Fisheries and Environment Canada
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Canadian Glaciers in the International Hydrological Decade Program, 1965-1974

No. 3. Ram River Glacier, Alberta – Summary of measurements

G. J. Young and A. D. Stanley

SCIENTIFIC SERIES NO. 70
(Résumé en français)

INLAND WATERS DIRECTORATE,
WATER RESOURCES BRANCH,
OTTAWA, CANADA, 1976.

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Abstract

A summary is given of work performed within the glacier basin during the International Hydrological Decade, 1965-74. The data collected fall into three categories—glaciological, meteorological and hydrological. The glaciological work is primarily concerned with glacier mass balance. The measurements of accumulation and ablation are described and annual summaries are given in the form of maps and tables. The collection of meteorological data near the glacier and the gathering of stream discharge data immediately below the glacier is described and illustrated in graphical form.

Résumé

Le présent rapport traite des travaux effectués dans la région du bassin glaciaire durant la Décennie hydrologique internationale, 1965 à 1974. Les données recueillies se divisent en trois grandes catégories: les données glaciologiques, météorologiques et hydrologiques. Les travaux en glaciologie avaient trait principalement au bilan de masse. Le rapport décrit les mesures de l'accumulation et de l'ablation et donne, à l'aide de cartes et de tableaux, les conditions pour les diverses années. De plus, il fournit une description et une représentation graphique des données météorologiques recueillies dans la région immédiate du glacier et des données relatives au débit d'eau sous le glacier.

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INTRODUCTION

The need for glaciological research on a global scale was emphasized by the General Assembly of the International Association of Scientific Hydrology (IASH) held in Helsinki in 1960 (IUGG/IASH, 1961). At that meeting more comprehensive work on glaciers was recommended to the Commission of Snow and Ice. The program subsequently prepared by the Subcommittee on Variation of Existing Glaciers was a major step forward in international glaciological research and was accepted by the Commission of Snow and Ice at the Symposium of Obergurgl in 1962 (IUGG/IASH, 1962). This led the 1964 General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO) to implement the world-wide International Hydrological Decade (IHD) program on glaciers in Resolution I-13 UNESCO/NS/198.

Canada participated in glaciological research and part of its commitment to IHD was the survey of a chain of five glacier basins for the study of mass and water balance. This chain represents a transect across the southern part of the Canadian Cordillera and forms part of the IHD network of glacier basins which extends through Europe and Asia in a west-east direction and extends from Alaska to South America in a north-south direction.

The five glacier basins in southwestern Canada selected for a long-term detailed study of mass and water balance were Sentinel, Place, Woolsey, Peyto and Ram River (Fig. 1). The rationale for the choice of glaciers and the types of measurements involved have been described by Østrem (1966), Østrem and Stanley (1969) and Stanley (1970). Responsibility for carrying out these studies was given to the Glaciology Section of the Geographical Branch, Department of Mines and Technical Surveys, which is now the Glaciology Division, Water Resources Branch, Inland Waters Directorate, Department of Fisheries and the Environment. This report deals with the data collected at Ram River Glacier during the International Hydrological Decade, 1965-74.

Ram River Glacier is the most easterly of the five study basins, lying in the extreme eastern ranges of the Rocky Mountains of Alberta. Its location is shown in Figure 1.

GENERAL FEATURES OF RAM RIVER GLACIER

Location	lat. 51°51′ N, long. 116°12′ W
Glacier area	1.89 km^2
Maximum elevation	3020 m a.s.l.
Minimum elevation	2560 m a.s.l.
Mean elevation	2750 m a.s.l.
Mean surface slope	13.5°
Mean azimuth of surface	10°
Mean specific winter balance, 1966-74	0.91 m (water equivalent) (standard deviation, 0.14 m)
Mean specific net annual balance, 1966-74	0.40 m (standard deviation, 0.66 m)
Mean equilibrium line altitude, 1966-74	2800 m a.s.l. (standard deviation 92 m)
Accumulation area ratio	0.30
Area above stream gauge	3.15 km^2

As a result of its continental situation, high elevation, smooth surface, small size and compact shape, Ram River Glacier is the least dynamic of the five glaciers in the Western Cordilleran study group. There are few major undulations in its surface and as a result it is almost entirely free of crevasses.

Ram Glacier lies in a cirque surrounded by rugged mountains composed primarily of dolomites which have been eroded into high, steep cliffs.

This glacier is one of the least accessible of the five IHD study basins in southern Alberta and British Columbia. The shortest walk in from the road covers a distance of some 45 km. The round trip helicopter time from Banff is about one hour.

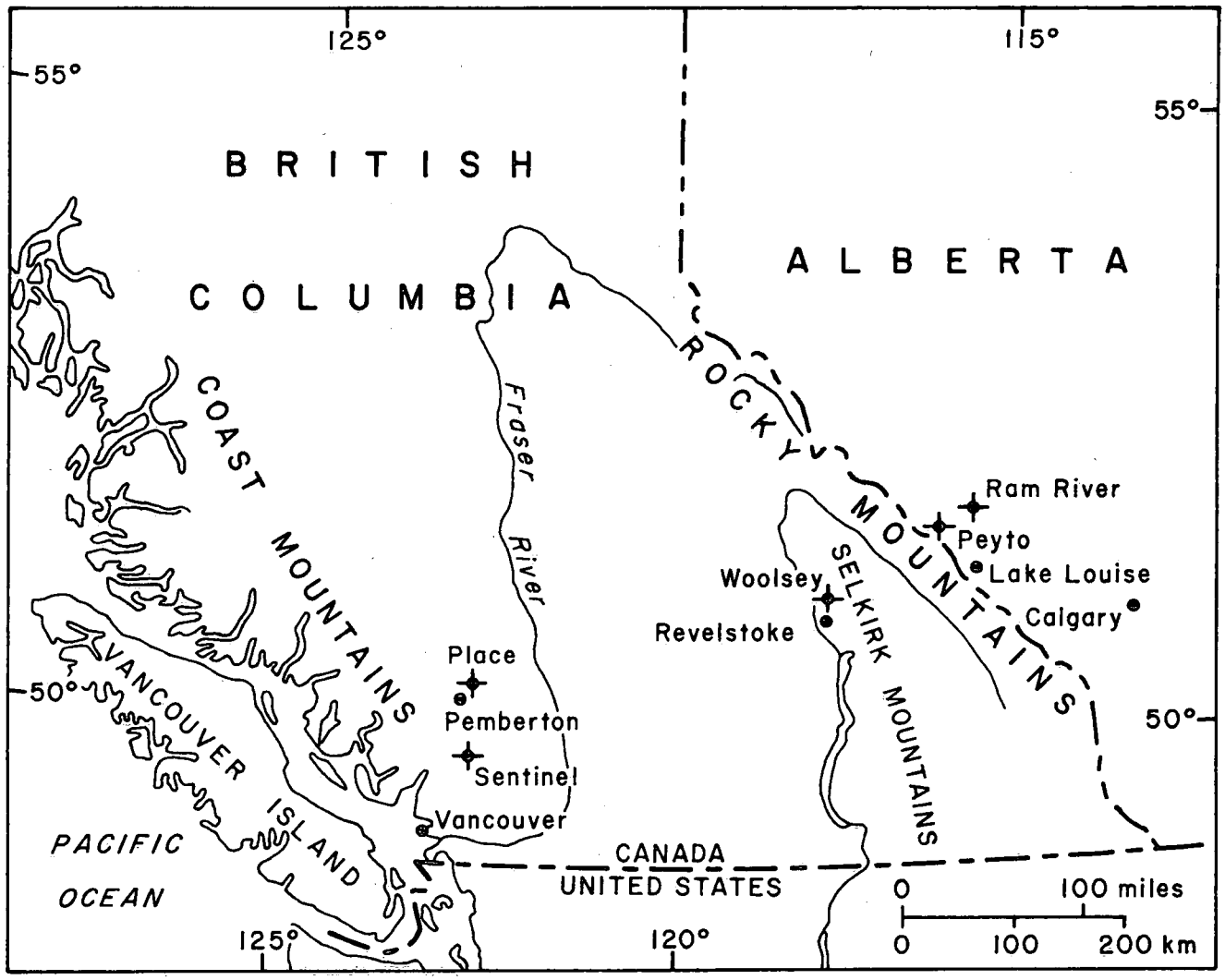

Figure 1. Glacier locations.

THE MEASUREMENT PROGRAM

During 1966-68 a field party was resident on Ram River Glacier throughout the summer months. For the rest of the Decade, visits to the glacier were made approximately once every month. As a result, the records for Ram River Glacier are not nearly so complete as those on nearby Peyto Glacier. All measurements were made, as far as possible, according to the recommendations detailed in Østrem and Stanley (1969).

Glaciological Measurements

In the years 1966-68 snow accumulation and ablation on the glacier were measured at stake locations approximately every 10 days; from 1969 to 1974 snow measurements were made approximately once a month. Stake locations are shown in Figure 2. Snow density measurements were made 3 or 4 times during the ablation season in order to convert snow depths into water equivalent (w.e.) values.

As a result of the relatively low winter accumulations, the slow changes in pack characteristics through the summer and the smooth and simple surface of the glacier, accuracy of estimation of water equivalent values is probably highest of all the basins in the Western Cordilleran study group. Snow water equivalent values are probably measured to within 3 cm on all parts of the glacier at all times of the year. Accuracies are considerably higher than this in the early summer and in the ablation area of the glacier. There are only small sections of the glacier which are difficult of access and thus the

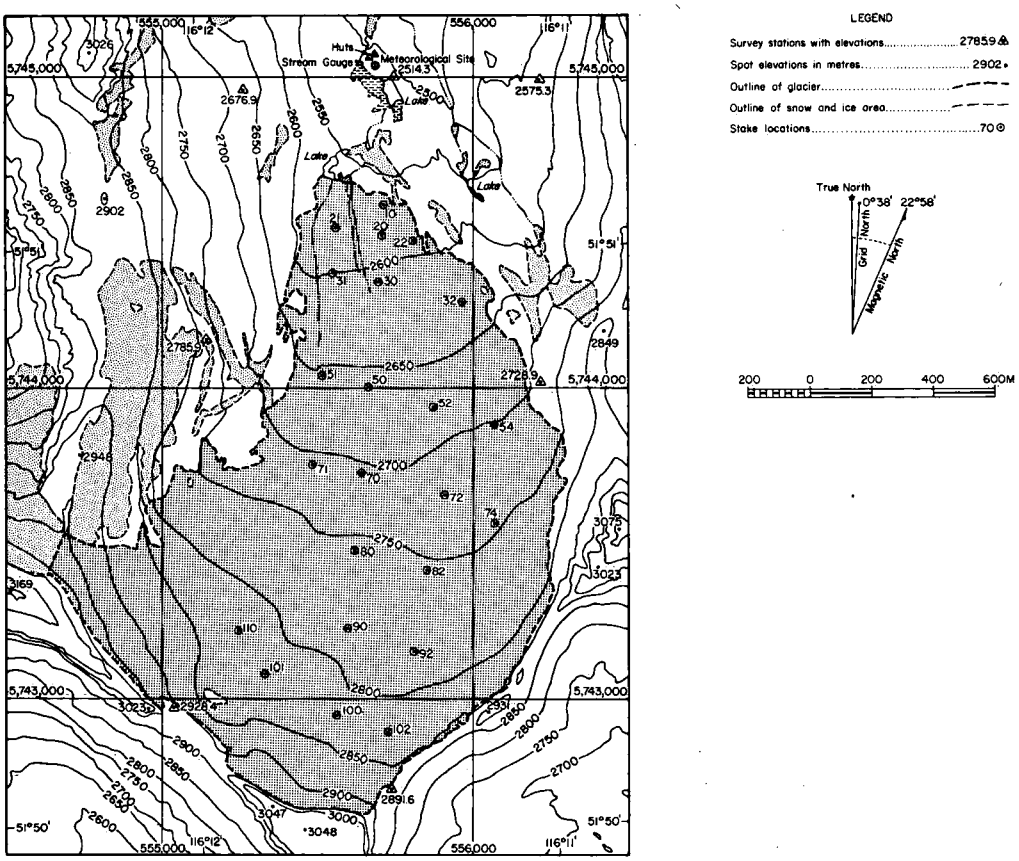

Figure 2. Stake locations.

problem of extrapolating water equivalent values for unvisited parts of the glacier is not nearly so great here as, for example, on Peyto Glacier.

Calculation of Mass Balance Quantities

Maps, graphs and tables summarizing net winter accumulations and net annual balances have been calculated by an algorithm described by Young (1976). The algorithm determines relationships between terrain shape and mass balance quantities at stake locations, then uses these relationships to estimate quantities in unvisited parts of the glacier.

Results obtained by this method are only slightly different from results obtained by the "conventional" methods of computation described by Østrem and Stanley (1969). The two methods are considered to be approximately equal in accuracy. The main advantage of the new algorithm is its speed of execution, which was the prime reason for its use in these studies.

Meteorological Measurements

An instrument station has been maintained at the base camp at 2510 m a.s.l. on rock about 300 m from the snout of the glacier. A standard Stevenson screen has always contained maximum and minimum thermometers and a thermohygrograph. During the years 1966-68 the instruments also included precipitation gauge, totalizing anemometer and sunshine recorder. During these 3 early years measurements were usually made every day at 0800, 1200, 1600 and 2000 hours mountain standard time. During the years 1969-74 use was made of monthly thermohygrograph records and long-term Rimco recorders for temperature and relative humidity measurements. Mean daily temperatures are considered accurate to ±1°C.

Discharge Measurements

A stream gauge (No. 05DC008) was maintained by the Water Survey of Canada, Calgary Office, during the

summer months, from the late summer of 1967 to the end of the 1974 summer. The gauge is situated just below the outflow of a small lake, which effectively traps all coarse sediments carried by the stream. An artificial rock gabion control was constructed a few feet below the gauge. For a glacier-fed stream, the site is very good, and flows have probably been estimated to within 5% of the truth.

SPECIAL PROJECTS

Only standard glaciological, hydrological and meteorological data have been collected at Ram River Glacier. All special projects were conducted at nearby Peyto Glacier, which is much more accessible.

ACKNOWLEDGMENTS

Although Ram River Glacier is outside Banff National Park, the personnel of the Warden Service have given encouragement throughout the history of this project. Their cooperation on numerous occasions is gratefully acknowledged.

Special thanks should be given to the personnel of the Water Survey of Canada, Calgary Office, for maintaining the stream measurements and reducing the discharge data collected.

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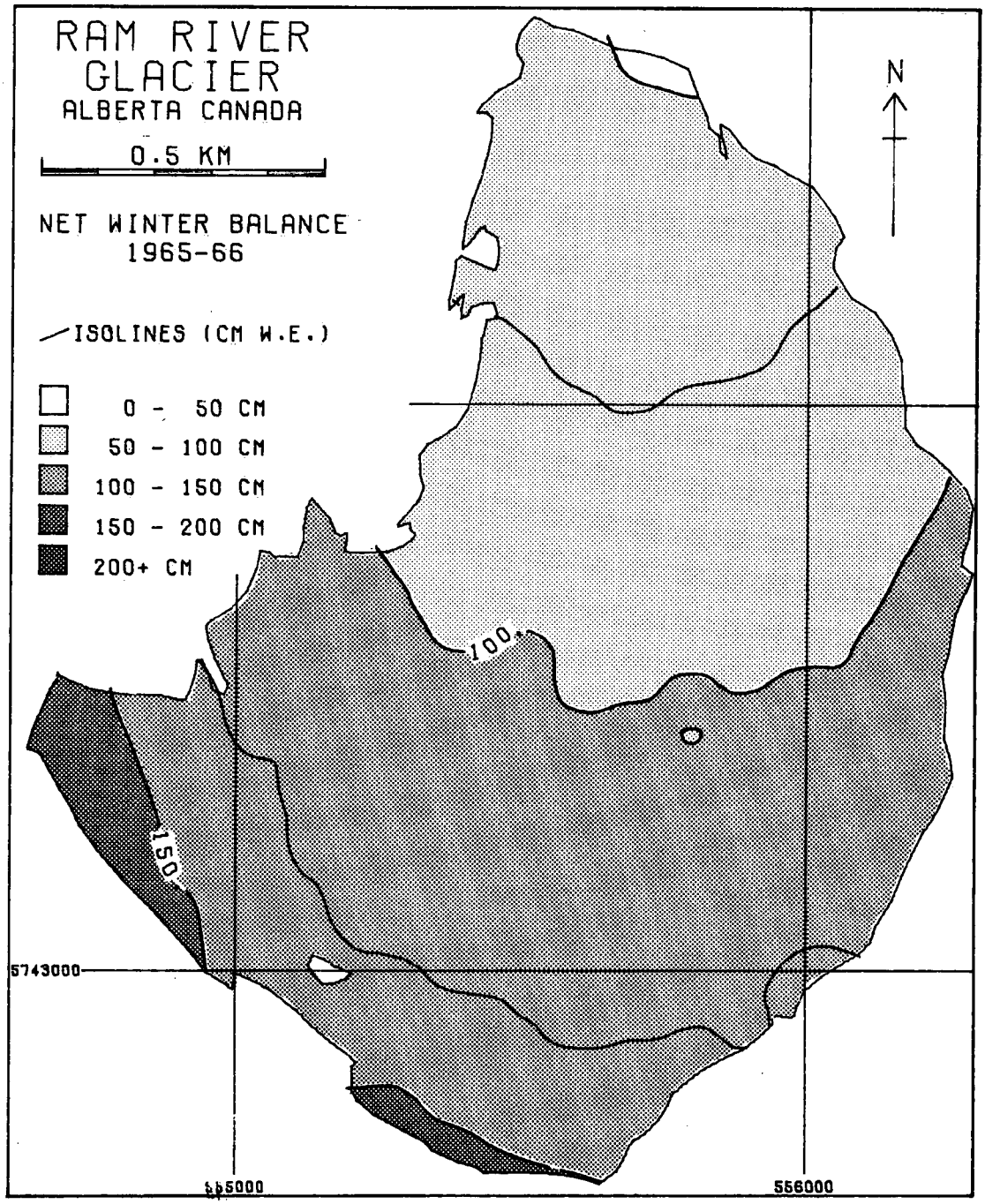
Appendix I

