UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

209 S. W. Fifth Avenue
Portland 4, Oregon
March 14, 1958

Dr. Vincent J. Schaefer
Director of Research
The Munitalp Foundation, Inc.
R. D. 3 - Schermerhorn Road
Schenectady, New York

Dear Vince:

As one who is familiar with our snow survey operations in the West, you are well aware of the many operational problems we encounter in our collection of the actual snow surveys. With rapidly increasing competition for water between agriculture, industry, and other users, the collection of basic data, so necessary in order to make sound decisions as to the greatest utilization and wisest conservation of this resource, exceeds in many watersheds our ability to meet new demands for snow courses and soil moisture data.

For years we have attempted to develop and assist in the manufacturing of a dependable economical over-snow machine. While progress has been made and models do exist which will quite satisfactorily operate within limited circumstances, we are still plagued with a multitude of machine breakdowns each year. Even if the ideal machine existed today, we still would not be able to collect data as frequently and from all watersheds which we desire and need to improve our forecasts.

It is for this reason that the snow survey supervisors have for years realized the importance of a method which could accurately measure the water content of the snow in a remote manner and thus reduce collection expense considerably while collecting data from areas not now sampled because of operational problems.

In our continuing efforts to find a workable scheme to measure the water content of the snow remotely, we would like to describe to you one of the more promising and yet simplest methods, not only for your comments as to utility, but to inquire as to your group's possible participation in the development of such a device or similar one, if within the realm of your present activities. This device perhaps of plastic material, partially filled with a fluid which would not freeze, would resemble a "pillow" and would weigh the snow. A "pillow" would be placed on the ground at each of the regular sampling points of a standard snow course.

Undoubtedly it would be best to place the "pillow" in a small depression with the top of the "pillow" or weighing element approximately level with the ground surface. It could rest on a smooth surface (plywood) to insure fairly uniform distribution of the enclosed fluid. The surface area of these "pillows" might be of the magnitude of a camping air mattress, from 3" to 6" thick. These dimensions are only conjecture and the critical size and material would have to be developed or proven from field testing.

All the "pillows" on a snow course would be connected independently to the sensing system in order to obtain an average weight of the snow resting on the "pillows". The individual "pillows" or weighing elements would be so designed and interconnected that a failure in one would only reduce the total number of weights contributing to the average. With these "pillows" acting as weighing elements of the water content of the snow, a communication system would translate this information via a pressure transducer into a battery-powered transmitter which would operate only when interrogated from a mother transmitter and receiver. Such a mother transmitter and receiver would be located in an aircraft which would merely fly over the snow courses and automatically record the data from each course on a micro-max recorder. Each snow course would identify itself by suitable code when interrogated. Fifteen to 20 seconds time would doubtless suffice to record necessary information from one snow course.

The ramifications of such a successful device would almost transcend any concept now of collecting data.

I am not sure just what The Munitalp Foundation policies are on such development, but we in the snow survey activity certainly would welcome any assistance that you might be able to give us directly or indirectly in developing such a device to give remote reading of water content of the snow pack from remote watersheds. Will you give me your views on this?

With kindest personal regards and best wishes from the Supervisors, I am

Sincerely yours,

R. A. Work, Head
Water Supply Forecasting Section

March 28, 1955

Mr. R. A. Work
Soil Conservation Service
Ross Building
209 S. W. 5th Avenue
Portland 4, Oregon

Dear Arch:

The following is a brief report of several items which may be useful to you in the preparation of a report of the Committee on Snow, of which you are chairman.

> "An International Classification for Snow has been issued by The Commission on Snow and Ice of the International Association of Hydrology. A committee consisting of Dr. V. J. Schaefer, Mr. G. J. Klein and Dr. M. R. de Quervain prepared a draft of the proposed classification and submitted it to the International Commission on Snow and Ice at Brussels in 1951. After receiving suggestions for improvements, a final draft was prepared and presented at the Rome meetings of IUGG in 1954. It has now been presented to the W.M.O. through its Technical Commission on Aerology with the recommendation that it be given field trials. The publication in final form was greatly assisted by the National Research Council of Canada thru the help of Mr. R. F. Legget, Chairman of its Committee on Soil and Snow Mechanics".

The classification has been designed as nearly as possible to conform to current field practice in various parts of the world.

Copies of the classification may be obtained from the National Research Council of Canada, Ottawa, Canada. It is available as Technical Memorandum No. 31 by the Associate Committee on Soil and Snow Mechanics.

It was good to see you, Arch! My only regret was the fact that you could not spend a couple of days at Schenectady. I hope the next time will be different.

Sincerely yours,

Vincent J. Schaefer
Director of Research
THE MUNITALP FOUNDATION, INC.

VJS:K
ENC.

A. G. C.

June 2, 1954

Mr. Eric Hinton
Hydro-Electric Manager
Bowater's Newfoundland Pulp & Paper Mills, Ltd.
Deer Lake, Newfoundland

Dear Mr. Hinton:

Many thanks for sending me the copy of the Report of the Committee on Snow. It contains many interesting items.

Sincerely yours,

Vincent J. Schaefer
Director of Research
THE MUNITALP FOUNDATION, INC.

VJS/meb

BOWATER'S NEWFOUNDLAND PULP AND PAPER MILLS LIMITED
INCORPORATED IN NEWFOUNDLAND
DEER LAKE
NEWFOUNDLAND

TELEGRAMS & CABLES:
NEWSPRINT CORNER BROOK
CODE: BENTLEYS

Hydro-Electric Power Development.
May 27th, 1954.

Mr. Vincent J. Schaefer,
R. D. 3 - Schermerhorn Road,
SCHENECTADY, New York, U.S.A.

Dear Mr. Schaefer:

In accordance with Mr. R. A. Work's request, I am attaching hereto the "Report of the Committee on Snow", of the American Geophysical Union. I presume that this report will be contained in the usual transactions produced annually.

Very truly yours,

HYDRO ELECTRIC MANAGER.

Encl. (1)
EH:gw

AMERICAN GEOPHYSICAL UNION

EXECUTIVE COMMITTEE

American National Committee of the
International Union of Geodesy and Geophysics
and Committee on Geophysics of the
NATIONAL RESEARCH COUNCIL

WASHINGTON, D. C.

COMMITTEE ON SNOW

c/o Soil Conservation Service
209 S. W. 5th Avenue
Portland 4, Oregon
May 3, 1955

Messrs. M. E. Baudendistel
Robert D. Elliott
Eric Hinton
Clyde E. Houston
Gordon J. H. Kidd
C. C. McDonald
Vincent J. Schaefer
J. van de Erve
C. C. Warnick

Dear Fellow Members:

Attached is a copy of the report submitted to R. N. Wilson, Chairman, Program Committee, Hydrology Section, AGU, for inclusion in the TRANSACTIONS.

Cordially yours,

R. A. Work, Chairman
Committee on Snow, AGU

Attachment

REPORT OF THE COMMITTEE ON SNOW, AGU
1954-1955

R. A. Work, Chairman

M. E. Baudendistel	Clyde E. Houston	Vincent J. Schaefer
Robert D. Elliott	Gordon J. H. Kidd	J. van de Erve
Eric Hinton	C. C. McDonald	C. C. Warnick

The following report has been prepared by the committee from a questionnaire sent to individuals and agencies active in snow research.

M. E. Baudendistel (U. S. Forest Service, Portland, Oregon)--Colorado, under supervision of B. C. Goodell, Fort Collins, Colorado. Studies are under way in five watersheds where snow is the primary source of streamflow. Logging is under way on two of the five watersheds and will be completed during 1955. Continued streamflow comparisons will show the effect of timber removal on streamflow, and indirectly, the effects on snow and accumulation and rate of melt. From one watershed the timber is being removed in a strip-wise pattern, strip widths varying from 66 to 396 feet, and strip directions ranging through 180 degrees. Cut-over strips alternate with uncut stripe. During years following the completion of cutting, measurements will be made to determine the effects of strip width and orientation on the accumulation, drifting and melting of snow.

Idaho, under supervision of Charles A. Wellner, Spokane, Washington. Soil moisture conditions are being studied in relation to snowmelt patterns by use of paired installations of fiberglass electrical units in conjunction with snow course measuring points.

Northeast, under supervision of Howard W. Lull, Upper Darby, Pennsylvania. Analysis is being made of snow and frost depth measurements collected twice weekly over a period of two winters. Data were secured in 15 to 20 land-use conditions at each of six locations scattered throughout the Northeast. The first objective is to determine for each location whether significant differences exist in snow accumulation and frost depth. Later the data will be analyzed to determine snowmelt and frost disappearance rates by land-use conditions. In New Hampshire, an exploratory study is under way to secure snow depth and water content on an experimental watershed where a watershed management research program is being developed. Results will be used to help design more detailed studies.

