds the Girdwood Trooper.

4. Trooper states that one loader and operator in route to start clearing the slides from south end. Miller pointed out that in his opinion road should be closed to all personnel and area below Bird Road should be vacated immediately - due to the high probability of additional natural released avalanches occurring.

5. The trooper radios D.O.T. personnel and advises of the recommendation. D.O.T. concurred.

6. Several additional avalanches released naturally and ran to and across the road during the next two hours.

7. Hamre - Miller recommended that the Seward Highway between Bird Point and Girdwood be flown to look for any victims or trapped vehicles and that stranded D.O.T. personnel be flown out.

8. Approximately 4:00 p.m. Miller, Hamre, Alyeska Mountain Manager L. Daniels flew by helicopter with explosives ready for bombing operation to location of D.O.T. gun 105 mm truck and crew, and landed 100 yds. North of gun to observe artillery results and discuss bombing operation with D.O.T.

9. D.O.T. fires one 105 round to the ridge crest above and released a large class 4-5 avalanche that crossed the highway a few yds. in front of the gun truck and crew. The slide continued down and spilled into Turnagain Arm.

10. The crew was lucky the avalanche did not propagate back-up the ridge or the crew would have been buried.

11. The helicopter bombing operation produced several additional avalanches across the highway approximated 50 charges were thrown.

12. March 24, Sat., clear, sunny, winds observed from N.W. along Turnagain Arm.

13. D.O.T. begin highway clearing project from north and south ends of avalanche debris with D.O.T. and leased equipment.

14. Miller - Hamre advise D.O.T. that they felt the snowpack conditions were still unstable on Bird Ridge due to deep snow instability. They advised of possible natural avalanche releases south of Girdwood. Miller and Hamre recommended use of U.S.F.S. and Alyeska's 75 mm for test shots at Peterson Creek slide area. D.O.T. concurred and the shots were scheduled for 2:00 p.m.

15. Five rounds were fired with negative results. Miller and Chris von Imhof recommended to move to Kern Creek slide area for more test shots. D.O.T. turned down recommendation.

16. Just prior to the test shooting at Peterson, Snow Ranger Jim Hackett discussed with D.O.T. on the north end of the slides that he felt, due to the deep snow instability that additional hazard still existed on Bird Ridge.

17. March 25, Sunday, clear, sunny.
Miller, Hackett recommend to D.O.T. that the 75 mm be used for more shots on Bird Ridge.

18. Miller - Hackett felt strongly that unstable conditions still existed Bird Ridge and that until all large snowfields had released that the potential of more avalanches reaching and crossing the highway was high. D.O.T. concurred and test shots were fired at 2:00 p.m.

19. Three large avalanches reaching the valley floor resulted from six shots.

20. Miller, Hackett, and Hamre recommended additional helicopter bombing that afternoon.

21. Highway clearing was completed and the road opened to the public at approximately 2-3 p.m.

22. Helicopter bombing was postponed due to railroad activities during late afternoon, exposing them to potential run-out zones.

23. Monday, March 25,1979.
Helicopter bombing performed on Bird Ridge at approximately 2:00 p.m. Several large avalanches occurred.

24. One avalanche deposited five piles of debris on the highway. One pile approximately 50 ft. wide and 20 ft. high, and the other 30 ft. wide, 20 ft. high. Both large enough to bury several vehicles.

Recommendation to D.O.T.

1. Consult experienced individuals and firms in highway and transportation corridor avalanche control and forcasting programs. (Rogers Pass, British Columbia which is considered the leading program in North America dealing with avalanche hazard)

2. Hire an experienced, qualified avalanche technician to constantly monitor snow stability and direct an avalanche control program.

3. Install meteorological instrumentation at necessary locations at ridge top elevations along the Seward Highway. This data received being a major imput for stability evaluations.

4. Set up control program of initiating slides prior to the time when they become critical and natural release in large volumes.

   a. Blind fire from fixed gun positions during and after storms.

   b. Helicopter bomb when weather permits.

5. Document an intensified Snow Safety Plan that outlines the procedures that state personnel shall follow to maximize state employee and public safety during snow avalanche occurrences.

6. Initiate a plan to relocate the highway from the runout zones where possible. Where not possible consider defense mechanisms, snow sheds, etc. Many of these considerations have been outlined by an avalanche study report prepared by the State of Alaska, Department of Highways Planning & Research Section completed in 1963.

7. In conclusion, considering the avalanche potential along the Seward Highway, that we, the State of Alaska, the community of Girdwood, residents of the Kenai Peninsula, and employees of the Alaska Railroad, have been very very lucky in the past. This is especially true during last week's Bird Ridge avalanche activity. In our opinion the avalanche problem along the Seward Highway is complex. Extensive effort, technology, and dollars must be spent in order that the safety of the traveling public is assurred.

Tom S. Miller

TOM S. MILLER
Head Snow Ranger
Chugach National Forest

J.E. Hackett

J.E. HACKETT
Snow Ranger
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