Glaciological summaries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GLACIER
ALBERTA CANADA
0.5 KM
NET WINTER BALANCE
1965-66
ISOLINES (CM W.E.)
0 - 50 CM
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100 - 150 CM
150 - 200 CM
200+ CM
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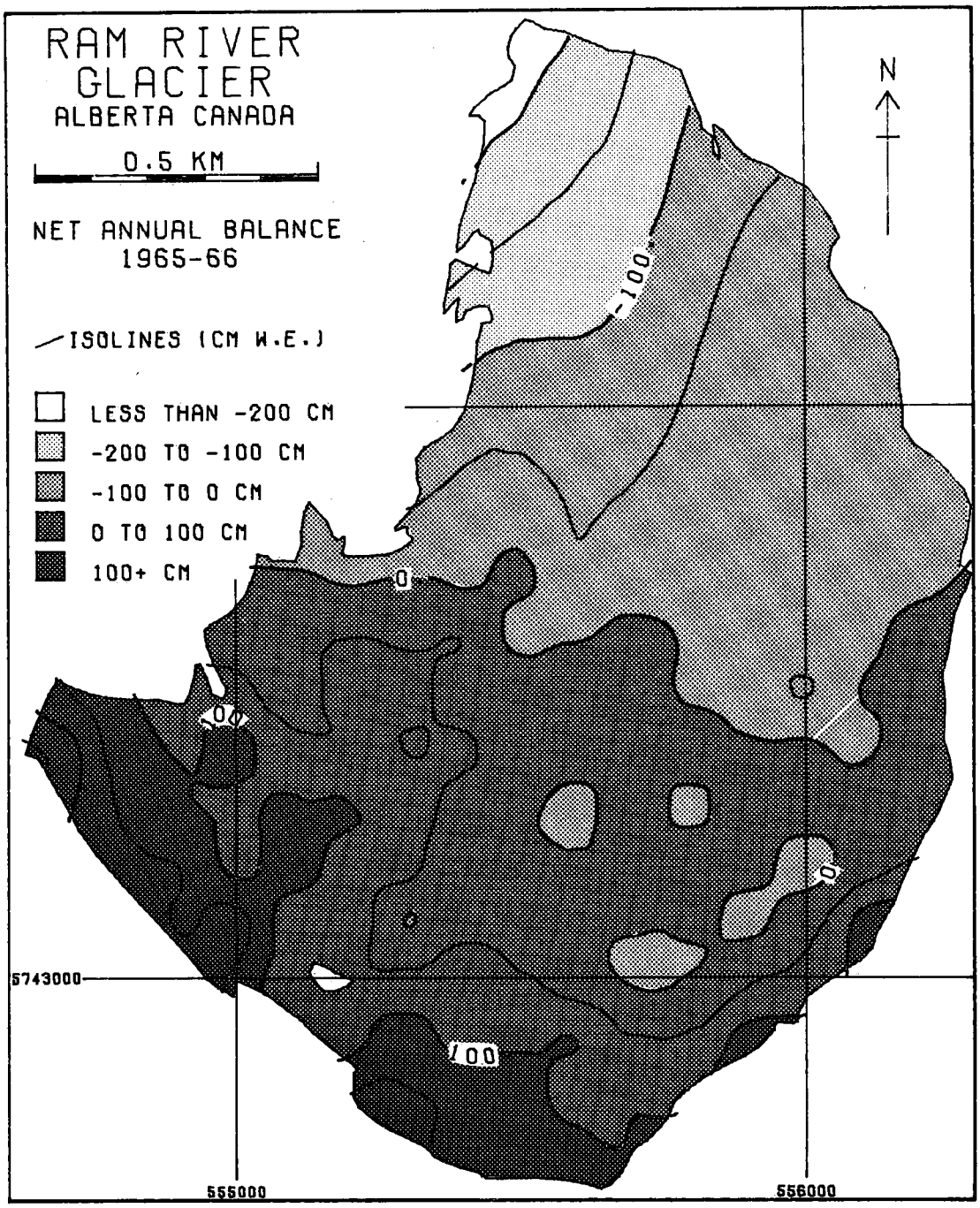
Figure I-1.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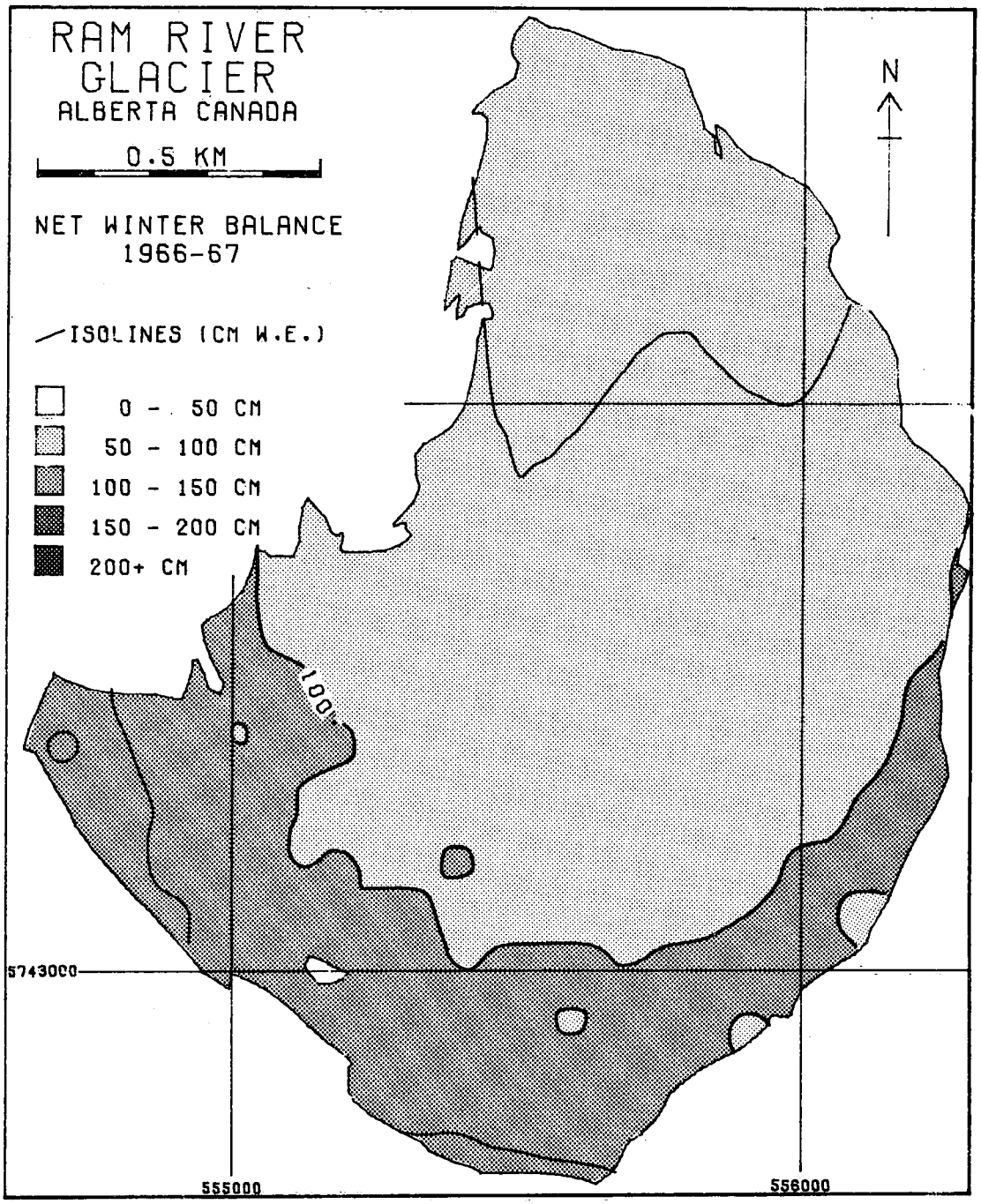
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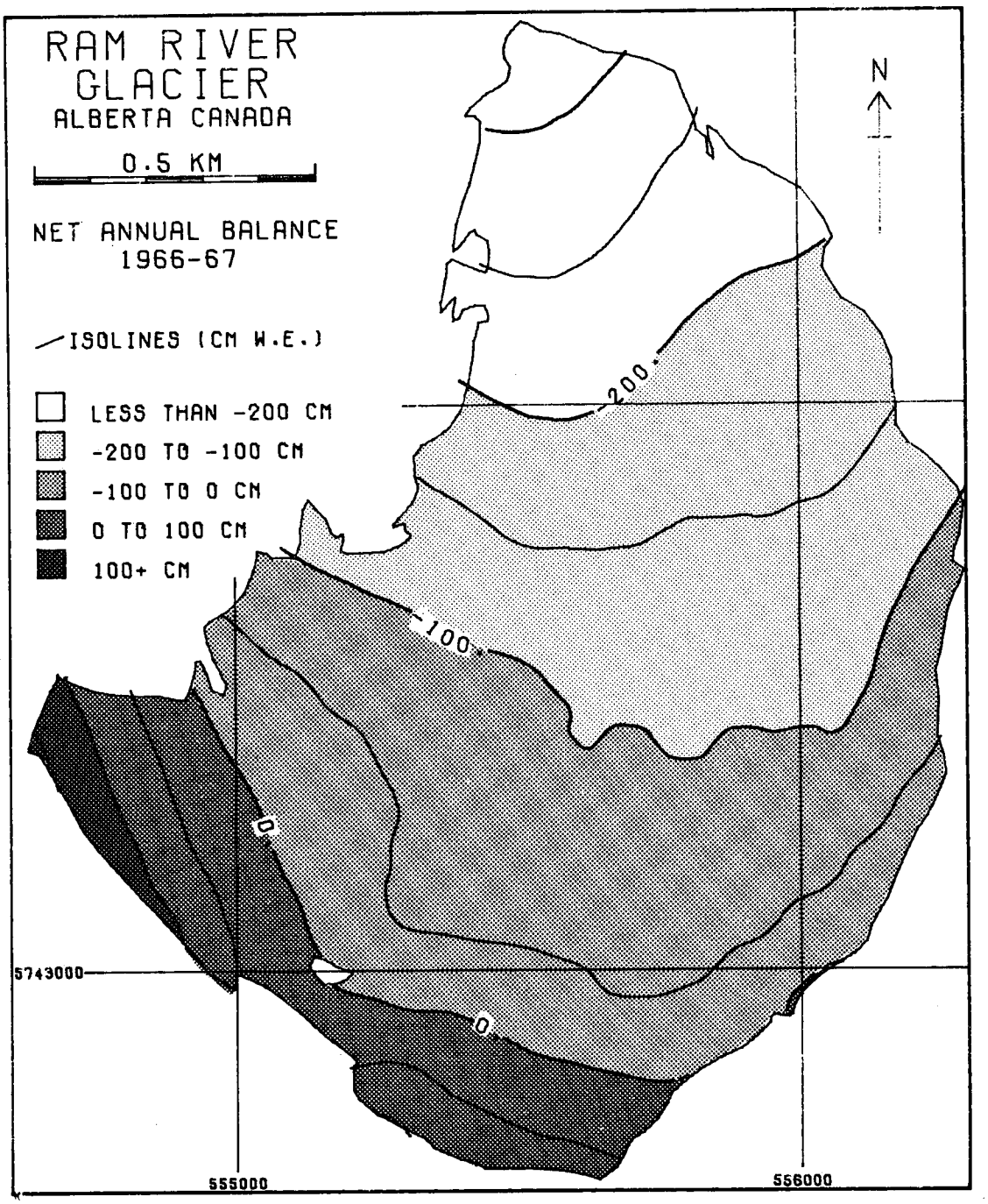
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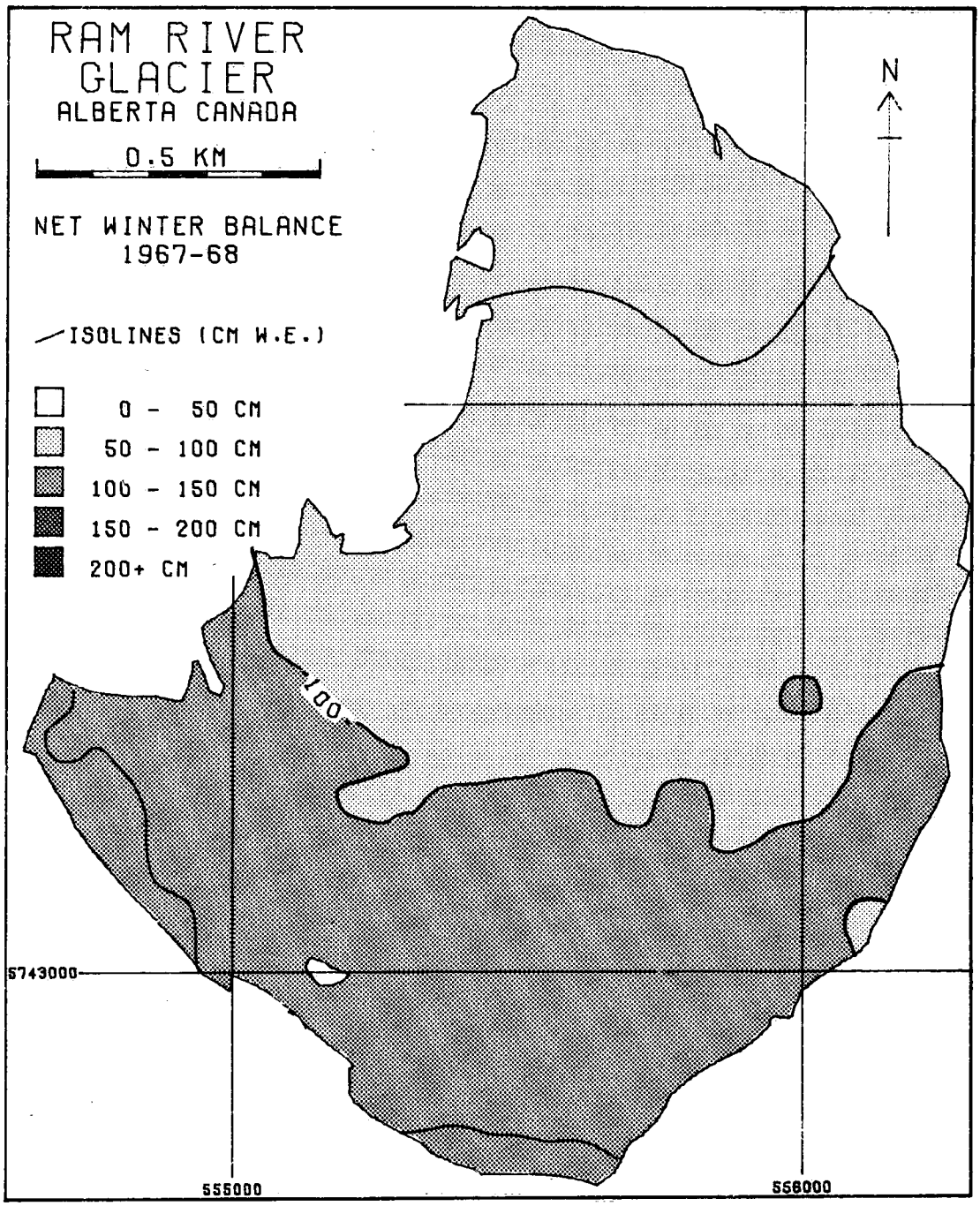
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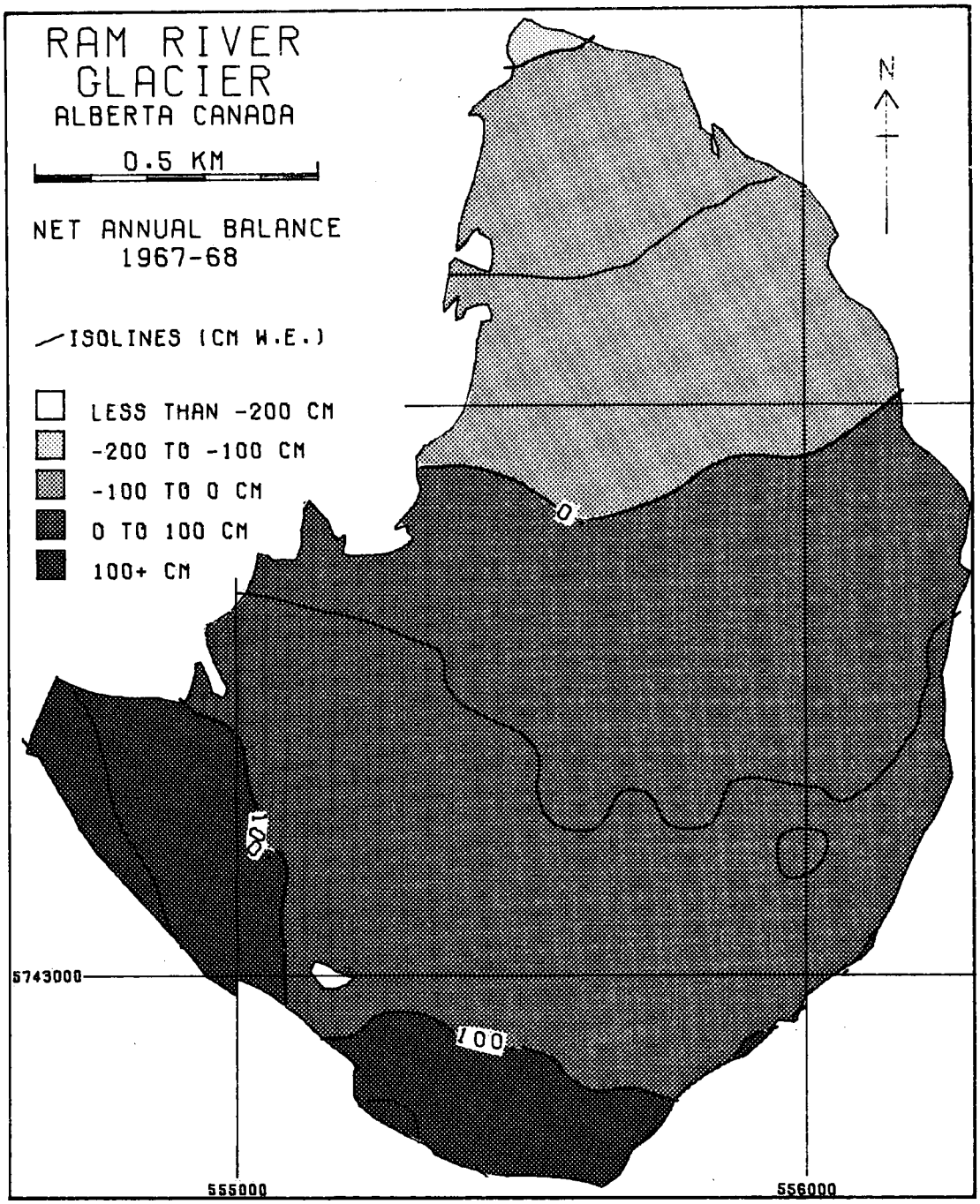
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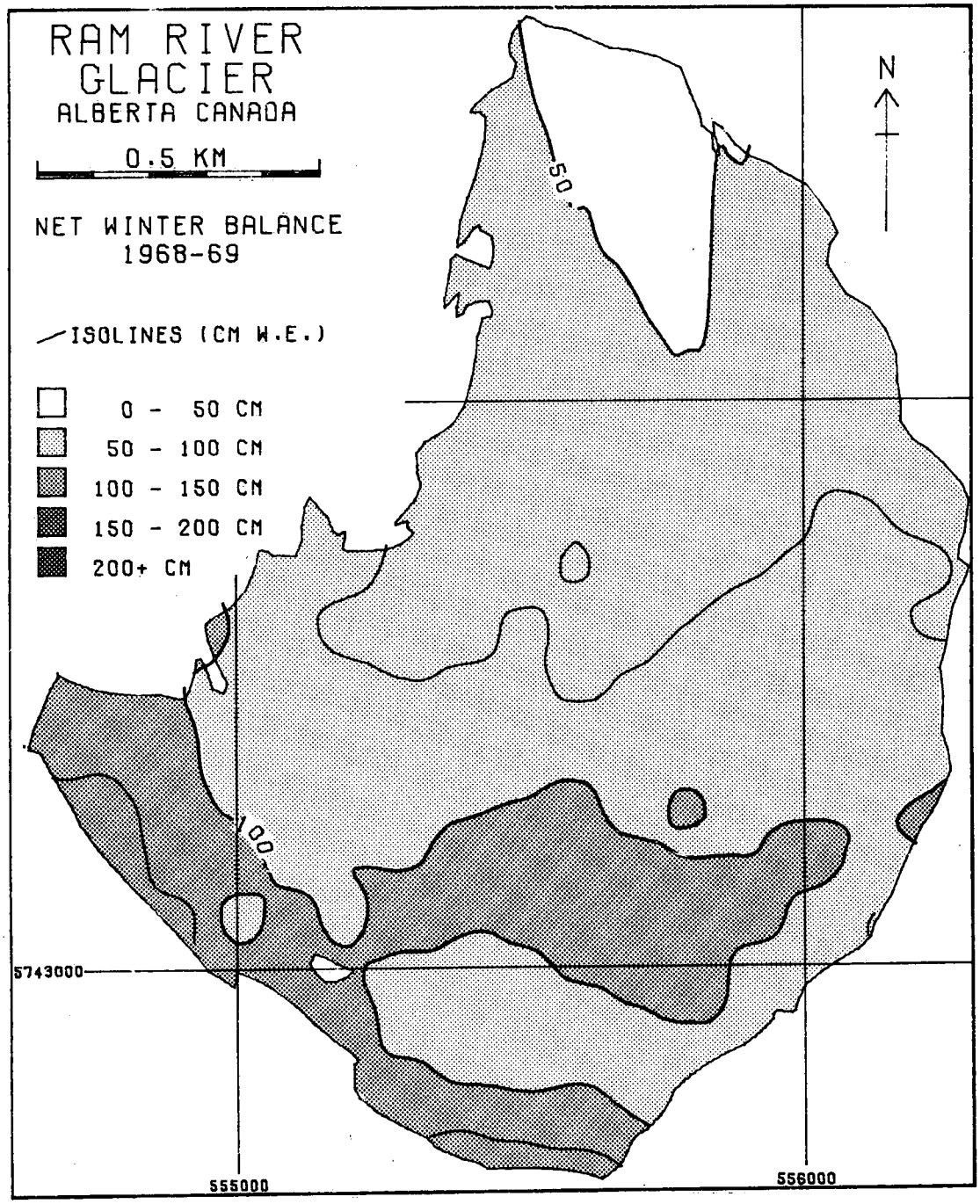
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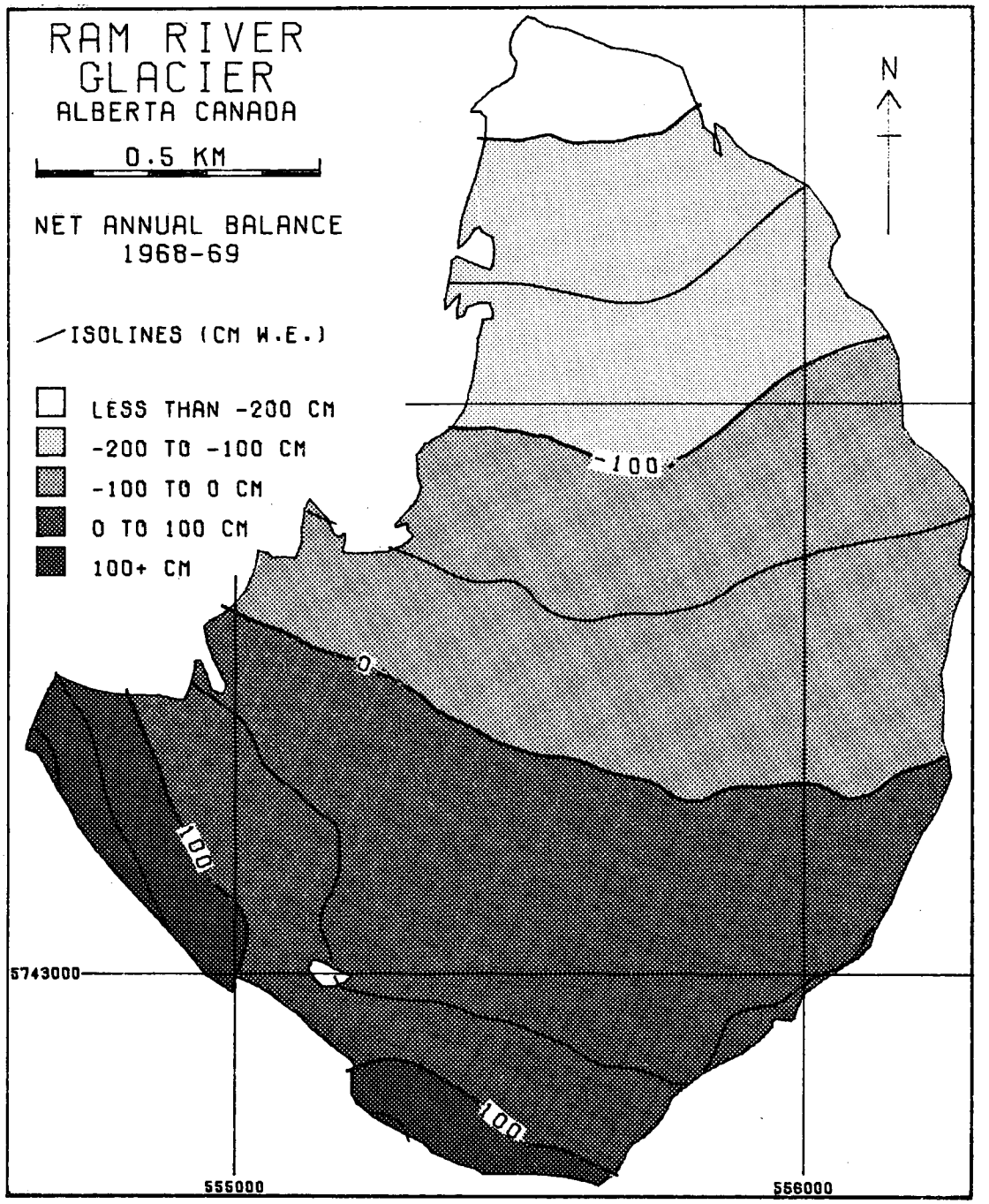
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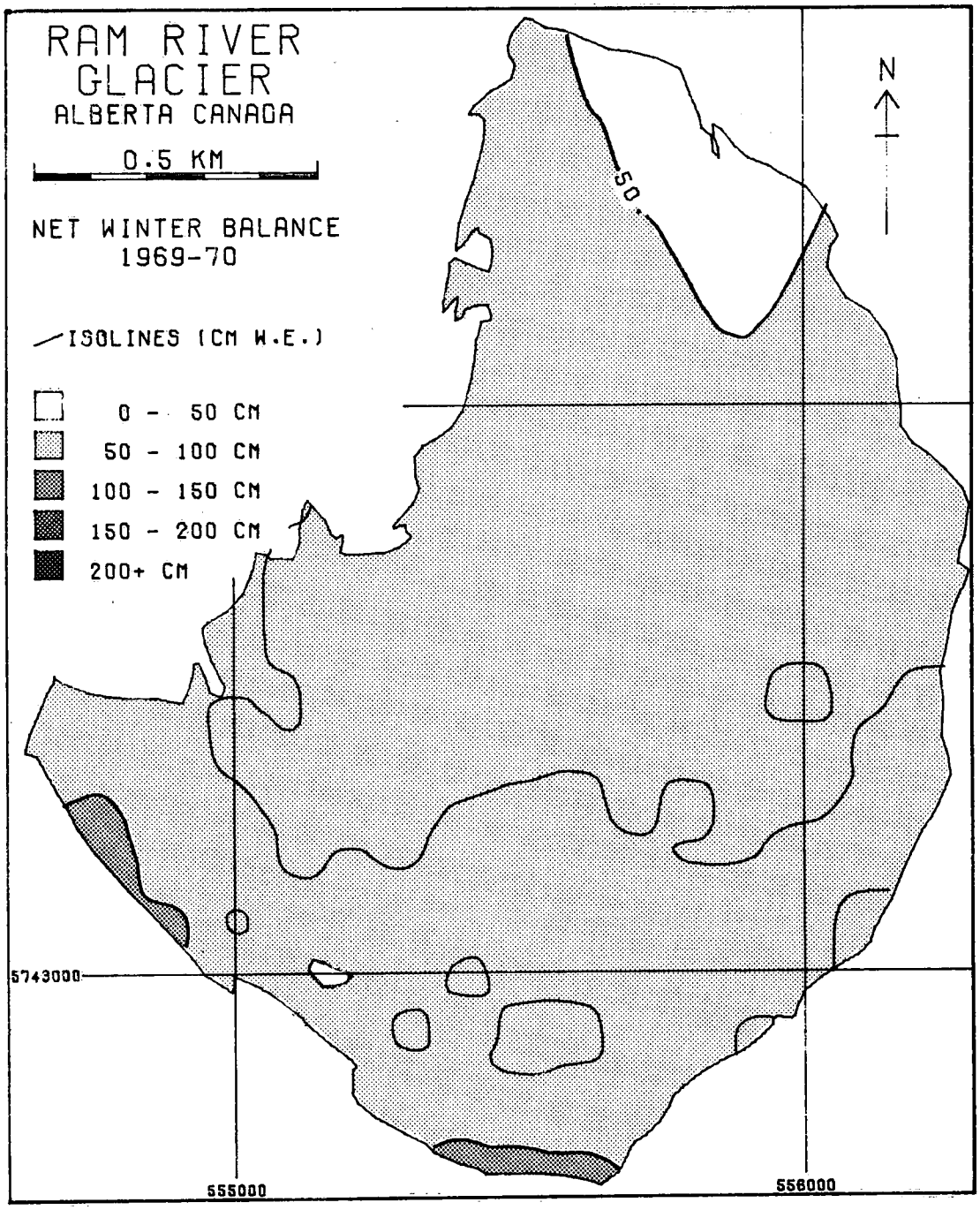
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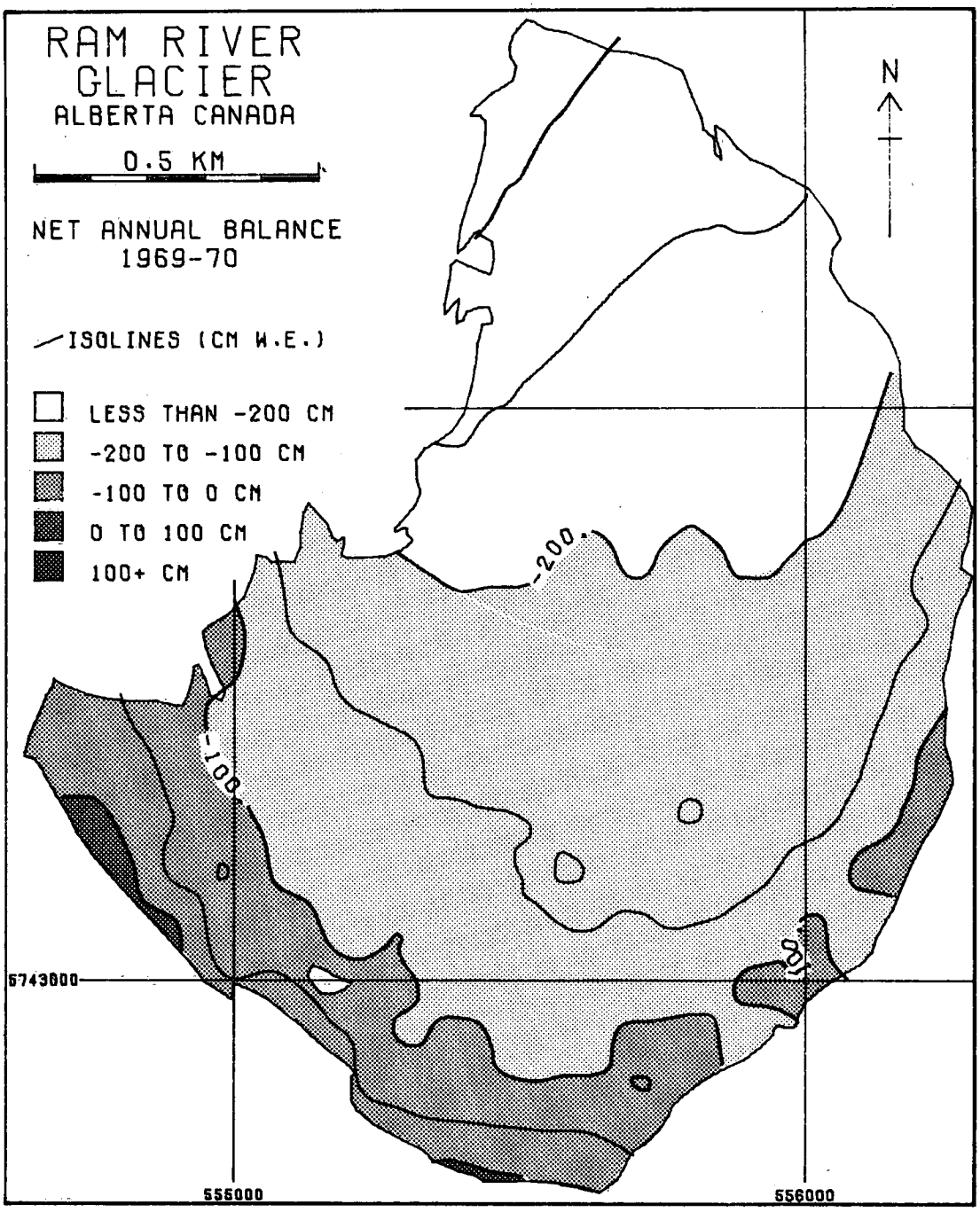
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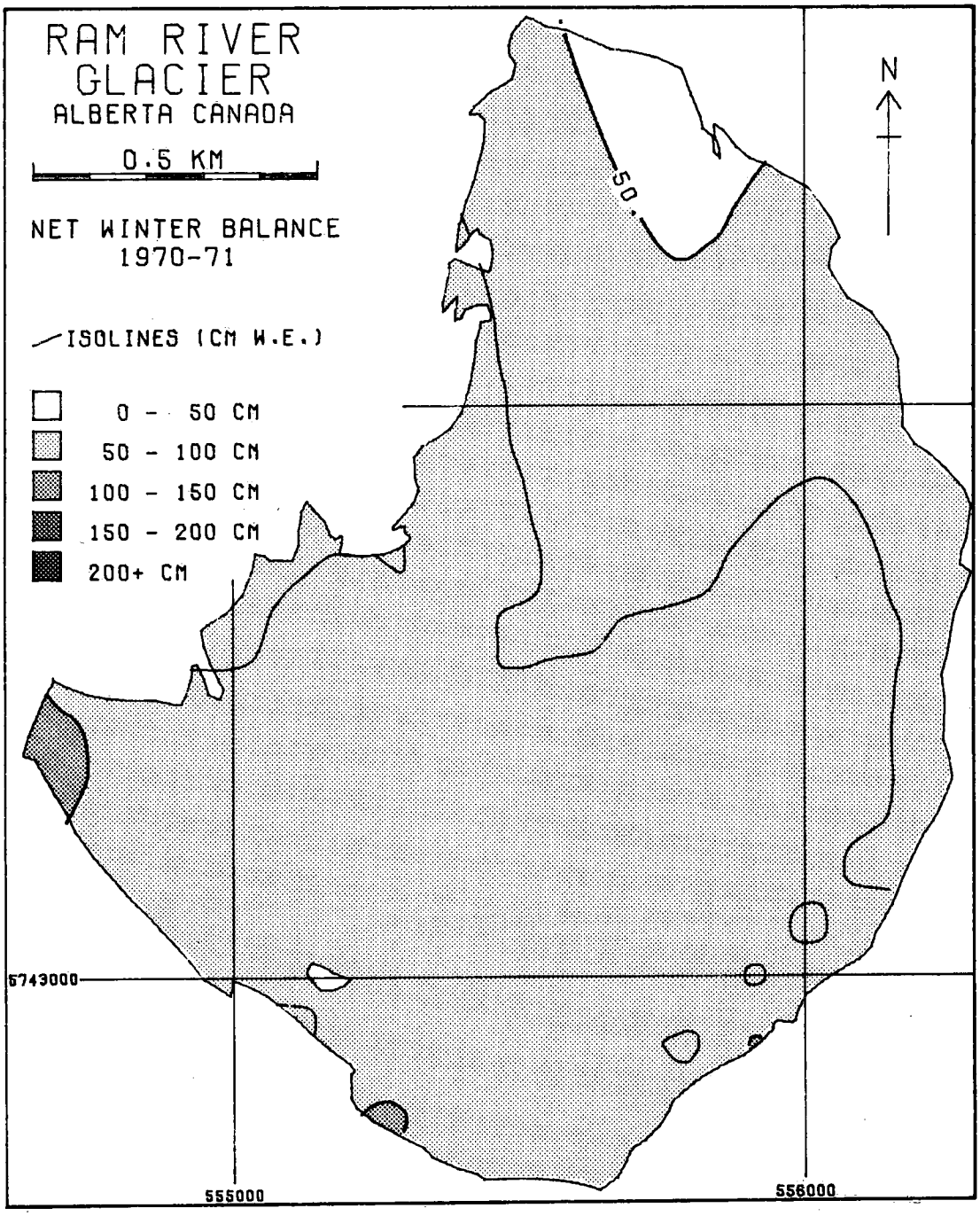
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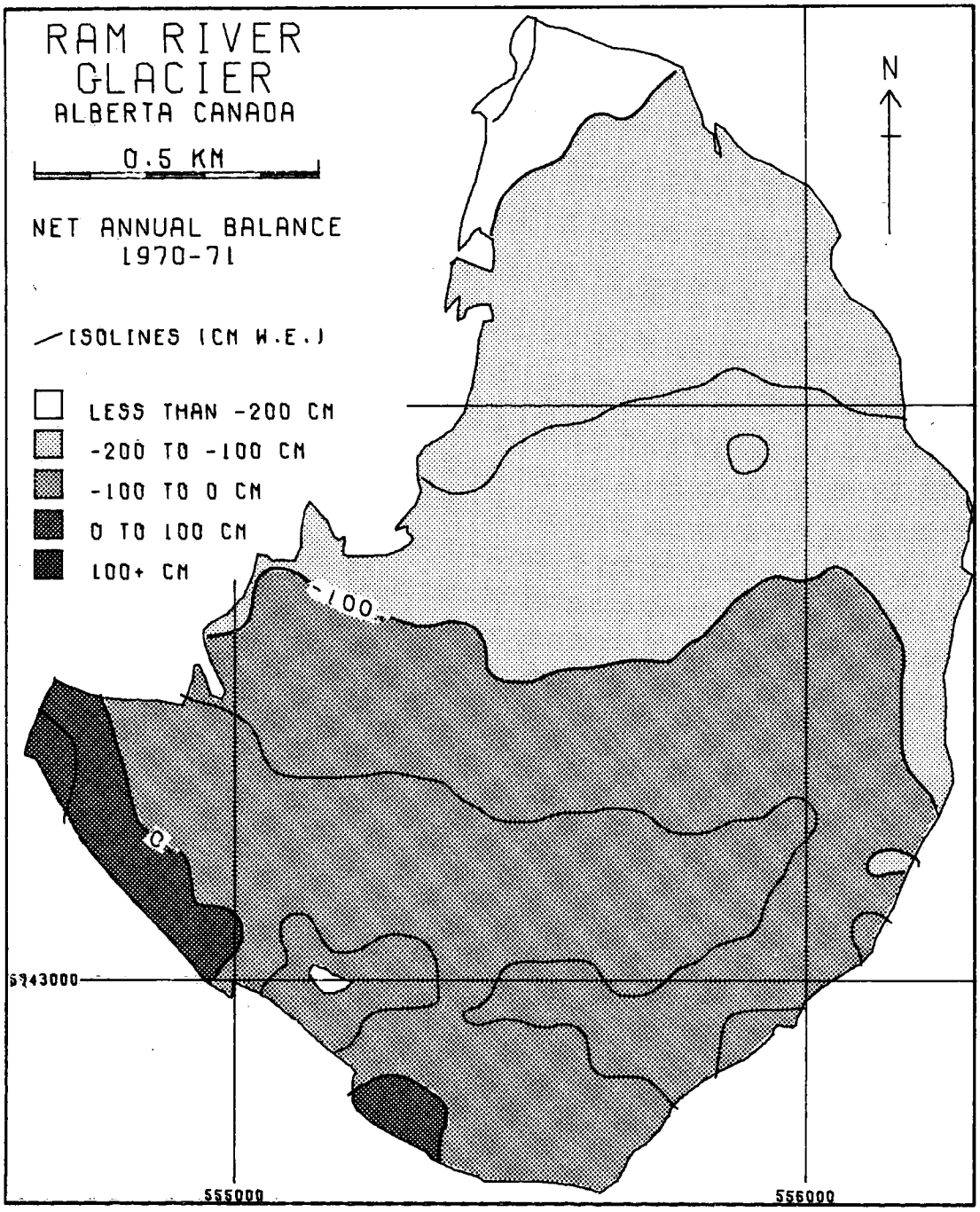
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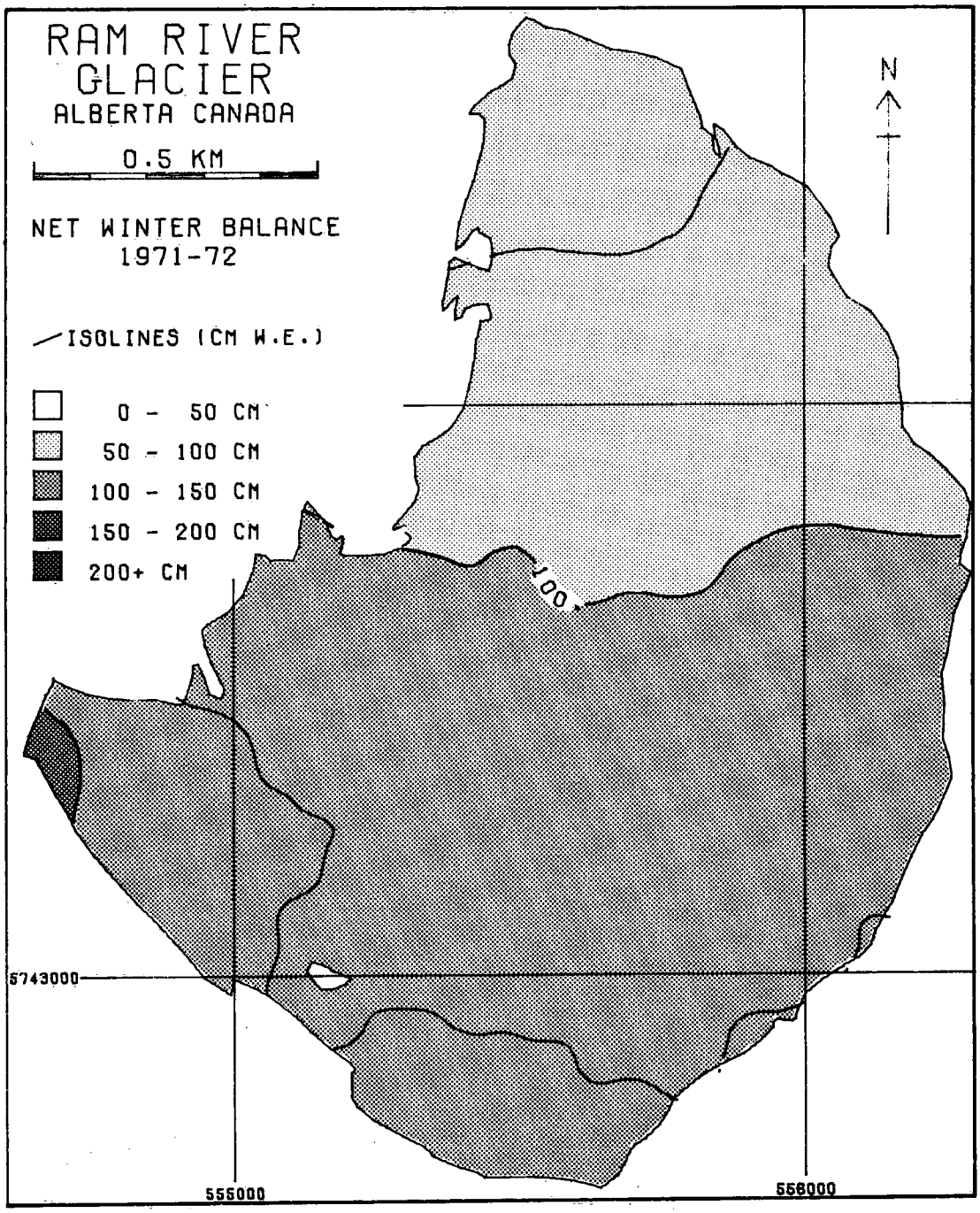
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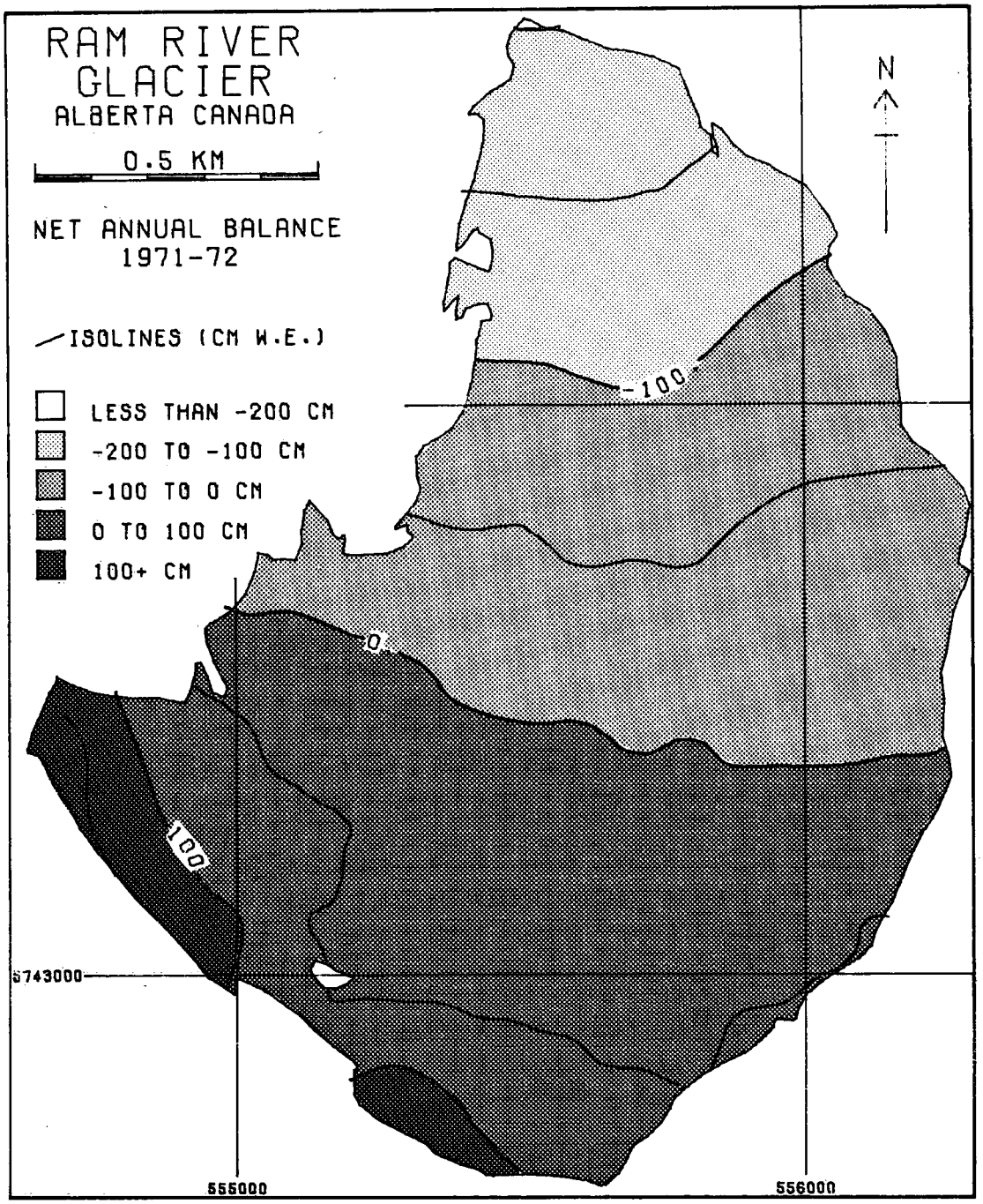
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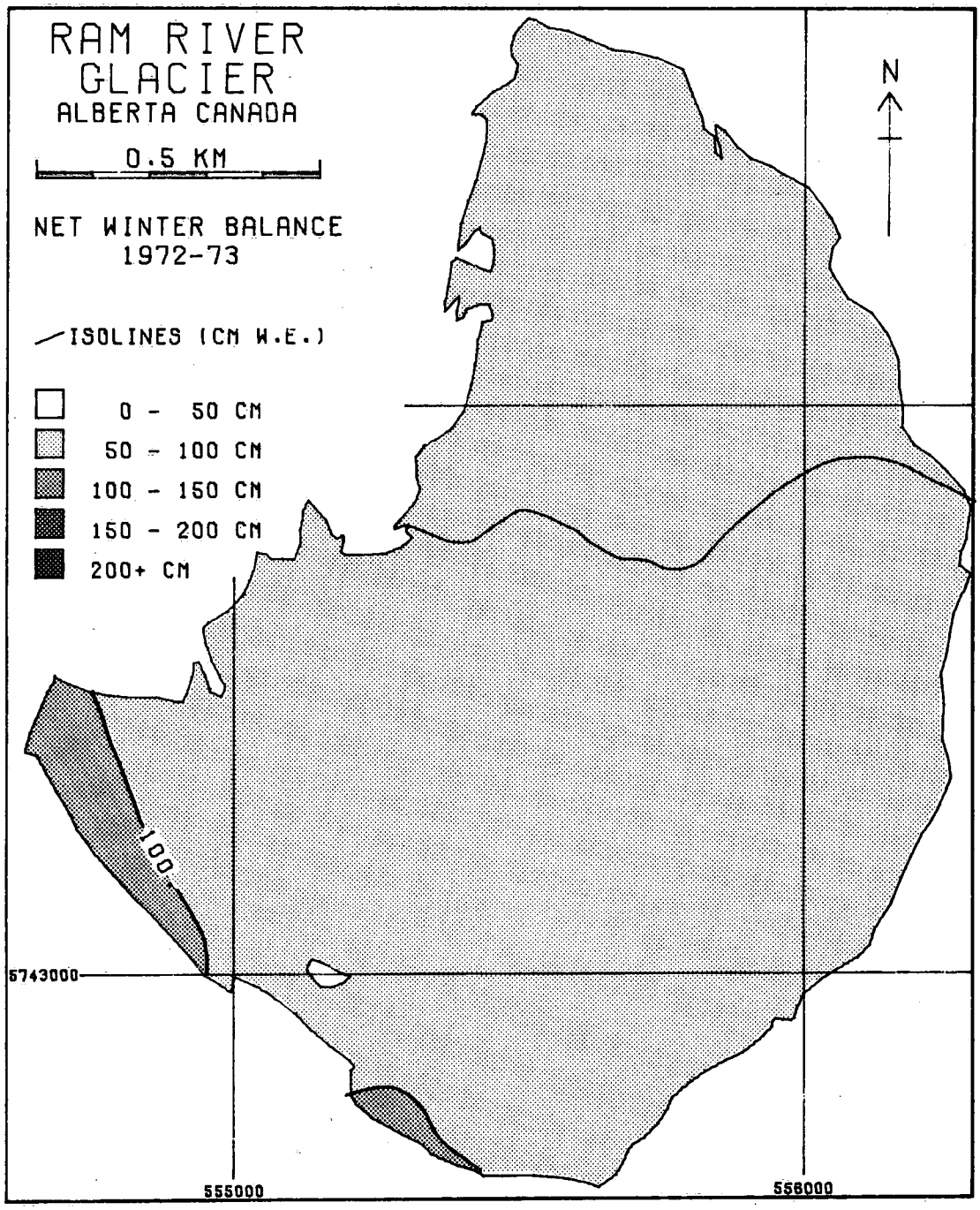
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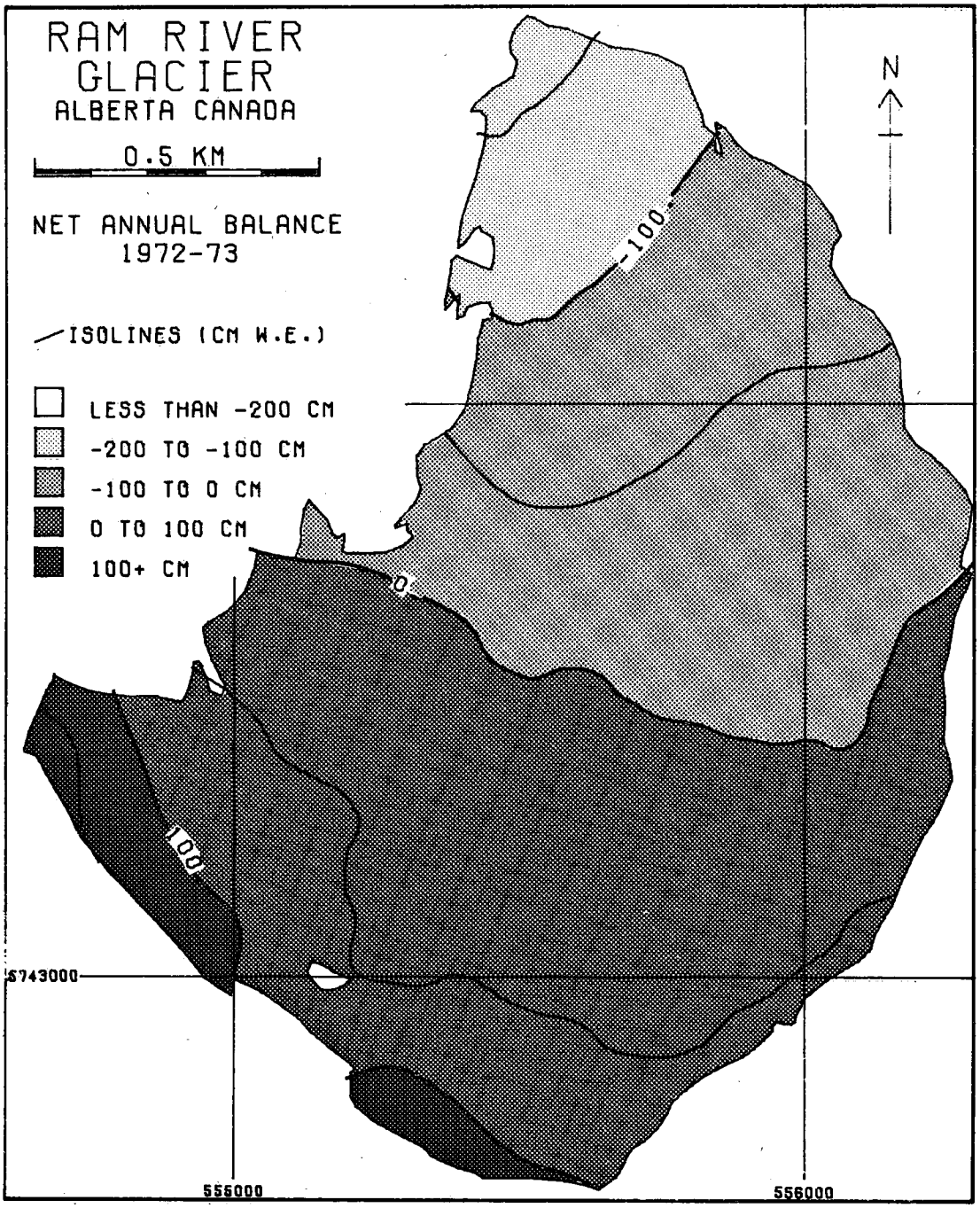
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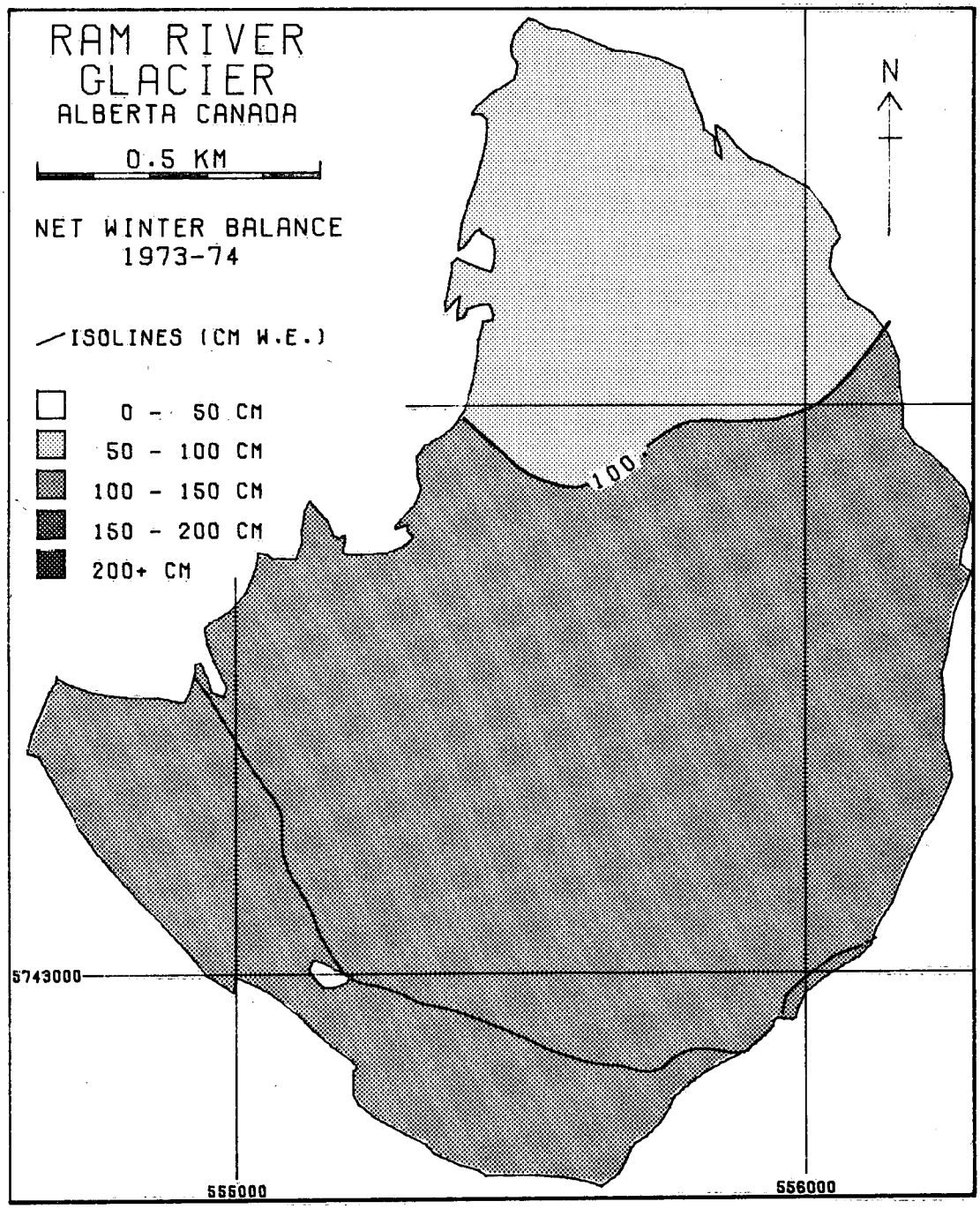
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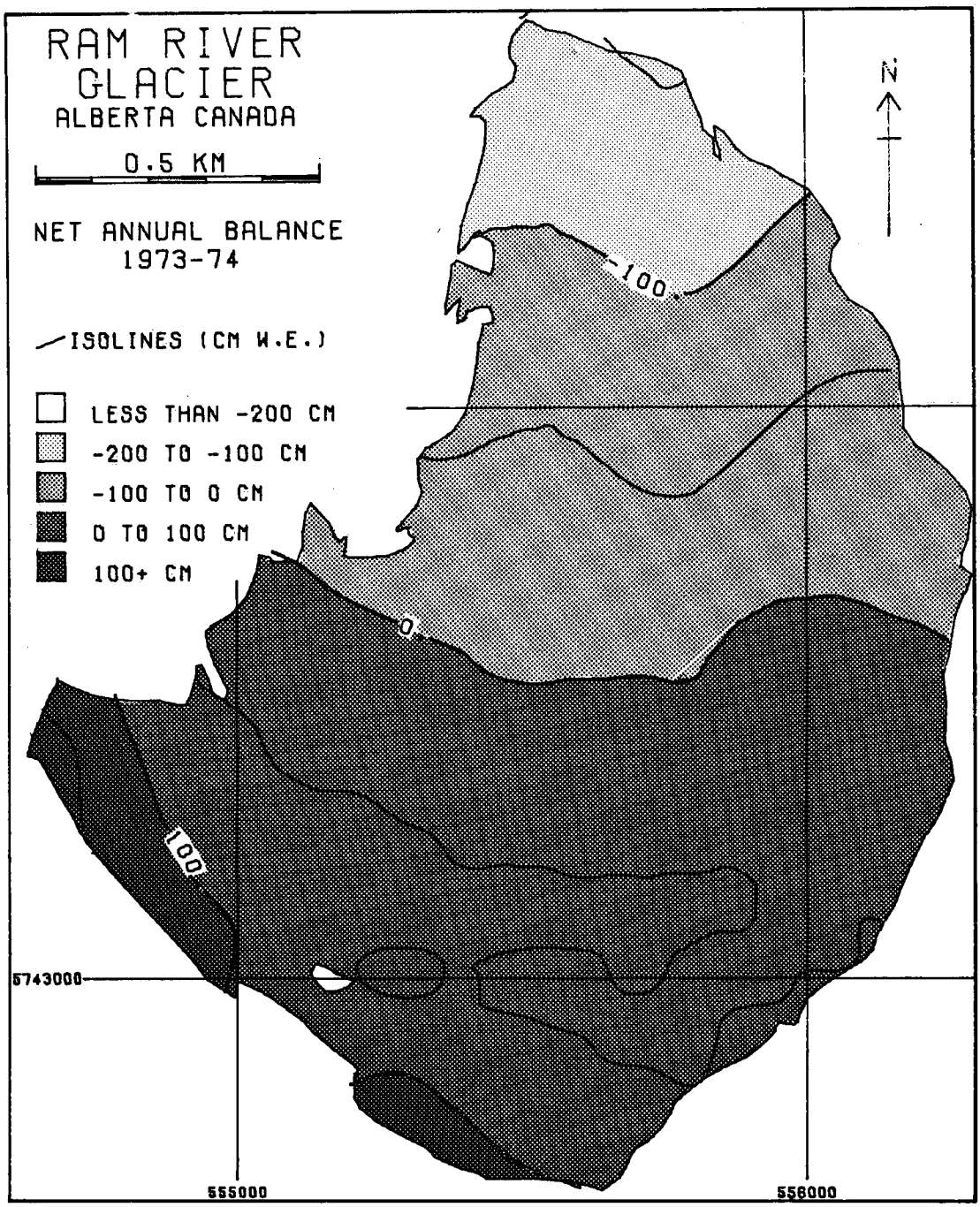
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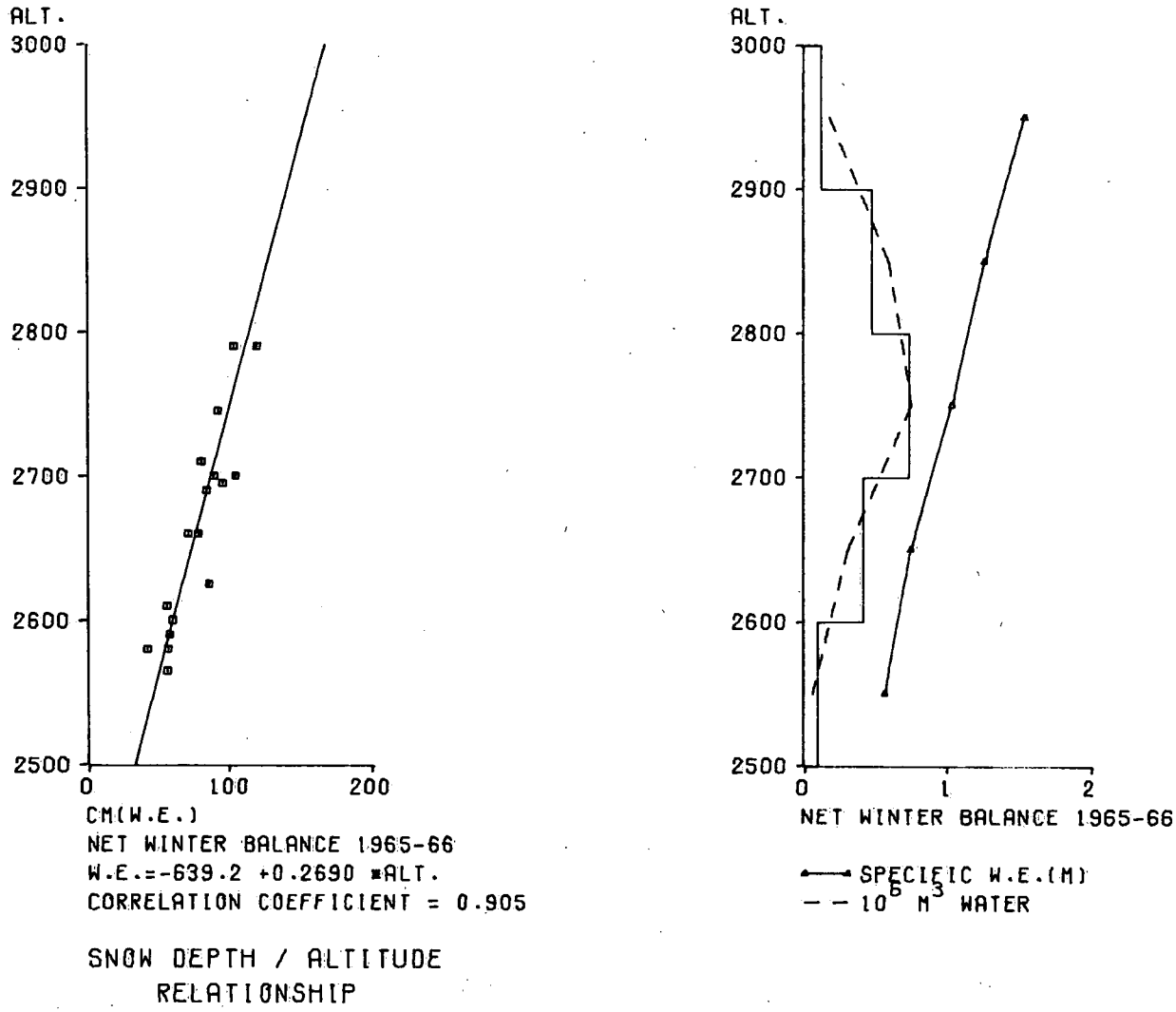
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2900
2800
2700
2600
2500
0
100
200
CM(W.E.)
NET WINTER BALANCE 1965-66
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CORRELATION COEFFICIENT = 0.905
SNOW DEPTH / ALTITUDE
RELATIONSHIP
ALT.
3000
2900
2800
2700
2600
2500
0
1
2
NET WINTER BALANCE 1965-66
SPECIFIC W.E.(M)
10^6 M^3 WATER