Northern Rocky Mountains. Paul Ingebo has prepared a short paper on "An Instrument for Measurement of the Density of Plant Cover Over Snow Course Points." Publication is scheduled this year; some results will be presented on relationships which exist between snow accumulation and plant cover density as measured by this instrument. In cooperation with the Weather Bureau, pictures are being taken at selected points during the snowmelt period to document the retreat of the snowmelt line on selected slopes. Accumulative readings at certain back country standpipe snow and rain gages are being made also in cooperation with the Weather Bureau.

Utah, under supervision of George W. Craddock, Ogden, Utah. Monthly storage gage snow records as part of the year-round precipitation record have been taken at elevations 4,500 feet, 7,000 feet, and 8,600 feet on the Davis County Experimental Watershed near Farmington, Utah, and also at 6,000 feet, 7,000 feet, 8,600 feet, and 10,000 feet in the Ephraim Creek Watershed at the Great Basin Research Center, Ephraim, Utah. The storage gage records have been supplemented by snow samples at the more elevated stations, as well as by regular snow course measurements.

California, under supervision of E. A. Colman, Berkeley, California. Work in snow research has been confined to planning for research in snowpack management which, it is hoped, will get under way soon. The land in which streamflow is fed mainly from snowmelt has been mapped. About 12 million acres are in this category, and this area (12 percent of the area of the State) is the source of 51 percent of the State's average annual runoff. Particular interest is in the part of the snowpack zone that lies within the commercial timber belt, because it is there that management of snow (for improved or increased water yield) has the best possibilities. The area of this portion is about 9 million acres; its runoff is estimated at 38 percent of the State's runoff, or some 27 million acre-feet per year. Most of the commercial timber land in these 9 million acres is still uncut, but logging is now moving upward within the area and eventually all but the reserved lands will be cut-over and converted into second-growth forests. Considering the large amount of runoff originating in this area and the fact that forests there will be cut-over, it is important to learn how forests there can be managed for snow control as well as timber production. Some preliminary analyses of snow data obtained in past years at the Central Sierra Snow Laboratory by the Corps of Engineers and the Weather Bureau have been made. Henry Anderson has found in these analyses that there are marked differences in snow accumulation and in melt rates between spots with different degrees of forest cover and shade. He concluded that forest stands with small openings held snow longer than either dense forests or large open areas. This conclusion is not new, of course, but as a result of his analysis there are some specific clues to kinds of research that would provide quantitative measures of the effectiveness of snow control under a number of forest stand conditions.

F. A. Strauss (California Division of Water Resources, Sacramento, California)--Aerial photographs of the snowpack on watersheds of the San Joaquin, Kings, Kaweah, Kern, Mono Lake and Owen Lake Basins are being secured. With an adequate amount of data, evaluation of summer snowmelt characteristics will be attempted.

K. Batson (U. S. Weather Bureau, Portland, Oregon)--The Weather Bureau has continued the photographic snow cover observation program described by Batson (Proceedings, Western Snow Conference, April 1953). Data are now available for the 1952, 1953 and 1954 melt seasons, and will be collected during the 1955 melt season. Observations are being secured in the Flathead, Coeur d'Alene, Clearwater and Payette River Basins.

Only preliminary analysis of the photographs has been accomplished to date. Snow cover percentages for about ten dates per year have been determined by placing a 10 x 10 per inch transparent grid overlay on the enlarged 620 photographs. By comparing the estimated snow cover on the photograph with other snow cover data on the same dates (aerial photographs, climatological substation snow depth reports, snow surveys, and other historical data which

ordinarily are not available on a daily or even a weekly basis), a relation between percent of snow cover on the photograph and on the river basin has been approximated for the Flathead River, Montana. The estimated basin snow cover has been tested for its value as a parameter in a snowmelt forecasting procedure. Although the number of years of available record is small, results to date are somewhat encouraging.

A day-to-day melt season forecasting procedure was developed for the Payette Basin, Idaho. The entire seasonal hydrograph, above base flow, was reconstructed from temperature, snow cover, and rainfall data without reference to observed flows. The choice of the Payette Basin above Emmett, Idaho was based on the relatively dense network of strategically located climatological substations and snow courses and frequency of available reports. Radiosonde temperatures provide the basis for most of the temperature parameter. Daily increments of total computed runoff from snowmelt and rainfall are divided into two components -- surface and ground water runoff. These are combined and routed to the Emmett gaging station with the electronic streamflow routing analogue, using separate storage and lag characteristics. A paper by A. L. Zimmerman, "Reconstitution of the Snowmelt Hydrograph in the Payette River Basin," will be published in the 1955 Proceedings of the Western Snow Conference.

D. M. Rockwood (Corps of Engineers, Portland, Oregon)--The Snow Investigation Unit is preparing a summary report on snow hydrology to be completed in 1956.

Snow Investigation Research Note #25, "Lysimeter Studies of Snowmelt," dated March 1, 1955, presents the analysis of the 1954 spring melt data on a lysimeter site in the Central Sierra Snow Laboratory. Radiation and condensation melts were independently determined from radiometer measurements and special moisture-exchange experiments. The residual melt was considered due to convective heat transfer. Derived melt equations gave condensation melts approximately equal to Sverdrup's (1936) and convection melts one-third of Sverdrup's.

In Research Note #24, "Analysis of February 1951 Rain on Snow in a Densely Forested Area," runoff resulting from rain on snow was studied. Another study was made of the storage capacity of snow over a basin during a rain storm.

Month-by-month water balances for the years 1946-47 through 1949-50 were computed for Skyland Creek, Upper Columbia Snow Laboratory, using methods as described in Research Note #22, "Forecasting Seasonal Runoff by the Water-Balance Method."

Other studies and work include construction and preliminary testing of an electronic analogue for storage-type routing which permits variation in the time-of-storage constant during actual routing. A study of diurnal variation of albedo at Central Sierra Snow Laboratory for the spring of 1954 show that the snow had measurable specular reflection. In another study, melt rates at several Upper California Snow Laboratory snow courses showed that ablation rates for the same air temperature varied directly with exposure to solar radiation.

Phil E. Church (University of Washington, Seattle, Washington)--The Department of Meteorology and Climatology has been investigating the albedo of snow mainly from data on the reflectivity of the Lemon Creek Glacier in Alaska. Dr. K. Buettner and Mr. R. Hubley find that the albedo of snow, water, ice, and clouds

vary strongly with the sun's zenith distance, cloudiness, and the melting-freezing processes. Work is going on concerning explanation of these changes as well as their importance for the heat balance of surface, troposphere, and stratosphere.

O. W. Monsen (Montana State College, Bozeman, Montana)---Continual effort has been made to further develop a small, easily transported over-snow vehicle. A machine just newly developed will provide transportation for two men and can be transported in a half-ton pickup truck.

V. J. Schaefer and C. J. Klein (The Munitalp Foundation, Inc., Schenectady, New York, and National Research Council, Ottawa, Canada, respectively)---An International Classification for Snow has been issued by the Commission on Snow and Ice of the International Association of Hydrology. A committee consisting of Dr. V. J. Schaefer, Mr. C. J. Klein, and Dr. M. R. de Quervain prepared a draft of the proposed classification and submitted it to the International Commission on Snow and Ice at Brussels in 1951. After receiving suggestions for improvements, a final draft was prepared and presented at the Rome meeting of the International Union Geodesy and Geophysics in 1954. It has now been presented to the World Meteorological Organization through its Technical Commission on Aerology with the recommendation that it be given field trials. The publication in final form was greatly assisted by the National Research Council of Canada through the help of Mr. R. F. Legget, Chairman of its Committee on Soil and Snow Mechanics.

Lorne W. Gold (National Research Council, Ottawa, Canada)---The Snow and Ice Section of the Division of Building Research occupied new cold room facilities. In this cold room a project to study the mechanical properties of ice, its ultimate strength in tension and compression, relationships between stress and strain, and its plastic properties was initiated. Some very preliminary observations have been made concerning the mode of failure of ice under load and the dependence of this mode on the direction of freezing of the ice.

In the field of snow and runoff the section has done little more than continue the snow survey project reported last year. Some observations that were made during the 1953-54 winter on the strength of snow have been analyzed and the results of this work will probably be published shortly.

C. C. Warnick (University of Idaho, Moscow, Idaho)---During the year a new project was initiated on a study of rime ice and snow-capping on high altitude gages. These gages were installed in the Boise River Basin.

R. A. Work (Soil Conservation Service, Portland, Oregon)---Soil Conservation Service personnel conducted extensive tests on two new designs of over-snow machines during the past winter in an effort to further development of equipment for over-snow travel.

J. W. Marr (University of Colorado, Boulder, Colorado)---The Institute of Arctic and Alpine Research is continuing its research on the interactions of snow accumulation and vegetation on the Front Range. Snow measurements and several other environmental factors are being taken at eight stations.

Robert D. Elliott (North American Weather Consultants, Goleta, California)---Efforts towards increasing snowpack through cloud seeding are under way in

many western watersheds. Indicated results to date have been encouraging enough to lead to the continuance of such programs. Prominent ones are, proceeding from North to South:

1. Southern Cascades project, sponsored by California-Oregon Power Company, which has now completed its 4th year of snowpack seeding.

2. The Lake Almanor, Mokelumne-Stanislaus, and Bass Lake projects, sponsored by Pacific Gas & Electric Company. PGE has sponsored cloud seeding - snowpack programs in the Sierras for 3 years.

3. The Upper San Joaquin program sponsored by the Southern California Edison Company, which is just completing its 5th year of operation.

4. Bishop Cops area project, sponsored by California Electric Power Co. One of the earliest projects, it was started in 1948 and has continued on a varying scale, to date.

5. Salt and Verde Rivers project, conducted by the Salt River Valley Water Users Association, from 1947 to date.

6. Moving east, the South Platte Water Resources Development Corporation has sponsored snowpack increasing projects for 4 years in the South Platte Watershed area.

In addition to the above, several relatively new snowpack projects have commenced in California, Utah, Idaho, and Wyoming, and British Columbia.

It is expected that the wealth of data being systematically collected by these various projects will reveal in detail the true effectiveness of weather modification techniques under various types of meteorological situations.

R. W. Gerdel (Snow Ice & Permafrost Research Establishment, Corps of Engineers, U. S. Army, Wilmette, Illinois)--Extensive stratigraphic studies were made by SIPRE during the past year on the permanent snow pack which constitutes the upper layer of the Greenland Ice Cap. At a site about 200 miles east of Thule and at an elevation of 7,000 feet a 100-foot vertical shaft was excavated and core drill used at the bottom of the shaft to collect snow samples to a depth of 165 feet. Even at that depth the density was less than that usually associated with glacier ice and considerable permeability was measured. Since the layers produced by winter and by summer deposited snow were readily identified and no melting occurred at this elevation, it was possible to determine the annual precipitation for this North Greenland area with an accuracy probably equal to that obtainable from any precipitation records for state side stations. The samples from the 165-foot level represented snow that fell during the Civil War.

A residual mass curve prepared from the pit study shows that there was a period of above normal precipitation in this area of Greenland from 1920 to 1932 with below normal occurring since 1933. It appears that such stratigraphic studies as these, made by SIPRE may help to explain some of the long shifts in circulation patterns and storm tracks.

At its Keweenaw Field Station near Houghton, Michigan, SIPRE has active research projects on the vehicular trafficability of a snow surface as influenced by meteorological phenomena and metamorphic processes in the snow. Other projects include studies on the drifting of snow in a manner analogous to the movement of sediments in streams, and on the attenuation of radiation by blowing snow during wind storms not accompanied by precipitation.

The micrometeorological research program originally initiated at the Central Sierra Snow Laboratory in California was transferred and greatly expanded at the Keweenaw Field Station.

The entire micromet, solar radiation and snow drifting program is being transferred to Greenland for the summer with all personnel and equipment including a 12-meter mast scheduled to be on the Ice Cap by 20 June.

J. R. Riter (Project Investigations Division, Bureau of Reclamation, Denver, Colorado)--The Bureau of Reclamation at the present time (March 1955), is not actively engaged in conducting field investigations of snow. As the work demands, we are making office computations of snowmelt in relation to the synthesis of design floods for spillway computations of proposed dams. We are also engaged in making a limited number of seasonal water yield forecasts which use snow survey data among other factors and also in the derivation of day-to-day rate-of-runoff of snowmelt forecasts for specific operational requirements. The Bureau of Reclamation continues to assist the Soil Conservation Service in the financing of the Federal-State Cooperative Snow Survey System through the contribution of funds which are made available for transfer on a reimbursable basis.

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Ans Dec 22

WESTERN SNOW CONFERENCE

EXECUTIVE COMMITTEE – GENERAL CHAIRMAN
AUSTIN E. HELMERS
INLAND EMPIRE RESEARCH CENTER
S. 157 HOWARD ST., SPOKANE 4, WASHINGTON

207 Federal Building
Tacoma 2, Washington
October 18, 1954

Dr. Vincent J. Schaefer
Munitalp Foundation
630 Fifth Avenue
New York, 20, New York

Dear Vince:

Preliminary contacts are being made for a program for the 1955 Snow Conference to be held in Portland, Oregon April 13-15.

As program chairman I have made an effort to determine the general subjects that appear to be of greatest interest to those who normally attend the annual meetings. Inevitably, weather modification stands high on the list of interested subjects. We had a good report last year on the activities of the Advisory Committee on Weather Control by Captain Orville, and I would like to include the subject of weather modification in the program again this year.

As far as I am aware, no significant change has occurred in the methods being used by the commercial operators. No doubt evidence of effectiveness of their operations is building up but such evidence is slow to appear in technical literature. In time, I presume, the Weather Bureau will make public its findings in the Western Washington tests by Ferguson Hall.

We would like very much to have a report from you at our April 1955 meeting on recent progress in the technology of artificial neucleation and weather modification. I am not familiar with the work of the Munitalp Foundation except as reported in Seattle newspapers recently, but I am sure you are familiar with the accomplishments and potentialities along these lines. I am sure you are aware that the Western Snow Conference numbers among its membership representatives of practically every group in the West concerned with the yield of water from melting snow. It is probably the most interested and representative group, from a practical standpoint, that could be found with respect to potentialities of cloud seeding.

If you can possibly fit it in your schedule, we would appreciate a report from you next April.

Sincerely yours,

C. C. McDonald

C. C. McDonald, Chairman
Program Committee

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Watershed Planning Branch

209 S. W. 5th Avenue
Portland 4, Oregon
April 25, 1955

To: Members, Committee on Snow, 1953-54, AGU

M. E. Baudendistel	J. C. Marr
Walter U. Garstka	C. C. McDonald ✓
Eric Hinton	Vincent J. Schaefer
Clyde E. Houston	Walter T. Wilson
Gordon J. H. Kidd	

From: R. A. Work, Chairman

Subject: Report of the Committee on Snow, 1953-54

It is a pleasure to be able to send you a few copies of this report. We have a small supply remaining and would be glad to send additional copies to you if you desire them.

R. A. Work

encl. 10

Coop. Res. - Snow Survey

1392

bc: VGC
MS(NYC)
REF

Airmail

March 28, 1958

Mr. R. A. Work, Head
Water Supply Forecasting Section
Soil Conservation Service - U.S. Dept. Agriculture
209 S.W. Fifth Avenue
Portland 4, Oregon

Dear Arch:

I have read your letter with regard to the development of a method for obtaining snow pack data from remote stations.

I wish this were a project which we in Municalp could support since it has many aspects of deep interest to me. However, our program is being shifted toward tropical meteorology so that it is unlikely this is possible.

There are several places, however, where I would think you might obtain help both with respect to ideas as well as project support in one way or another.

I suggest you contact Dr. Marcel de Quervain, Director, Snow and Avalanche Research Institute, Weissfluhjoch, Davos dorf, Switzerland. I know that Marcel has devices which measure the pressure of potential avalanche snows. The method of making contact with the snow may be of interest as well as his recording instruments. I am not current on whether they have developed remote recorders. If you are not in touch with his group, I am sure you should be, in view of your many mutual interests.

You may wish to contact Paul MacCready, Jr., President, Meteorology Research Incorporated, 939 East Union Street, Pasadena, California, with respect to your problems. Paul's group have been interested in simple automatic weather stations and, I am sure, have given considerable thought to remote transmitting stations. His group are doing some very interesting work in the development of meteorological instruments of highly specialized uses.

Have you given consideration to the possibility that project support might be available through S.I.P.R.E. ? This would seem to be the logical governmental group to lean on, but I am, of course, aware of some of the personnel problems and personalities involved which may make this approach impractical at the moment.

Finally--we have in our area an inventive genious who has from time to time become interested in hydrologic problems. He owns a number of the instruments used by Robert Horton who lived near his home and apparently influenced him to a certain extent. If you obtain project money and need someone who might be useful in devising mechanical linkages, etc., I would be glad to put him in touch with you.

It is assumed from the tone of your letter that you have completely recovered from your indisposition of last year. I sincerely hope this is the case, Arch, and I hope to have the pleasure of seeing you one of these days.

Sincerely,

Vincent

Vincent J. Schaefer
Director of Research
THE MUNITALP FOUNDATION, INC.

VJS:K

Transactions, American Geophysical Union Volume 36, Number 1 February 1955

REPORT OF THE COMMITTEE ON SNOW, 1953-1954

R. A. Work, Chairman

M. E. Baudendistel	Clyde E. Houston	C. C. McDonald
Walter U. Garstka	Gordon J. H. Kidd	Vincent J. Schaefer
Eric Hinton	J. C. Marr	Walter T. Wilson

The following report has been prepared by the Committee from a questionnaire sent to individuals and agencies active in snow research.