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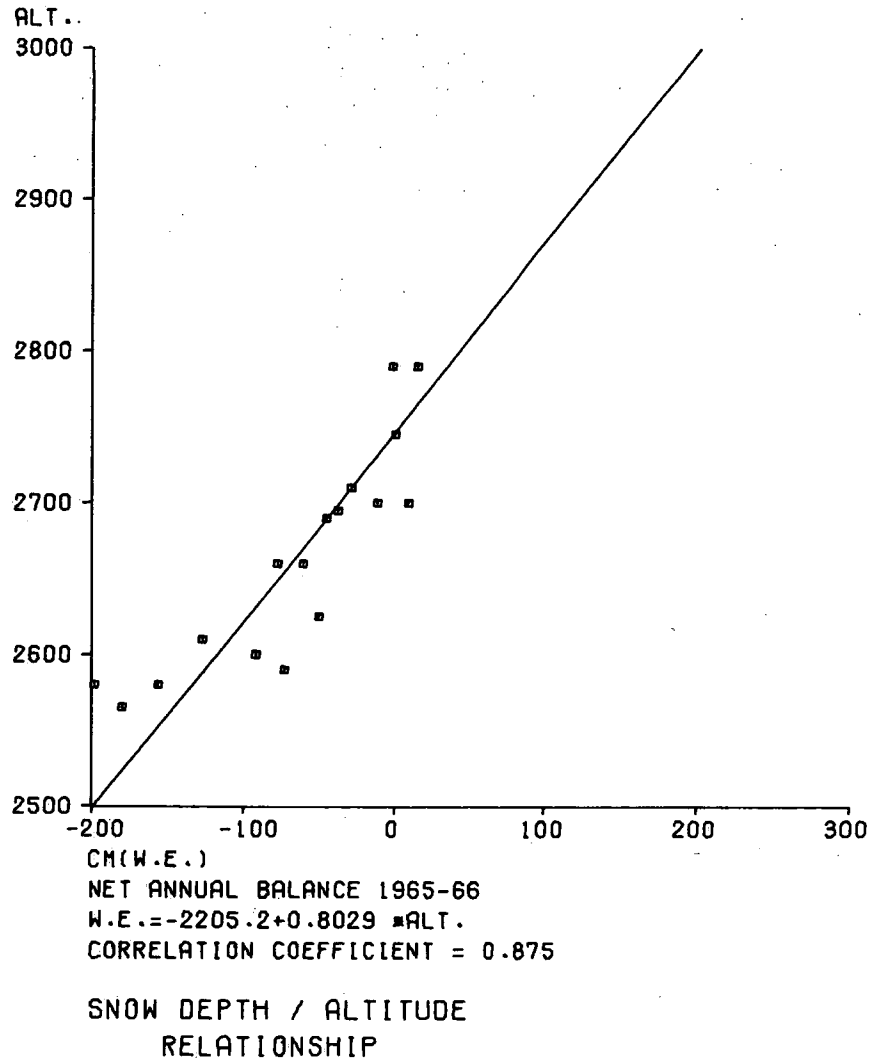