M. E. Baudendistel (U. S. Forest Service, Portland, Oregon)--Studies will soon be initiated on the H. J. Andrews Experimental Forest to determine differences in runoff from snow melt from areas logged wholly or in part as compared with uncut areas.

George W. Craddock (Chief, Division Watershed Research, U. S. Forest Service, Ogden, Utah)--Studies of snow blowing and drifting from adjoining experimental watersheds are planned in order to reveal some variations of runoff which cannot logically be attributed to differences in the amount of snow that falls directly on the catchment areas.

W. T. Frost (Oregon Snow Survey Leader, U. S. Soil Conservation Service, Portland, Oregon)--A network of aerial snow-course markers to be photographed from the air has been established in Oregon. Density factors from nearby snow courses will be applied to depths photographed from the aerial markers. Results will be compared with those of regular snow-course measurements.

Several electrical fiberglass soil-moisture measuring units are to be established in selected watersheds of Oregon. Measurements will be made and studied in cooperation with Oregon State College Agricultural Experiment Station to assess water contributions from the winter snow pack necessary to bring watershed soils up to field capacity in the spring.

Walter Garstka (U. S. Bureau of Reclamation, Denver, Colorado)--The experimental studies of ice pressure by the Bureau of Reclamation were discontinued in 1951. The more important results of both field and laboratory investigations were summarized in a paper, Ice Pressure Against Dams, Experimental Investigation by the Bureau of Reclamation, by G. E. Monfore [Proc. Amer. Soc. Civ. Eng., v. 78, Sep. no. 162, December, 1952]. Essentially the same data are contained in Bureau of Reclamation Laboratory Report no. C-662.1A, Ice Pressure Measurements, December 7, 1953. The latter report includes an annotated bibliography of 22 references on the subject of ice pressure.

The active data-gathering phase of the Bureau of Reclamation-Forest Service Cooperative Snow Investigations terminated with the 1950 snow-melt season. Analyses of that season were presented in Report no. 3, 1950 Snow-Melt Season, Progress in Snow-Melt Investigations at the Fraser Experimental Forest, Colorado, released by the Bureau of Reclamation and Forest Service. All analyses for this cooperative effort have been completed and a final report is being assembled.

R. W. Gerdel (Snow, Ice, and Permafrost Research Establishment, Wilmette, Illinois)--We have been studying the settling and deformation of snow profiles with a unique slide-wire device, originally developed in Switzerland. It is giving us some interesting information on the self-compaction, melting, and possible upward sublimation of snow layers without disturbing the snow. This device may solve the problem of snow melt and soil priming during the winter. Effectively we have one leg of a Wheatstone bridge permanently installed in the snow and read the change in thickness of a layer as a change in resistance of the wire.

W. A. Lang (Chief Hydrographer, Southern California Edison Co., Los Angeles, California)--A network of 12 snow-survey aerial markers has been installed in the San Joaquin River Basin and Sierra Nevada Mountains. These aerial snow markers are to be photographed from the air at monthly intervals from December to July.

John W. Marr (Director, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado)--The Institute, in its long-range study of the ecology of the East Slope of the Front Range, is making measurements of snow depth and water content. Total precipitation and soil moisture are recorded also in order to determine 'all' aspects of environment water each month. Evaporation measurements are to be added as soon as possible.

Information on the interrelations between plant species, plant communities, and snow accumulation are being collected. This includes observations of the effect of snow accumulation on the reforestation of areas in the Sub-Alpine Forest and the distribution of types of tundra plant communities in the Alpine tundra.

The results are being used to interpret vegetation features in the Sub-Arctic Forest-Arctic Tundra Transition Area in Quebec (or Ungava). Investigations are being conducted attempting to work out the particular role for which snow accumulation is responsible in altering the environment on different exposures in the Montane Forest.

C. C. McDonald (Staff Engineer, U. S. Geological Survey, Tacoma, Washington)--In the field of forecasting seasonal runoff from snow-survey data, joint studies of the Soil Conservation Service, Geological Survey, and Oregon State College have indicated the adaptability of antecedent base flow of the stream to the improvement of the relationship between water content of the snow and runoff [Nelson, McDonald, and Barton, Western Snow Conf., April, 1953].

Milton S. Sachs (Chief, Water Utilization Section, Bonneville Power Administration, Portland, Oregon)--In the interest of effective utilization of water for electric energy production, the Bonneville Power Administration has entered into a hydrologic cooperative research program with the University of Washington. A report by D. R. Makela, Short-Term Stream Flow Prediction from Snow Melt, Middle Fork Flathead River, has been submitted by the University of Washington. Copies may be received from the Bonneville Power Administration.

C. C. Warnick (Associate Research Professor, Engineering Experiment Station, University of Idaho, Moscow, Idaho)--Work during the past year involved testing precipitation gages of different diameters in the wind tunnel under artificial snowstorms, using sawdust that had terminal velocities the same as two different types of snow crystals. Additional development work was carried forward on the Shasta windshield for the Bureau of Reclamation's new radio-reporting rain and snow gage. Improved performance was obtained both with the wind tunnel gages and the experimental field gages.

The Forest and Wildlife Experiment Station at the University of Idaho is studying snow depth as it influences the availability of forage for deer and elk. A series of measurements of snow depth are being correlated with feeding habits of big game animals.

Walter T. Wilson (Acting Chief, Cooperative Studies Section, reporting for Max A. Kohler, U. S. Weather Bureau, Washington, D. C.)--Recent investigations by the Weather Bureau in its program of water-supply forecasting have disclosed instances where forecasts can be improved by including snow-pack water equivalent as one of the variables along with seasonal precipitation.

A recent study has indicated that much of the variation in seasonal precipitation catch and accumulated snow pack from station to station in rugged terrain is related to the amount of natural shelter at each site of observation, and that average wind speed is a good measure of the degree of shelter. A completed analysis of the midwest April, 1952, flood is to be published as Weather Bureau Technical Paper no. 23.

Lorne W. Gold (Snow and Ice Section, reporting for R. F. Legget, Director, Division of Building Research, National Research Council, Ottawa 2, Ontario, Canada)--A cold laboratory for this Section will be completed and in use by summer of 1954. A program of research on snow and ice, which we have looked forward to for some time, will then be initiated. The initial work on this program will place emphasis on the behavior of snow and ice under applied loads.

The Snow Survey of Canada, which began in 1947, has continued with at least ten observation stations each year. Technical Memorandum no. 21 describes the preliminary results of this project to 1950.

Morlan W. Nelson (Snow-Survey Leader for Columbia Basin, U. S. Soil Conservation Service, Boise, Idaho)--Two additional forecasting variables, which have proven reliable in forecasting

seasonal runoff from snow melt, have been incorporated into forecast procedures. A soil-priming variable has been used as an estimate of soil-moisture status over any particular watershed. Secondly, base flow of a river as measured near the first of November has also been used successfully as an indication of soil-moisture status on a watershed. Papers published on these procedures are: Soil Priming in Relation to Snow Surveys and Flood Regulation by Nelson, Wilm, and Work [Trans. Amer. Geophys. Union, v. 34, pp. 240-248, 1953]; Base Flow as the Parameter in Forecasting April through June Runoff by Nelson, McDonald, and Barton [Trans. Western Snow Conf., April, 1953]. Preliminary work has been completed on the use of a consumptive-use factor for increasing the accuracy of forecasts of flow from melting snow. This material has not been completed at this time.

David M. Rockwood (Technical Director, Snow Investigations, U. S. Corps of Engineers, Portland, Oregon)--In 1953-1954 the Snow Investigations Unit, Corps of Engineers, has concentrated on analysis of data collected during the operation of three snow laboratory basins (Central Sierra, Upper Columbia, and Willamette Basin). The Central Sierra Snow Laboratory remained in limited operation during the 1953-1954 snow season to obtain more data from two snow lysimeters together with related special observations during the melt season. The Snow Investigations Unit was transferred to North Pacific Division, Portland, in June, 1953, and has a staff of ten.

Heat transfer to the snow continued to be the principal subject of analysis. Two studies of radiation and heat exchanged in late-season snow patches in heavy forest were based on observations of short-wave and long-wave radiation and melt at Willamette Basin Snow Laboratory in July, 1952. Based on observations of a melting snow patch in dense forest during clear, calm weather, a melt formula is developed with heat components expressed in terms of air temperature, absolute humidity, and short-wave radiation. For the conditions described, about one-half the melt is due to long-wave radiation (Research Notes 11 and 12).

The thermal-balance approach was also used in two studies based on observations of melt at two snow lysimeters at Central Sierra Snow Laboratory. On the basis of a study of clear-weather snow melt, recommendations were made on the use of the thermal-budget method of estimating snow melt (Research Note 17). Estimates of melt made by thermal-balance and water-balance methods agreed closely with observed amounts of snow melt occurring during a heavy rain on a deep snow pack (Research Note 18). Using Willamette Basin Snow Laboratory data, regression equations were derived for rainless periods in April and May by correlation of daily volumes of snow-melt runoff with air temperature and vapor pressure (Research Note 19). A modified day-degree factor was used in computing melt in a water-balance method of forecasting runoff for a 400-sq mi Cascade drainage basin where meteorological data are scanty (Research Note 21). Ground melt of the bottom of the snow pack was studied, using data from deep-pit and snow-settling meter observations made by the Snow, Ice, and Permafrost Research Establishment at Central Sierra Snow Laboratory during the 1952-1953 snow season (Project CW-171, Tech. Bull. 16). The relation between upper-air flow and thermal balances and snow-melt runoff in the Western United States, May, 1949, and May, 1950, was investigated in an exploratory study. Results show how changes in the circulation of the upper air are reflected in snow-melt runoff (Research Note 15).

Two studies of precipitation distribution and estimated gage deficiency were nearing completion. In a study using yearly precipitation data at Willamette Basin Snow Laboratory, it is suggested that where gage deficiencies and poor areal sampling of the basin give an unsatisfactory basis for estimating mean basin precipitation, a more reliable value of mean basin precipitation may be computed as measured runoff plus estimated losses. The Thornthwaite formula was used to compute the evapotranspiration component of the losses (Research Note 20). Precipitation gage deficiencies were the subject of analysis for Central Sierra Snow Laboratory data. Here the network of paired precipitation gages and snow courses, the frequent snow surveys, and the infrequency of rain on snow permitted a direct comparison of precipitation-gage snowfall catch with accumulated water equivalent at the adjacent snow course (Research Note 22).

In an exploratory study, relations were examined between spring-season snow-melt runoff from the Columbia River at The Dalles and winter runoff for selected coastal streams. In another miscellaneous study, plans were made for a reliable and inexpensive electric analog for rapid computation using standard routing procedures. The report on the radioisotope-radio-telemetering snow gage (Project CW-170) is being completed by personnel of the Hydrology Section of South Pacific Division, Corps of Engineers.

During the past year, the unit issued seven research notes, two technical bulletins, and the hydrometeorological log for Central Sierra Snow Laboratory for 1951-1952. Five more research notes are scheduled for early publication, and a paper summarizing the results of the lysimeter studies was prepared for the Rome meeting of the International Union of Geodesy and Geophysics.

George W. Peak (Snow Survey Leader, U. S. Soil Conservation Service, Casper, Wyoming)--Some work has been done by this office with respect to the methods required to introduce temperatures into a multiple correlation for April 1 stream-flow forecasting.

The April 1 water content of the snow pack represents the algebraic sum of the values of all the climatological factors involved in this accumulation. Prior to the April 1 snow survey, evaporation and transpiration losses are not considered; however, the extent of snow melt in the late winter is highly significant. A correlation involving only April 1 water content, the extent of soil moisture at fall freeze-up, and the influence of spring precipitation produces errors of estimate which, when plotted against February and March temperatures, produce a positive regression curve, indicating temperatures to be proportional to the increase in soil moisture and therefore directly related to the yield from the measured values of the April 1 snow cover.

There is an interval, beginning with the April 1 snow survey and ending with the change from winter flow to the upward surge of the hydrograph, during which time the stream flow does not reflect snow melt. Part of the depletion in the snow cover is the transfer of storage in the snow to storage in the soil plus a very minor contribution to the dependent variable, April-September runoff. During this period, the extent of this 'loss' is the requirement of the remaining soil deficit and this amount is determined by two variables, namely, the soil-moisture index of the preceding fall and the degree of melt prior to the snow survey. There are also real losses from evaporation and transpiration. The regression line, in this second interval, is negative, indicating temperatures to be directly proportional to losses in the water content of the snow pack and, therefore, indirectly proportional to the amount of runoff.

The third temperature interval begins at the time of soil saturation and continues as long as the soil maintains storage capacity. The date at which the hydrograph reaches its peak indicates the end of this period. Temperatures during this interval form a positive regression line and are directly proportional to seasonal runoff. High temperatures indicate an earlier and heavier runoff with less loss from seepage, evaporation, and transpiration than that which occurs with comparatively low temperatures, which slow down the runoff and, therefore, increase the losses from seepage and evapotranspiration.

Although temperatures undoubtedly influence the entire runoff, the correlation between temperatures and runoff depreciates when carried beyond the peak of the hydrograph. The snow cover has been depleted and, with this depletion, the water content of the soil recedes; with this recession, all climatological factors that influence runoff are proportionately reduced in value.

U. S. Soil Conservation Service (R. A. W.),
Ross Building,
Portland 4, Oregon

(Manuscript received June 11, 1954, and, as revised, September 17, 1954; presented at the Thirty-Fifth Annual Meeting, Washington, D. C., May 3, 1954; open for formal discussion until July 1, 1955.)

June 2, 1954

Mr. Eric Hinton
Hydro-Electric Manager
Bowater's Newfoundland Pulp & Paper Mills, Ltd.
Deer Lake, Newfoundland

Dear Mr. Hinton:

Many thanks for sending me the copy of the Report of the Committee on Snow. It contains many interesting items.

Sincerely yours,

Vincent J. Schaefer
Director of Research
THE MUNITALP FOUNDATION, INC.

VJS/meb

REPORT of the COMMITTEE ON SNOW
1953—1954

R. A. Work, Chairman

Eric Hinton..... 1956	C. G. MacDonald..... 1954
Gordon J. H. Kidd 1956	Vincent J. Schaefer 1956

In order to provide a relatively wide review of activities, the Committee quotes from recent reports that it has received from many individuals or agencies active in studies of snow.

Montgomery Atwater, U. S. Forest Service, Salt Lake City, Utah:
We now have three avalanche research and observation stations;

Stevens Pass, Washington - Coastal alpine zone.
Alta, Utah - - - - - - - - - Middle alpine zone.
Berthoud Pass, Colorado- - High alpine zone.

These designations as to zone are purely arbitrary, for our own purposes and refer to predominating characteristics of snowfall, temperature, altitude, wind action, avalanche types.

The following avalanche study projects are being carried out:

1. Precipitation Intensity - combined with related factors such as wind action and snow type, has been developed as a guide to avalanche hazard, direct and delayed action.

2. Snowfall intensity - as a guide to avalanche hazard, direct action.

3. Snow settlement - as a guide to stabilization.

4. Wind action on snowfall and on snow transported from the surface - as a guide to slab avalanche hazard.

5. Time profiles - as a guide to metamorphosis of the snowpack.

6. Resistance profiles - as a guide to stability of the snowpack.

7. Avalanche occurrence timing - as a check on hazard forecasting.

8. Stabilization of the snowpack by use and by explosives - as a means of reducing or eliminating hazard.

9. Relationship of snowfall type and average density to upper air temperatures - as an aid to hazard forecasting.

10. Contributory avalanche factor studies, correlating old snow depth and surface, new snow depth, type and average density, wind action, precipitation intensity, snowfall intensity, temperature and settlement with avalanche occurrence - as a means of forecasting hazard.

11. Windbaffles and snow fences - as a means of modifying wind action in selected areas in order to reduce or control avalanche hazard.

M. E. Baudendistel, U. S. Forest Service, Portland, Oregon:
I will call your attention to Bullard's recent summary paper "A REVIEW of SOIL FREEZING as AFFECTED BY SNOW COVER, PLANT COVER, and SOIL CONDITIONS in NORTHWESTERN UNITED STATES"; also to Dr. Colman's recent book "VEGETATION and WATERSHED MANAGEMENT" which has some references and discussion on snow.

You are familiar with the three stream gages we have installed on the H. J. Andrews Experimental Forest. These are still in the watershed calibration stage. Eventually two of the watersheds will be logged, in whole or in part, and studies made on the effects. In that area a substantial part of the runoff comes from melted snow.

George W. Craddock, Chief, Division Watershed Research, U. S. Forest Service, Ogden, Utah:
The only direct work in snow being done currently by this Station is a continuation of snow records on several snow courses at the Great Basin and the Wasatch Research Centers in Utah. These records are regularly reported to the SCS at Salt Lake City, Utah.

We have not made any specific snow studies for the past few years. We are, however, very much interested in what appears to be a snow influence on streamflow at some of our experimental watersheds. Analysis of the runoff records from various pairs of adjoining watersheds reveal some variations which cannot logically be attributed to differences in the amount of snow that falls on the catchment areas. We suspect instead that the variations in streamflow are due to differential blowing of snow out of and into the watersheds. Strong winds are common over these areas during the winter months. It has been observed however, that wind erosion channels in the snow mantle on wind swept slopes and snowdrifts on leeward slopes have been more pronounced in some years than in others. These snow blowing effects conceivably could account for much of the variations we have noted in the comparative runoff behavior of paired watersheds. We plan to make a further study of snow blowing on our experimental watersheds and may have more to report to you on this problem in another year.