SNOW DEPTH / ALTITUDE
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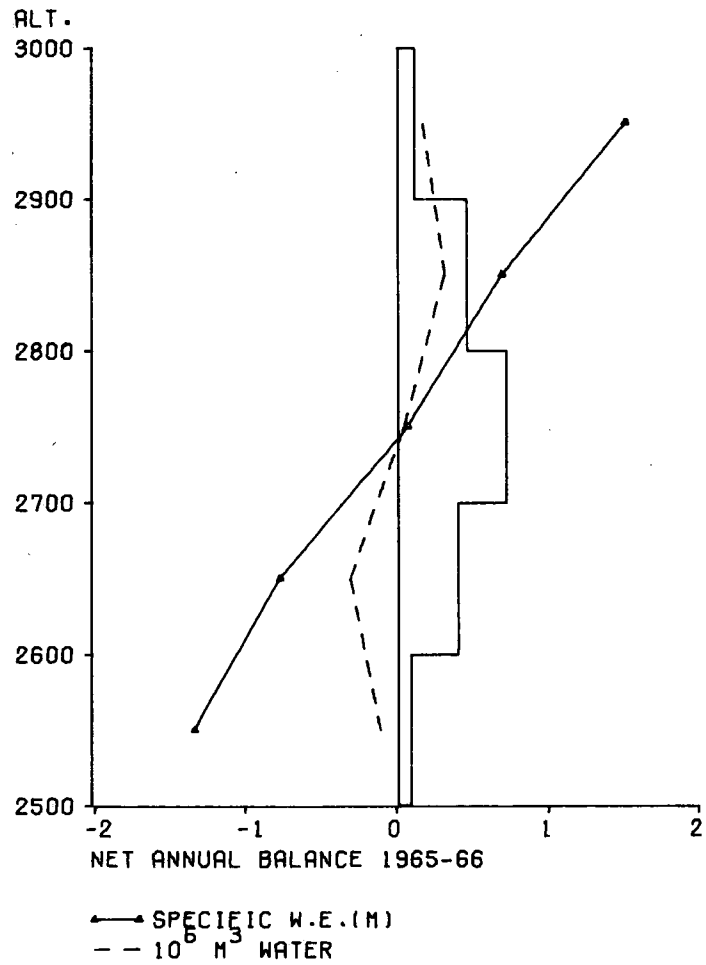

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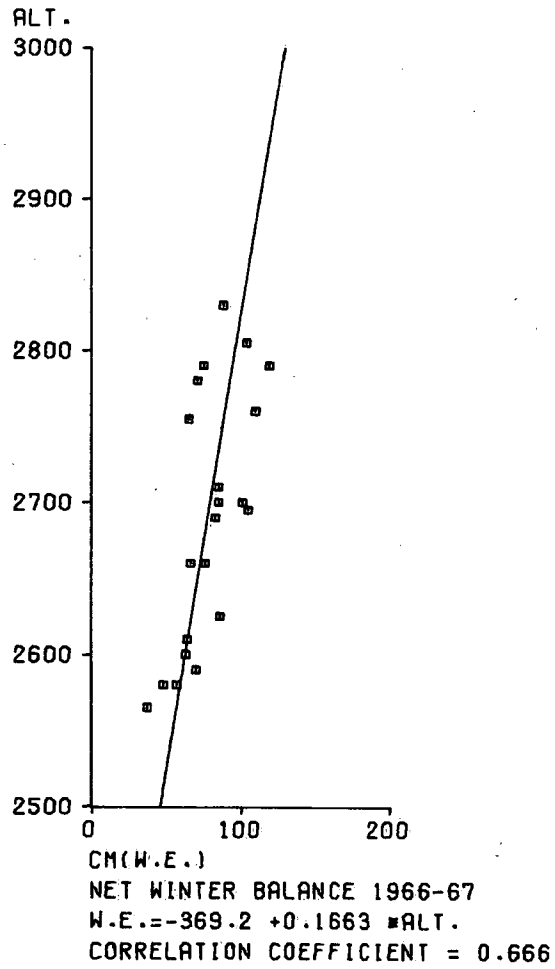