R. W. Gerdel, SIPRE, Wilmette, Illinois:
We have been studying the settling and deformation of snow profiles with a unique slide wire device, originally developed in Switzerland. It is giving us some interesting information on the self compaction, melting and possible upward sublimation of snow layers without disturbing the snow. This device may solve the problem of snow melt and soil priming during the winter. Effectively we have one leg of a wheatstone bridge permanently installed in the snow and read the change in thickness of a layer as a change in resistance of the wire.

Norman S. Hall, Assistant Snow Survey Leader, Soil Conservation Service, Reno, Nevada:
Additional courses were surveyed for the first time on both February 1st and March 1st. For the February 1 survey we took 35 courses this year while in previous years, on the same date, 29 surveys were made. March 1, 1954, surveys made numbered 92 while there were 85 measured on that date in previous years. On April 1 we took our usual courses.

At the request of a local irrigation district, we are instituting May 1 surveys on the Walker River Watershed, sampling two courses.

This year, at the request of Nevada Fish and Wildlife Commission, a runoff forecast has been made on the Little Truckee River near Boca.

Austin E. Helmers, Forester, U. S. Forest Service, Spokane, Washington:
Our snow studies at Priest River were terminated in May-1952. No new field work has been started since then. I believe a brief description of the field setup was submitted to the AGU some years ago.

Certain of the data were analyzed for purposes of the USDA flood control survey of the Columbia River. These remain unpublished. We recently started working up the data in hopes of reporting the results of the past studies.

Eric Hinton, Hydro-electric Manager, Bowater's Newfoundland Pulp and Paper Mills, Ltd., Deer Lake, Newfoundland:
We have not been able to conduct any research work during the past year but we made our annual Snow Survey, as usual, in March. Owing to unseasonably mild weather some of the snow melted and produced abnormally high runoff during the first week of March.

The snow blanket was measured to be only 59.4% of the average of the previous 28 years. The resultant flood forecast indicates that water storage reserves, while not abundant, will be adequate.

W. A. Lang, Chief Hydrographer, (reported for A. C. Warden, Jr., Superintendent of Hydro Generation) Southern California Edison Company, Los Angeles, California:
GENERAL: The Southern California Edison Company, along with many other

agencies in California, is cooperating with the State Division of Water Resources in obtaining pertinent data on snowpack conditions. Each agency either does its own work in its own area or contributes funds to the State to have said work done, with the State collecting data not provided for by private cooperators. All data, private and public, is coordinated, published, and released by the State Division of Water Resources in their bulletins on Water Conditions in California issued monthly February through May.

SNOW SURVEYS: Edison Company hydrographers take snow surveys at 13 courses and we use the data from 28 snow courses in connection with our runoff forecasting program. These courses range from 6,650 to 11,450 feet in elevation, and are located in the San Joaquin River Basin on the west slope of the Sierra Nevada mountains.

SNOW STAKES: In addition to our snow course ground surveys we have installed 12 snow stakes that are photographed from the air. This program consists of oblique pictures of the area and closeup views of the stakes taken at monthly intervals from December to July each year. Some of the stakes are located on snow courses and some are located at remote areas not surveyed by ground crews. In addition, we make use of data from eight additional stakes in the San Joaquin River Basin.

John W. Marr, Director, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado:
The Institute is currently studying a variety of environment factors in the different vegetation zones on the East Slope of the Front Range. This is part of our long-range study of the ecology of the area. Our observations on snow consist of weekly determinations of depth, in areas with a minimum of drifting, and determinations of water content in the same sites each month. Since we are also measuring total precipitation and soil moisture, it will be possible for us to determine "all" aspects of environment water each month. (We don't take evaporation readings and that is one thing we want to add as soon as possible.)

We are also collecting information on the inter-relations between plant species and plant communities and snow accumulation. Specifically we have observations on the effect of snow accumulation on the reforestation of deforested areas in the Subalpine Forest and on the distribution of types of tundra plant communities in the Alpine tundra. The results are being used to interpret vegetation features in the Subarctic Forest-Arctic Tundra Transition Area in Quebec (or Ungava). We are also attempting to work out the particular role that snow accumulation plays in altering the environment on different exposures in the Montane Forest.

C. C. McDonald, Staff Engineer, U. S. Geological Survey, Tacoma, Washington:
In the field of forecasting seasonal runoff from snow survey data, joint studies of the Soil Conservation Service, Geological Survey, and Oregon State College have indicated the adaptability of antecedent base flow of the stream to the improvement of the relationship between water content of the snow and runoff. (Nelson, McDonald, and Barton, Western Snow Conference, April-1953.)

George W. Peak, Snow Survey Leader, Soil Conservation Service, Casper, Wyoming:
Some research has been done by this office with respect to the methods required to integrate snowmelt into a multiple correlation for April 1, forecasting purposes.

The April 1, water content of the snow pack represents the algebraic sum of the values of all the climatological factors involved in this accumulation. Of the major temperature factors contributing to loss, evaporation and transpiration, prior to April 1, need not be considered, however, the amount of snowmelt that has occurred is highly significant. When plotted against errors of estimate, temperatures, prior to the survey, form a positive regression line, indicating temperatures to be directly proportional to the amount of soil recharge, and therefore directly proportional to the yield from the measured values of the snow cover.

There is an interval, beginning with the April 1, snow survey and ending with the change from winter flow to the upward surge of thehydrograph, during which time the streamflow does not reflect snowmelt. This "loss" in the snow cover is the transfer of storage in the snow to storage in the soil plus a very minor contribution to the dependable variable, April-September runoff. During this period, the extent of this "loss" is the requirement of the remaining soil deficit and this amount is determined by two variables...the fall soil moisture index, and the degree of melt prior to the snow survey.

Losses from evaporation and transpiration are now significant. The regression line, in this second interval, is negative, indicating temperatures to be directly proportional to the loss in the April 1 water content and, therefore, indirectly proportional to the amount of runoff.

The end of the negative regression period occurs when soil storage reaches its capacity and additional melt becomes direct runoff.

The third interval, involving temperatures, begins with soil saturation and continues as long as the soil maintains storage capacity. The peak of the hydrograph will approximate the end of this period. Temperatures form a positive regression line and are directly proportional to seasonal runoff. High temperatures now indicate an earlier and heavier runoff with less loss from seepage, evaporation and transpiration, than that which occurs with comparatively low temperatures, which slow down the runoff and, therefore, increase the losses from seepage and evapotranspiration.

Although temperatures undoubtedly influence the entire runoff, the correlation between temperatures and runoff depreciates, when carried beyond the peak of the hydrograph. The snow cover has been depleted and with this depletion, the water content of the soil recedes, and with this recession all climatological factors, including precipitation, are proportionately reduced in value.

Gregory L. Pearson, Hydraulic Engineer, Soil Conservation Service, Salt Lake City, Utah:
Research activities of the past year have largely been directed toward evaluating the influence of the snow cover at high, intermediate and low elevations on the total volume and seasonal distribution of runoff. Water content of the snowpack at low and intermediate elevations has been shown to have much more influence than has previously been realized. Coleman fiber glass units for measuring soil moisture are being installed on or near snow courses in selected areas. Rain gauges are also being located at snow course sites to measure fall and spring precipitation for refining the runoff forecasts based on the April 1 water content of the snowpack.

Milton S. Sachs, Chief, Water Utilization Section, Bonneville Power Administration, Portland, Oregon:
The Bonneville Power Administration in the interest of effective utilization of water for the production of electric energy at the various Federal power plants has entered into a hydrologic cooperative research program with the University of Washington. One of the problems investigated under this program is the development of procedures for forecasting increased flow from snowmelt for periods of five to ten days. As a result of this investigation, the University of Washington submitted a report to us entitled "SHORT-TERM STREAMFLOW PREDICTION FROM SNOWMELT - MIDDLE FORK FLATHEAD RIVER" by Donald R. Makela. Mr. Makela is a graduate research student at the University. The Bonneville Power Administration has also utilized snow data in the development of procedure for forecasting the seasonal volume inflow to Hungry Horse Reservoir on the South Fork Flathead River in Montana.

C. C. Warnick, Associate Research Professor, Engineering Experiment Station, University of Idaho, Moscow, Idaho:
SNOW MEASUREMENT STUDIES - The Engineering Experiment Station at the University of Idaho has continued a study of shielding precipitation gauges to obtain a more consistent catch of snow that falls when winds are blowing. Work the past year involved testing gauges of different diameter in the wind tunnel under artificial snowstorms using sawdust that had terminal velocities the same as two different types of snow crystals. Additional development work was done on the Shasta windshield for the Bureau of Reclamation's new radio-reporting rain and snow gauge. Improved performance was obtained both in the wind tunnel and at experimental field gauges. The tests on snow gauges at Mullan Pass, Idaho, have continued. Record snowfall at this station was measured.