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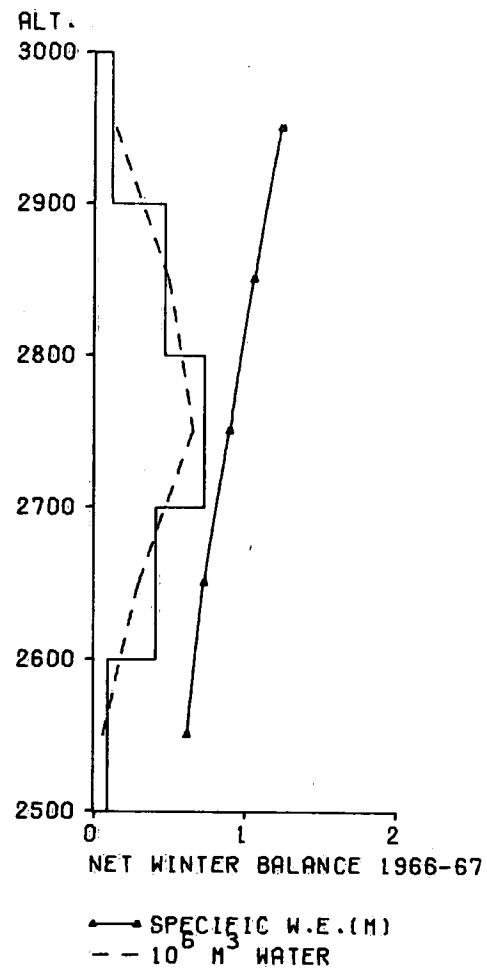
RELATIONSHIP



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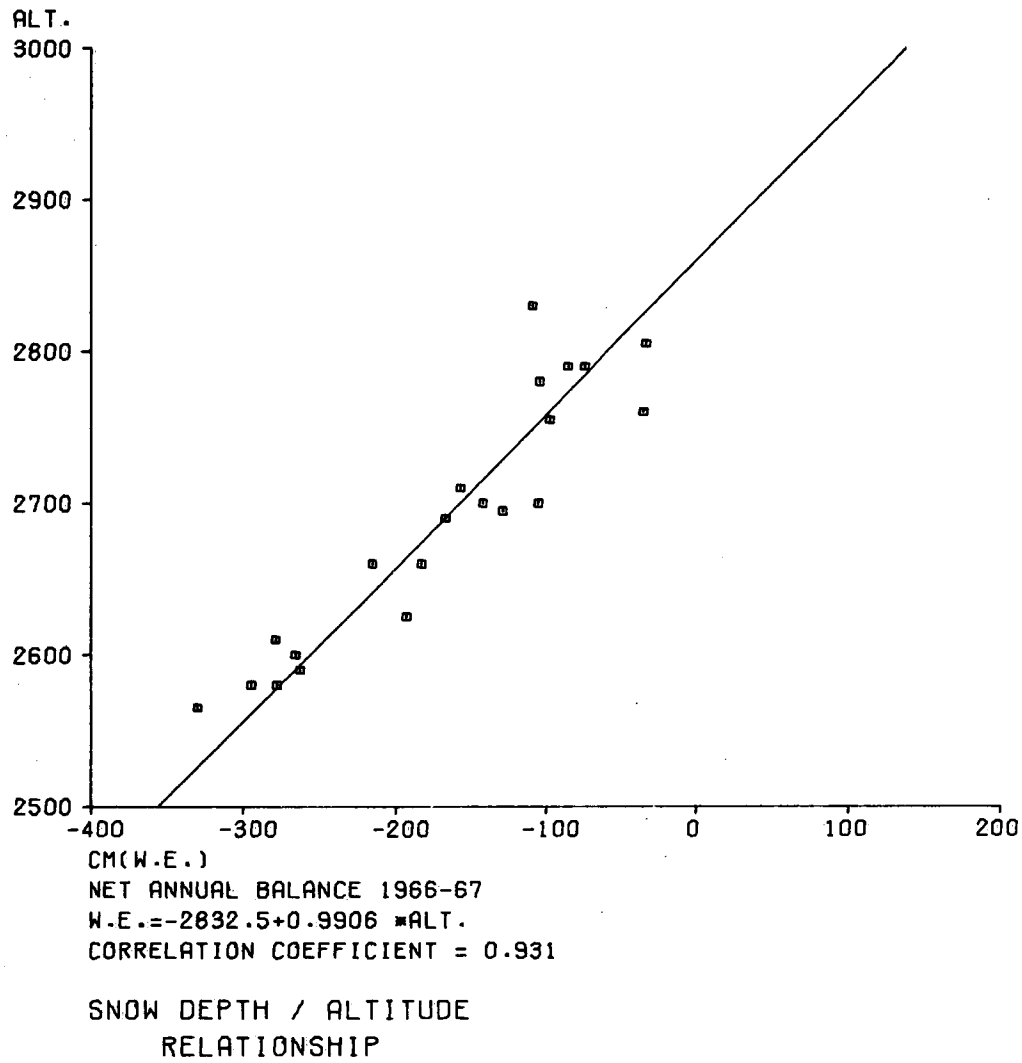


SNOW DEPTH / ALTITUDE
RELATIONSHIP

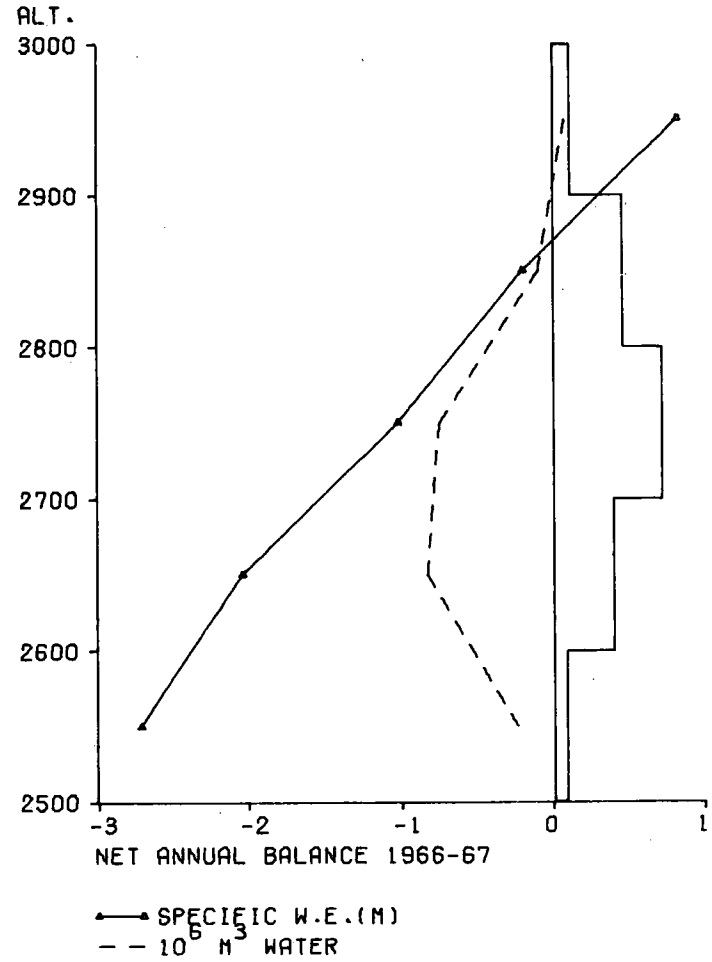
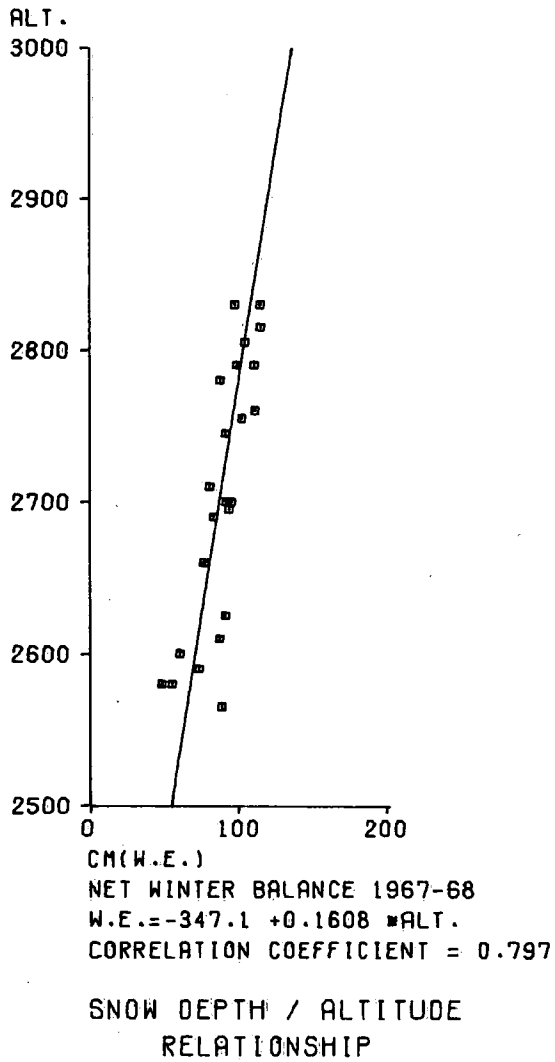


Figure I-22.