The Forest and Wildlife Experiment Station at the University is also studying snow and snow depth as it influences the availability of forage for deer and elk. A series of measurements of snow depth are being correlated with feeding habits of big game animals.

J. A. West, Chief Hydrographer, Salt River Valley Water Users' Association, Phoenix, Arizona:
After completion of Roosevelt Dam in 1910, the question in the minds of the people was directed toward weather conditions, snow cover, and spring runoff, which would provide storage in the new reservoir for the current season and a carry-over for future prosperity.

Because of the inaccessibility of our mountainous watershed in the winter months, we were never able to provide that information and service until the advent of the over-snow vehicle in recent years.

In cooperation with the Soil Conservation Service in the field of snow surveying, a bi-monthly service of forecasting runoff to our reservoir system on both the Salt and Verde Rivers is now being provided.

Other activities on the watershed as an outgrowth of the results from the field of snow surveys and runoff, are research in the field of Forest and Range management to produce a greater water yield from the snow pack. Reduce the loss in soil-stored moisture and soil erosion by the eradication of noxious water-wasting plants. Prescribed burning in the Virgin Ponderosa Pine to reduce the fire hazzard, increase forage for livestock, reduce competition for limited soil moisture which will improve timber quality, open up the canopy which will well reduce sublimation losses in the snow pack, improve the soil-stored moisture, and again increase water yield for the State's greatest economy, agriculture.

Walter T. Wilson, Acting Chief, Cooperative Studies Section, (reporting for Max A. Kohler) U. S. Weather Bureau, Washington, D.C.:
The Weather Bureau has continued its development work in the field of water-supply forecasting. Recent investigations have disclosed some instances where forecasts can be improved by including snow pack water equivalent as one of the variables along with weighted seasonal precipitation. A recent study has indicated that much of the variation in seasonal precipitation catch and accumulated snow pack from station to station in rugged terrain is related to the amount of natural shelter at each site of observation, and that average wind speed is a good measure of the degree of shelter. A recently completed analysis of the midwest April-1952 flood is to be published as Technical Paper No. 23.

Lorne W. Gold, Snow and Ice Section, (reporting for Dr. R. F. Legget, Director, Division of Building Research) National Research Council, Ottawa (2) Ontario, Canada:
A cold laboratory for this Section will be completed and ready for use this spring. A programme of research on snow and ice, which we have looked forward to for some time will then be initiated. The initial work on this programme will place emphasis on the behaviour of snow and ice under applied loads.

The one project which this Section has conducted during the last six years and which is most directly related to your inquiry is that of the Snow Survey of Canada. Technical Memorandum No. 21, The Canadian Snow Survey 1947 - 50, describes the preliminary results of this project to 1950. Since that time, the project has been continued with at least ten observation stations every year. The initial stations used in this survey were at exposed areas such as Aklavik, N.W.T.; Churchill, Manitoba; Edmonton, Alberta; Malton, Ontario; Winnipeg, Manitoba, etc. In Technical Memorandum No. 21 we expressed our view that observations should be made at more sheltered areas. Since 1950 we have adopted this policy. Unfortunately, we have been limited in the number of snow kits available for these observations and this has kept us from expanding this project to the degree necessary for a complete coverage of our country.

Last winter's observations were made at the following stations:

Aklavik, N.W.T.
Gander, Newfoundland
Ottawa, Ontario
Resolute Bay, N.W.T.

These were considered as exposed areas and have been in the survey since its inception in 1947.

University of New Brunswick -
Fredericton, N.B.
Forestville, Quebec
Maniwaki, Quebec
Glacier, B.C.
Gogama, Ontario, and
Shawbridge, Quebec.

These are considered as sheltered areas.

At present our staff is not large enough to process the results of this survey to the degree that they deserve. We look forward to doing this in the not too distant future.

Morlan W. Nelson, Snow Survey Leader for Columbia Basin, Soil Conservation Service, Boise, Idaho:
In the past two years we have isolated two new forecasting variables which have proven reliable in forecasting seasonal runoff from snow melt streams. The first one isolated was termed the soil priming factor which led to the discovery of a second independent variable known as the base flow of a river as measured near the first of November. Both factors are used as corrective factors with the maximum snow pack as the most important independent variable. The two new factors are believed to give a quantitative estimate of the soil moisture status over any particular watershed.

Two papers have been completed on this. One is entitled, "Soil Priming in Relation to Snow Surveys and Flood Regulation," by Marlan W. Nelson, H. G. Wilm, and R. A. Work. The other is entitled, "Base Flow as the Parameter in Forecasting the April through June Runoff," by M. W. Nelson, C. C. McDonald and M. Barton. A second paper on this same subject was written this year entitled, "Effect of Antecedent Base Flow in Forecasting Runoff of the Columbia River from Snow Survey Data," by C. C. McDonald and M. W. Nelson.

Other research has been completed concerning the use of fiberglas electrodes to give a measure of soil moisture status. These electrodes have proven highly efficient in determining the soil moisture status, but a period of record has not yet been established. Preliminary work has been completed on the use of a consumptive use factor for increasing the accuracy of forecasts of flows from melting snow. This material has not been completed at this time.

B. S. Barnes, 7920 West Ninth Avenue, Denver (15) Colorado:
Another development of the past two years has been the "hydrothermogram" method of determining daily discharge from snow melt. In this procedure the daily discharge of direct runoff and of ground water are determined independently, each with its own time lag, from the daily maximum temperatures at an index station. Since the amount of overland flow from snow melt is virtually nil, all direct runoff can be treated as interflow and its normal depletion accomplished by the daily application of a constant factor. Ground water flow is depleted in the same way, with its own factor.

In the preliminary hydrothermograms, used to develop the relation curves for base temperature and discharge factor, net temperatures are treated as quantities of water and the discharge is expressed in degrees. The final hydrothermogram expresses discharge in cfs. Net temperature is obtained by subtracting a base temperature from the daily maximum temperature at the index station. The base temperature is constant in the preliminary hydrothermogram, but in the final type it is a variable function of the accumulated percent of total seasonal runoff.

The net temperature represents the mean discharge of the first 24 hours' runoff produced by the day's snowmelt. In the final hydrothermogram it is converted into cfs by a discharge factor, which is a variable function of the accumulated per cent of total seasonal runoff. The discharge increment is added to the residual flow from previous melting and the total represents that day's discharge. The latter is then multiplied by the constant depletion factor to obtain the next day's residual flow. To demonstrate the final hydrothermogram in its simplest form, fragments of a computation of the direct runoff of Willow Creek near Park View, New Mexico, are presented in the accompanying table. (Table attached at end of this report.)

In the table, Column (5) is the difference of (3) and (4), and (7) is the product of (5) and (6). Column (9) is the sum of (7) and (8), and Column (8) is the product of the previous day's discharge of Column (9) and the depletion factor (9.666) of direct runoff in Willow Creek Basin. In practice, Column (8) can be omitted.

All melt previous to March 1 has been disregarded in this computation, as the resulting error would become negligible by the end of March. If an accurate reproduction of the March hydrograph had been desired, the computation would have been started in February and the discharge factors would have been expressed to tenths instead of units. The first few weeks of melt runoff, however, are usually hard to reproduce because of the non-uniform distribution of fresh snow at the lowest elevations.

Techniques have been developed that greatly simplify the derivation and adjustment of the relation curves for base temperature and discharge factor. There is also a simple method for combining a series of daily increments and determining their joint effect on any future date. We are using the latter method in some of our studies, in preference to the one shown in the example.

David M. Rockwood, Technical Director, Snow Investigations, North Pacific Division, Corps of Engineers, Portland, Oregon

Summary of activities 1953-54 Snow Investigations Unit of Corps of Engineers. In 1953-54 the Snow Investigations Unit, Corps of Engineers, has concentrated on analysis of the data collected during the operation of three snow laboratory basins (Central Sierra Snow Laboratory, Upper Columbia Snow Laboratory, Willamette Basin Snow Laboratory). The Central Sierra Snow Laboratory remained in limited operation during the 1953-54 snow season to obtain additional data from two snowmelt lysimeters with related special observations made during the melt season. The Snow Investigations Unit was transferred to North Pacific Division, Portland, in June 1953 and is now staffed by ten persons.

Heat transfer to the snow continued to be the principal subject of analysis. Two studies of radiation and heat exchange in late season snow patches in heavy forest were based on observations of short-wave and long-wave radiation and melt at Willamette Basin Snow Laboratory in July 1952. In a study based on observations of a continuously melting snow patch in dense forest during five days of clear, calm weather, a melt formula is developed in which the heat components are expressed in terms of air temperature, absolute humidity, and short-wave solar radiation. For the conditions described, about one-half the melt near the snow surface is due to long-wave radiation, one-fifth to convective-conductive transfer of heat from the air, one-seventh to latent heat of condensation, and the remainder to short-wave solar radiation.