ALT.
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2900
2800
2700
2600
2500
0
100
200
CM(W.E.)
NET WINTER BALANCE 1967-68
W.E.=-347.1 +0.1608 *ALT.
CORRELATION COEFFICIENT = 0.797
SNOW DEPTH / ALTITUDE
RELATIONSHIP

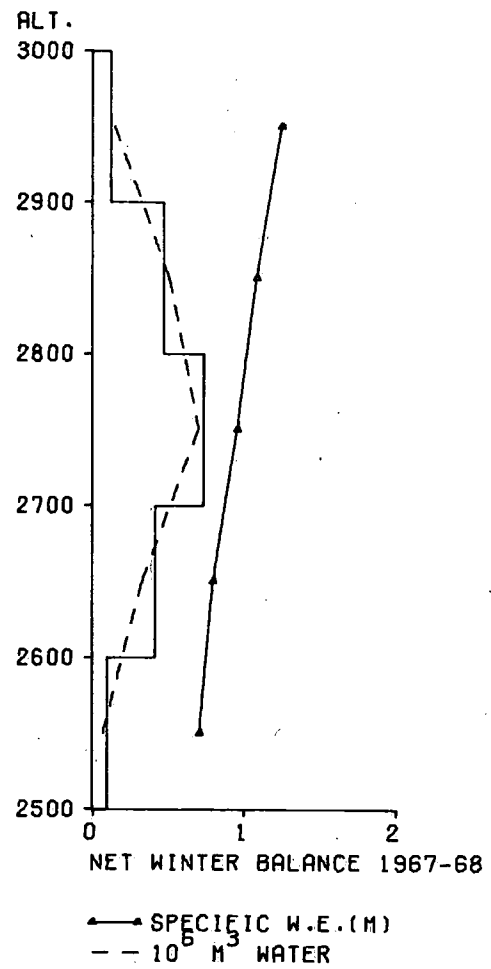
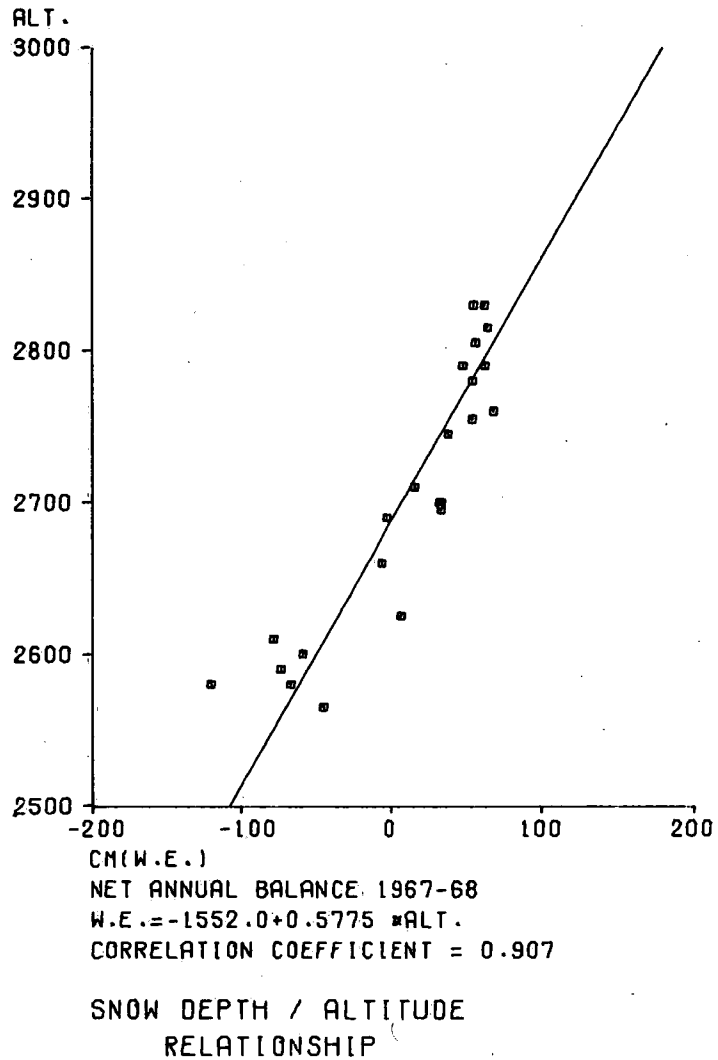

ALT.
3000
2900
2800
2700
2600
2500
0
1
2
NET WINTER BALANCE 1967-68
SPECIFIC W.E.(M)
10^6 M^3 WATER

Figure I-23.



SNOW DEPTH / ALTITUDE RELATIONSHIP

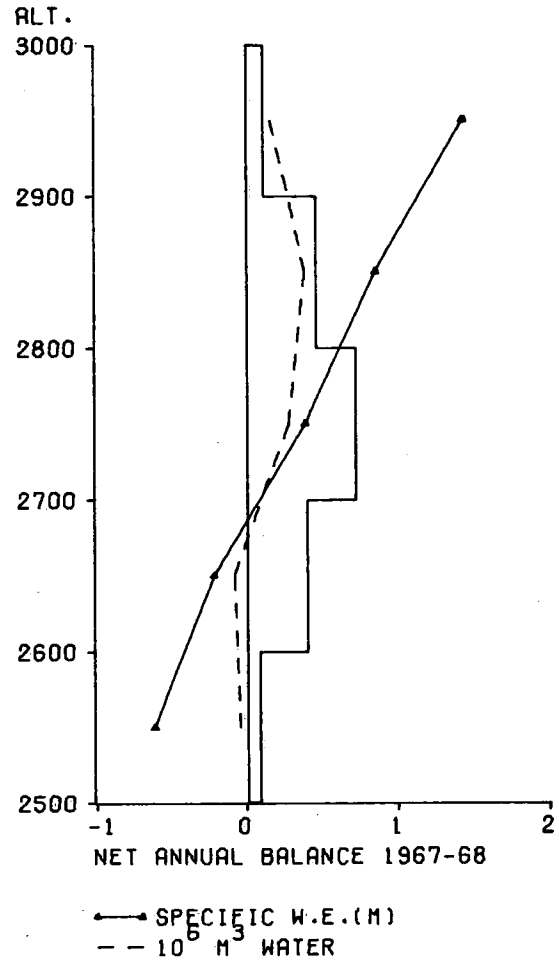
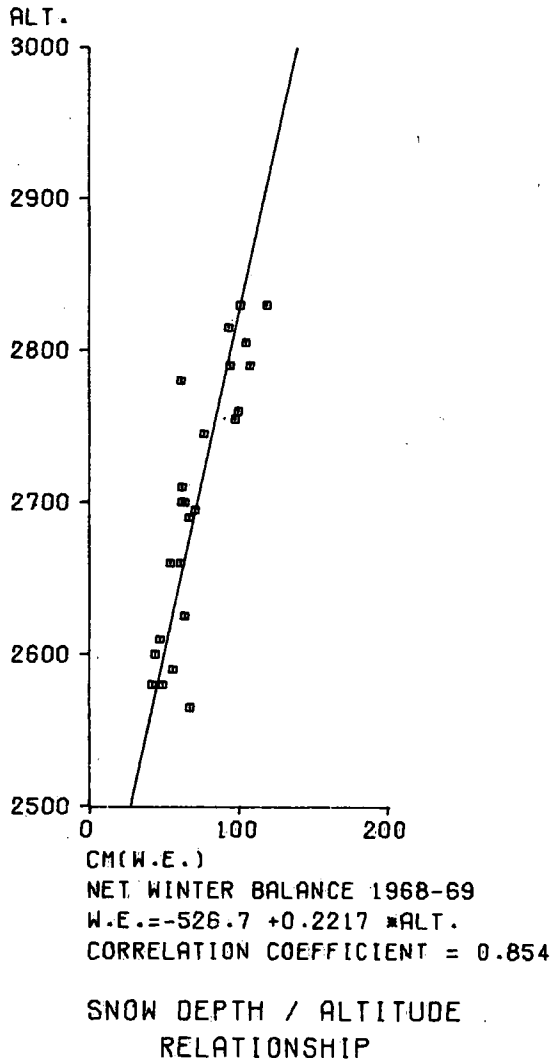


Figure I-24.


ALT.
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2800
2700
2600
2500
0
100
200
CM(W.E.)
NET WINTER BALANCE 1968-69
W.E.=-526.7 +0.2217 *ALT.
CORRELATION COEFFICIENT = 0.854
SNOW DEPTH / ALTITUDE
RELATIONSHIP

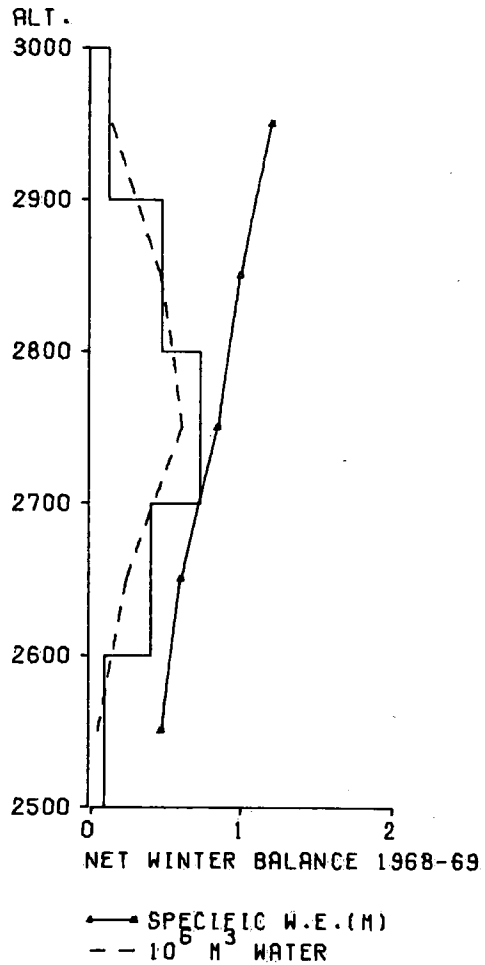
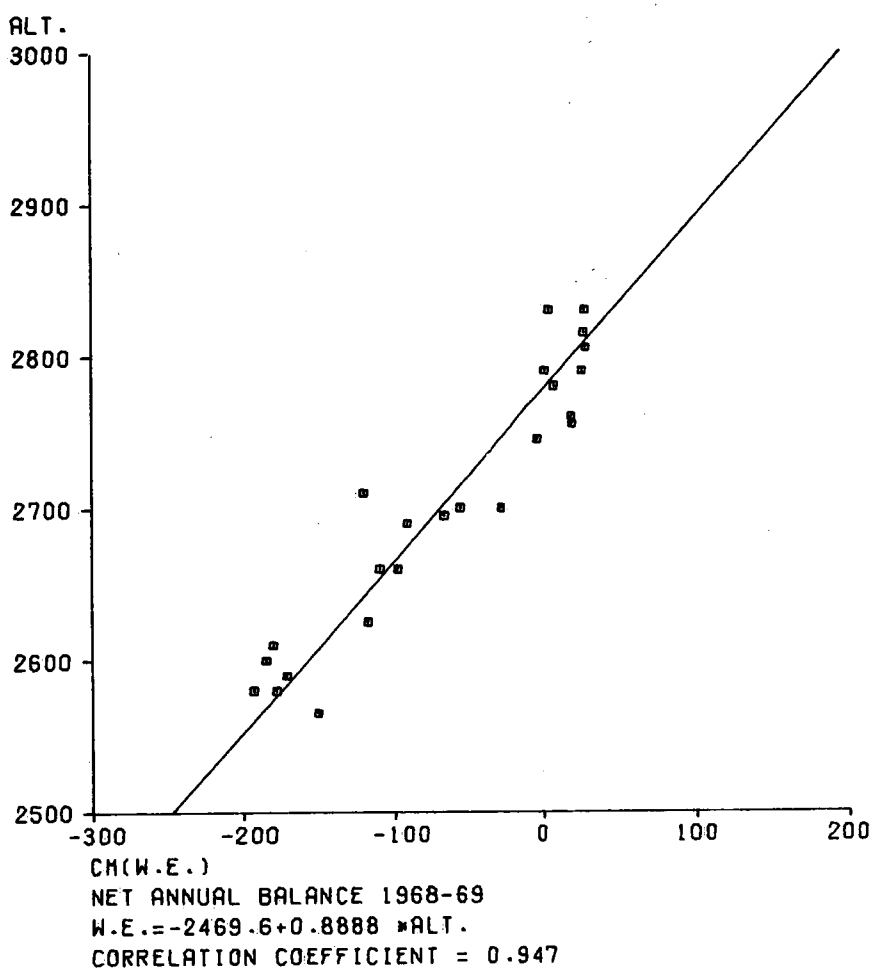

ALT.
3000
2900
2800
2700
2600
2500
0
1
2
NET WINTER BALANCE 1968-69
SPECIFIC W.E.(M)
10^6 M^3 WATER

Figure I-25.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

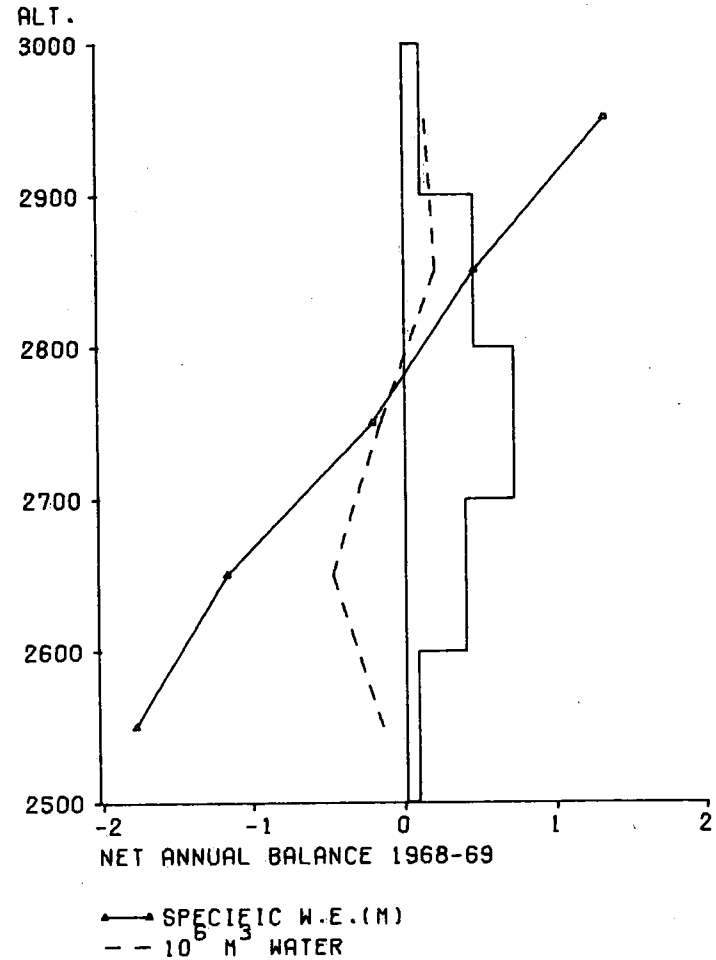
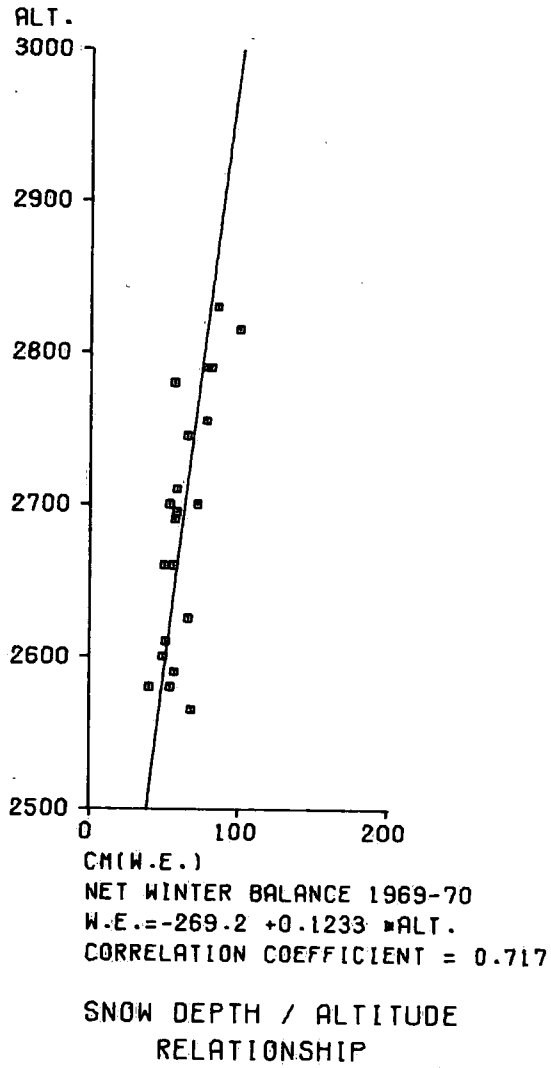


Figure I-26.