The thermal-balance approach was also used in two studies based on observations of melt at the two snow lysimeters, both at unforested sites, at Central Sierra Snow Laboratory. In a study of clear weather snowmelt at the meadow lysimeter, thermal-budget estimates of snowmelt were shown to be decidedly more accurate than estimates made by any of

a variety of temperature indexes. Recommendations were made on use of this method where meteorological data are not satisfactory. Observations of a heavy rain on a deep snowpack on 8-9 January 1953 were the basis of a second lysimeter study. Melt computed by thermal-budget method and by water-balance method agreed closely with observed data. The outflow hydrograph was satisfactorily reproduced by two routing methods.

Heat transfer in terms of a modified day-degree factor was used in computing melt in a water balance method of forecasting runoff for a 400 square-mile Cascade drainage basin where meteorological data are very scanty.

Using Willamette Basin Snow Laboratory data linear regression equations were derived for rainfree periods in the months of April and May by correlation of daily volumes of snowmelt runoff with air temperature and vapor-pressure data from a single station. Estimates of snowmelt runoff based on temperature and humidity are shown to be approximately 15 per cent better than estimates based only on temperature index.

Using data from the deep pit and snow-settling meter observations by Snow, Ice, and Permafrost Research Establishment at Central Sierra Snow Laboratory in the 1952-1953 snow season, a study was made of the bottom two layers of the snow pack from the standpoint of the amount of ground-melt of the bottom of the pack.

Snow cover was the second principal subject of emphasis. A report was made of the experience in estimating snow cover in the Kootenai and Flathead Basins by aerial reconnaissance. An intensive study was made of the relation between snow-cover depletion and runoff, primarily at Central Sierra and Upper Columbia Snow Laboratories. Relations analyzed included topography and sequence of melting, extent of snow cover and pack depth, per cent of snow cover and amount of seasonal runoff remaining. Appendixes include evaluations of various methods of estimating extent of snow cover from ground surveys alone, a discussion of the influence of topography on snow cover and on depletion, and a detailed discussion of melt contributions by different topographic units for Central Sierra Snow Laboratory, 1947. Recommendations for snow-cover aerial reconnaissance flights emphasize the many benefits to be derived from reliable snow cover data.

Distribution of snow in a basin is also studied in a statistical analysis continuing the study begun in an earlier research note of the influence of topographic characteristics (elevation, slope, aspect, vertical curvature, exposure, and vegetation) on the distribution of accumulated water equivalent in a small mountain watershed.

The relation between upper-air flow and thermal balances and snowmelt runoff in the Western United States, May 1949 and May 1950, was investigated in an exploratory study. Items studied were location of strong westerly flow on the 500-millibar surface over the Western United States, concurrent values of constituents of the thermal balance over the snowpack in three headwater basins, and resulting snowmelt runoff from these basins. Results show how changes in the circulation of the upper air cause changes in heat supplied to the earth's surface and

in the components of the energy balance of the snowpack, and how these changes in the heat economy are then reflected in snowmelt runoff.

Two studies of precipitation distribution and estimated gauge deficiency were nearing completion. In a study of the distribution of annual precipitation, at Willamette Basin Snow Laboratory, it is suggested that where gauge deficiencies and poor areal sampling of the basin give unsatisfactory basis for estimating mean basin precipitation, a more reliable value of mean basin precipitation may be computed as measured runoff plus estimated losses using the Thornthwaite formula proves good approximations of measured evapotranspiration amounts and requires as basic data only mean monthly air temperatures, monthly precipitation, and latitude of the station. Precipitation gauge deficiencies were the subject of analysis for Central Sierra Snow Laboratory data. Here the network of paired precipitation gauges and snow courses, the frequent snow surveys, and the infrequency of rain on snow permitted a comparison of precipitation gauge snowfall catch with accumulated water equivalent at the adjacent snow course. On this basis gauge deficiencies vary from zero (in small clearings) to fifty per cent (windy location).

In an exploratory study, relations were examined between spring season snowmelt runoff from the Columbia River at The Dalles and winter runoff for selected coastal streams. Since winter precipitation in the Columbia Basin occurs during periods of strong westerly atmospheric flow, winter runoff from coastal streams, fed almost entirely by rainfall alone, is considered to be an index to the winter's precipitation in the Columbia Basin, and thus an index to the spring snowmelt volume. In another miscellaneous study, plans were made for a reliable and inexpensive electric analog for rapid computation using standard routing procedures.

The report on the development, use, and recommendations of the radioisotope-radiotelemetering snow gauge (Civil Works Project 170) is being completed by personnel of the Hydrology Section of South Pacific Division, Corps of Engineers. During the past year the unit issued seven research notes, one technical bulletin and hydrometeorological log for Central Sierra Snow Laboratory 1951-1952. Five more research notes are scheduled for early publication, and a paper summarizing the results of the lysimeter studies was prepared for the Rome meeting of the International Union of Geodesey and Geophysics.

* * *

(References: See Page 9 - Last Paragraph)

SAMPLE HYDROTHERMOGRAM COMPUTATIONS

Date	Accumulative percent of March-June runoff	Maximum temperature at Chama, °F	Base temperature for direct runoff °F	Net temperature °F	Discharge factor for direct runoff	Discharge increment cfs	Residual discharge, cfs (factors, 0.666)	Total direct discharge, cfs
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
March								
1	0	43	34	9	1	9	0	9
2	0	40	34	6	1	6	6.0	12
3	0.1	46	34	12	1	12	8.0	20
4	0.1	44	34	10	1	10	13.3	23
April								
13	36.0	63	43	20	47	940	1,060	2,000
14	39.1	66	43	23	46	1,060	1,330	2,390
15	42.9	64	44	20	45	900	1,590	2,490
16	46.8	63	44	19	43	817	1,660	2,480

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U. S. Soil Conservation Service
Snow Surveys Section
Colorado Experiment Station
Fort Collins, Colorado

Postal Card mailed 3-5-58

to receive the Snow Survey and Water Supply Forecast Bulletins for Colorado, Platte, Arkansas, and Rio Grande Drainage Basins.

(signed) Vincent J. Schaefer
March 3, 1958

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Water Resources Division
Surface Water Branch

October 20, 1954

Post Office Box 948
Albany 1, New York

File

Mr. Vincent J. Schaefer
R. D. #3, Schermerhorn Road
Schenectady, New York

Dear Vince Schaefer:

The Executive Committee of the Eastern Snow Conference met in Albany on October 15 and accomplished some business despite the winds and the hurricane threat. The members of the committee are pleased that you may be able to participate in the 1955 meeting. You will be placed on the agenda with the understanding that you are subject to call elsewhere.

As I recall, your subject is "Studies of High Clouds". Please let me know at your convenience how you wish to be identified on the program, by title and business connection.

The meeting will be held on October 10, 11, 1955 at Burlington, Vermont in the Hotel Vermont. You will receive an advance copy of the agenda but please feel free to contact me about any phase of the meeting that may need clarification.

With best regards,

Dean B. Bogart

Dean B. Bogart
Secretary
Eastern Snow Conference

DBB/dal
CC: Charles E. Knox, Boston, Massachusetts
H. M. Finlayson, Montreal, Canada

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Water Resources Division
Surface Water Branch

September 29, 1954

Post Office Box 948
Albany 1, New York

Mr. Vincent J. Schaefer
R. D. # 3, Schermerhorn Road
Schenectady, New York

Dear Vince Schaefer:

The summer has rolled by and once again the assembling of an agenda for the Eastern Snow Conference is under way. The meeting likely will be held at Burlington, Vermont, in the second week in February 1955 and we all hope that you will be able to attend.

Since we missed connections with you last year, we are wondering if you will have a paper available for the next meeting. I am sure that everyone concerned would like to have you on the program for we know that your papers always are well received. As vice-president of the Eastern Snow Conference, Charlie Knox, U.S.G.S., Boston, is program chairman and hopes to get the agenda roughed out within the next two weeks. Please let me know at your earliest convenience about your possible participation--perhaps you could phone me about it if that would save you time. I usually am at Albany 6-7611, extension 39, during business hours.

We consider you one of the "stalwarts" of the organization and I am wondering with your new set-up if you will be able to take a more active role. Although the Eastern Snow Conference seems to be operating at a satisfactory level, an increased interest on your part surely would give it a high degree of impetus.

Hope you will be with us this year and I look forward to hearing from you.

With best regards,

Dean

Dean B. Bogart
Secretary, Eastern Snow Conference

DBB/dal

Mill Creek Canyon
Snow Water Supply Forecast
Bulletin for Utah