SNOW DEPTH / ALTITUDE RELATIONSHIP

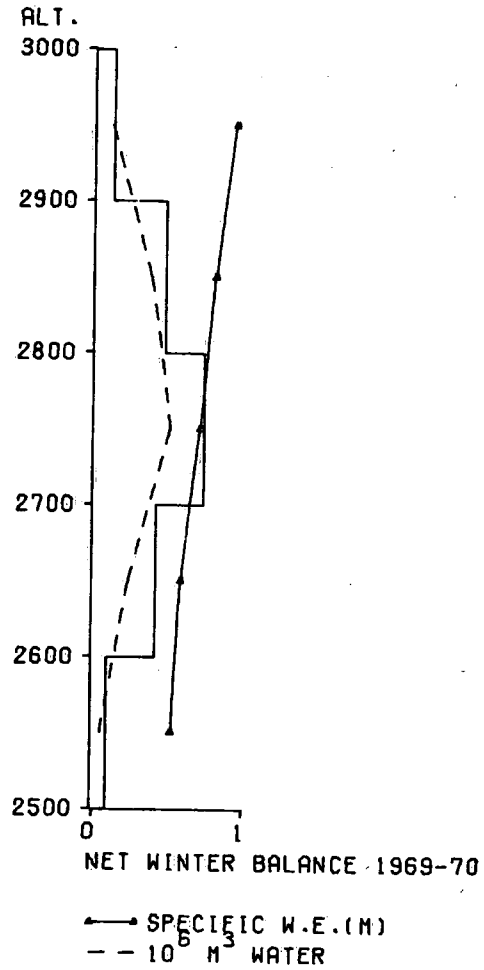
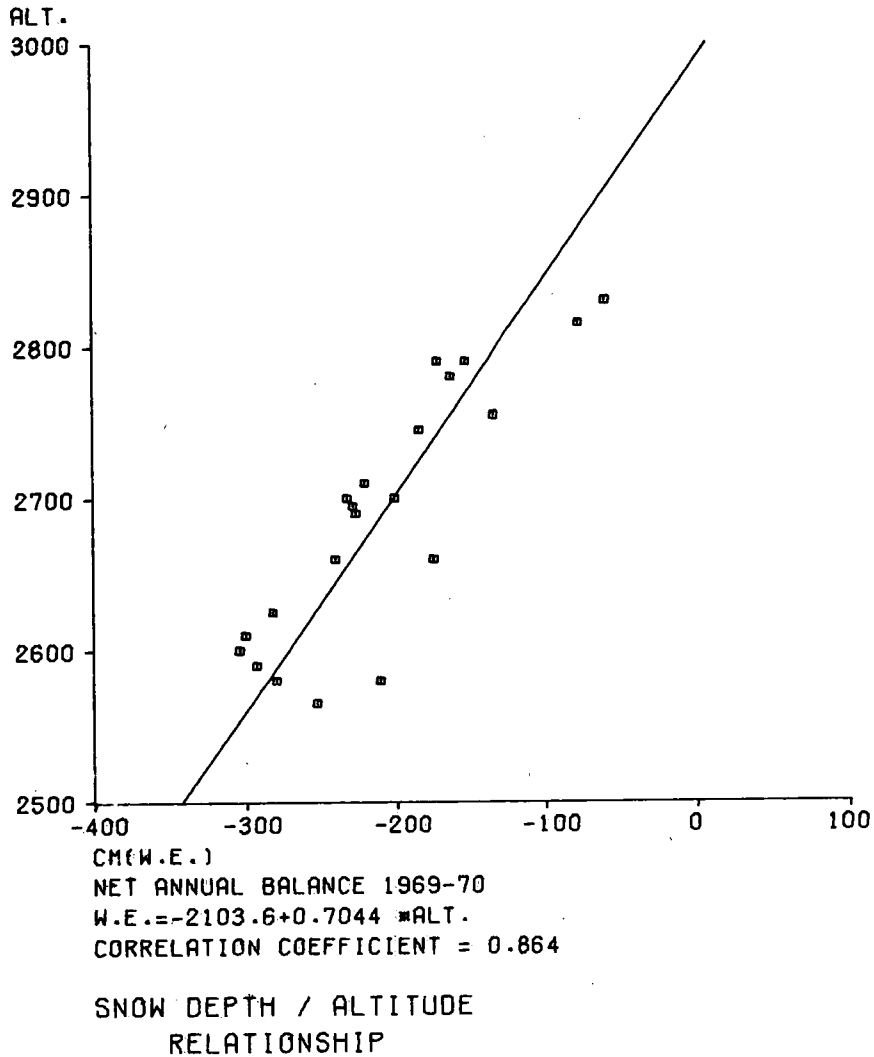


Figure I-27.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

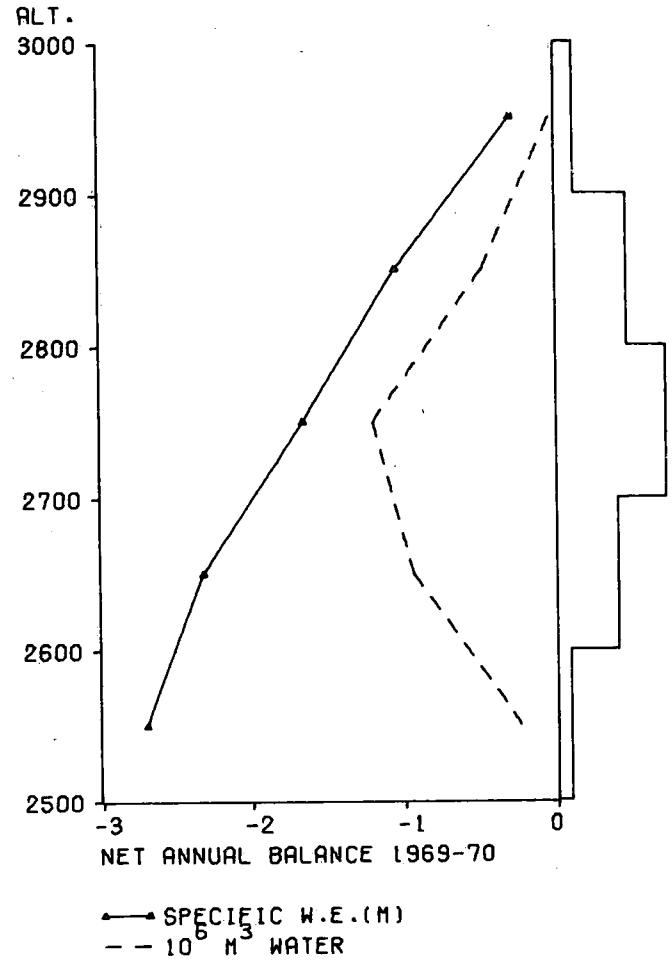
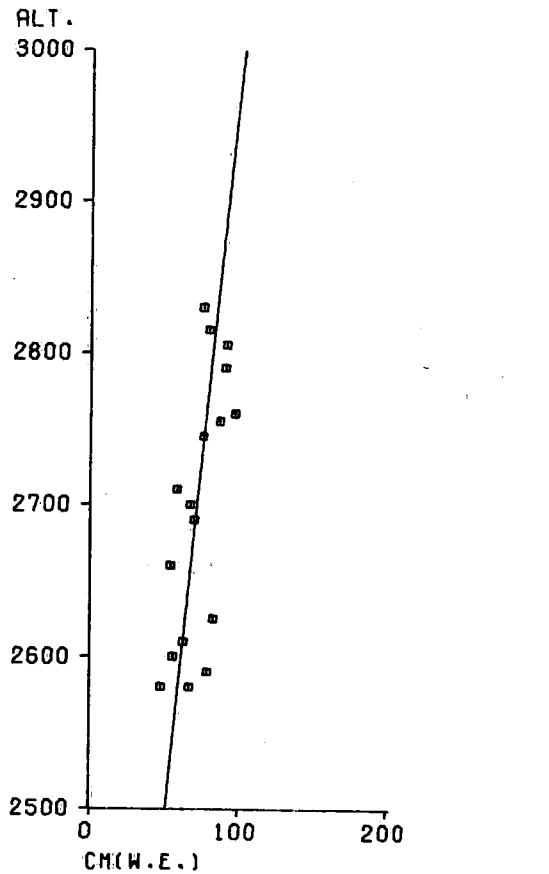
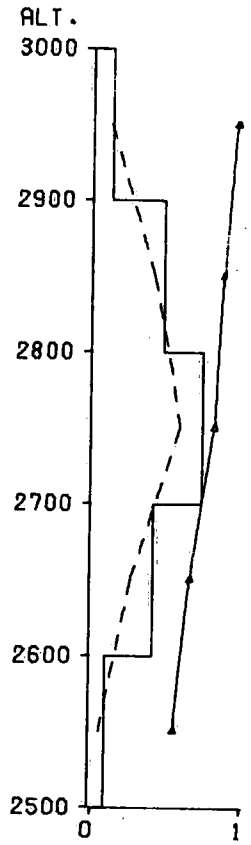


Figure I-28.



NET WINTER BALANCE 1970-71
W.E.=-194.4 +0.0988 *ALT.
CORRELATION COEFFICIENT = 0.610

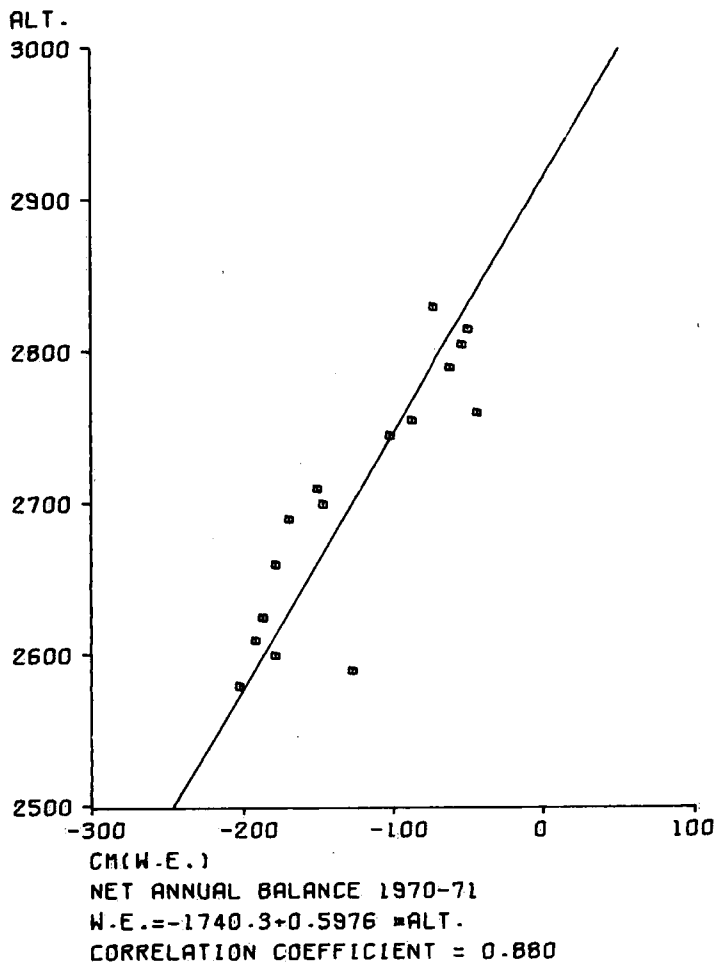
SNOW DEPTH / ALTITUDE
RELATIONSHIP



NET WINTER BALANCE 1970-71

SPECIFIC W.E.(M)
10^6 M^3 WATER

Figure I-29.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

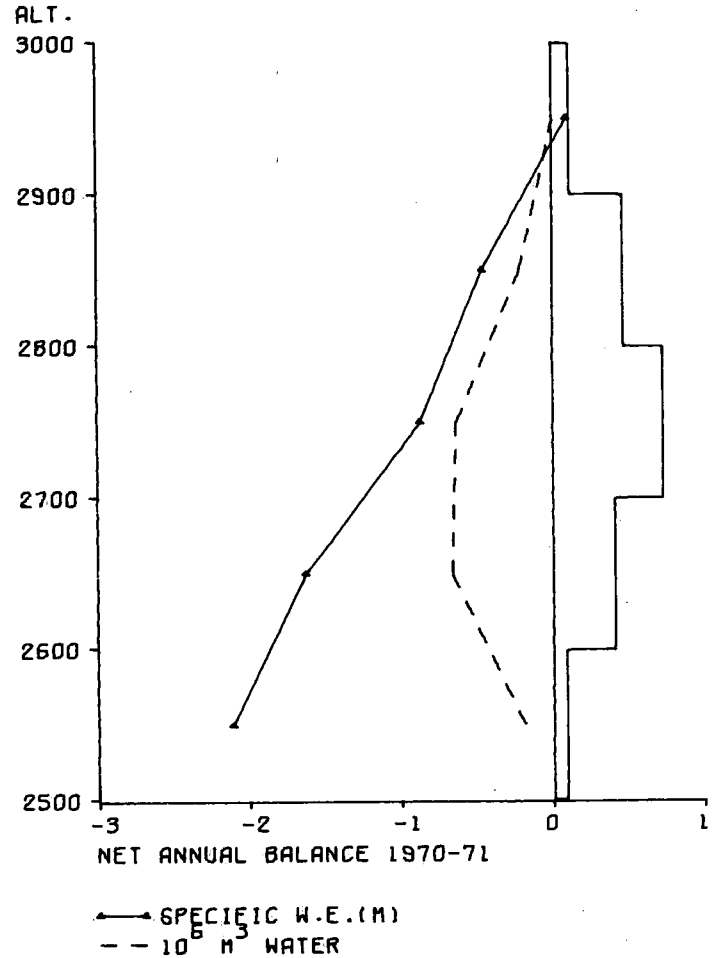
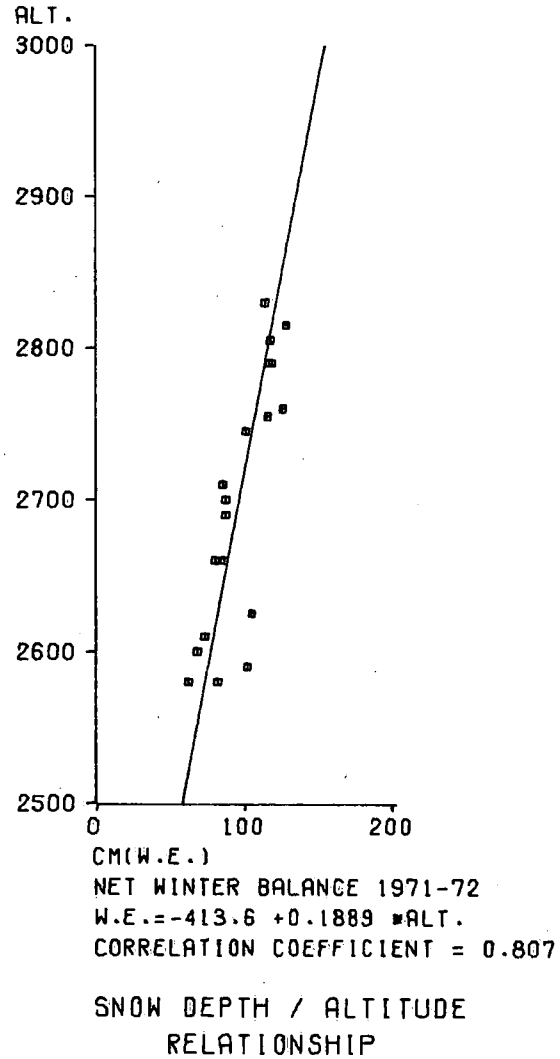


Figure I-30.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

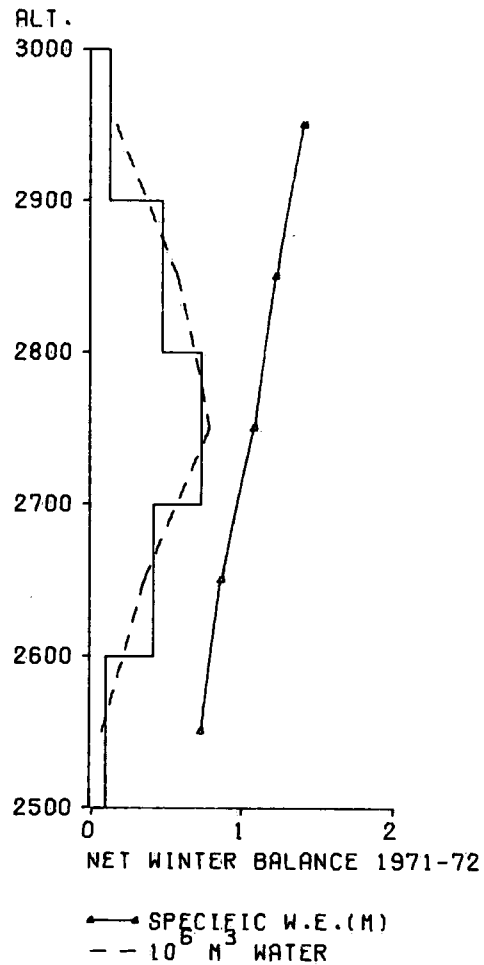
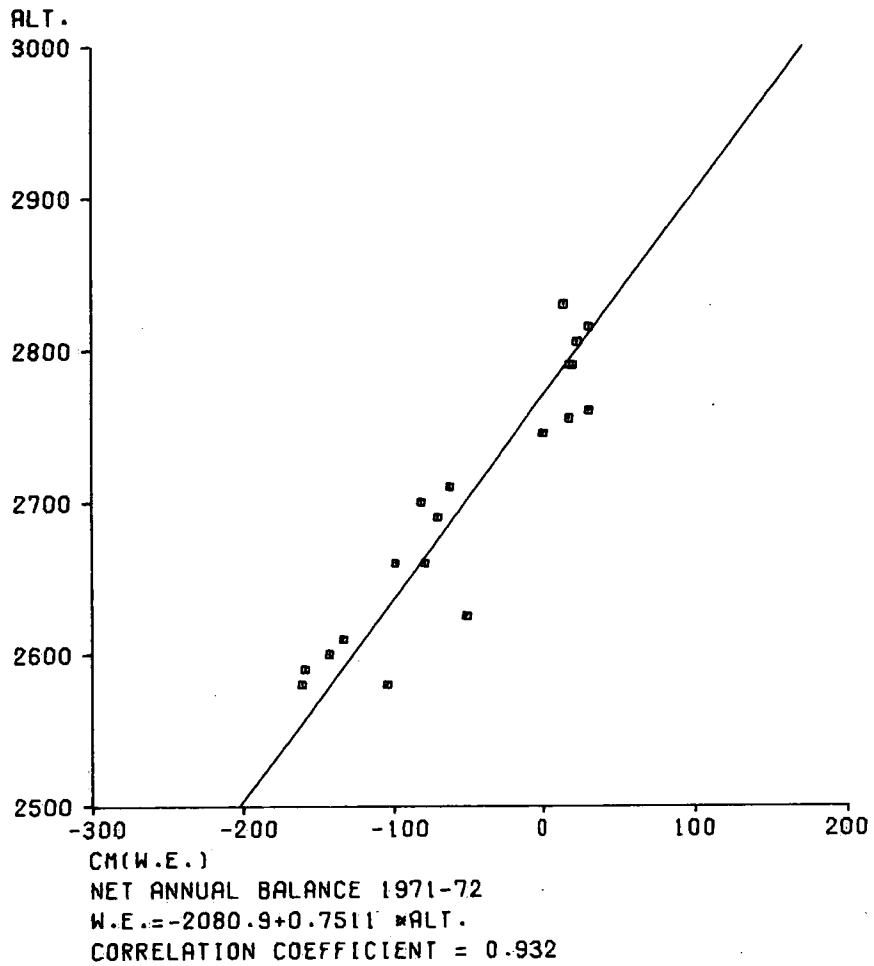


Figure I-31.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

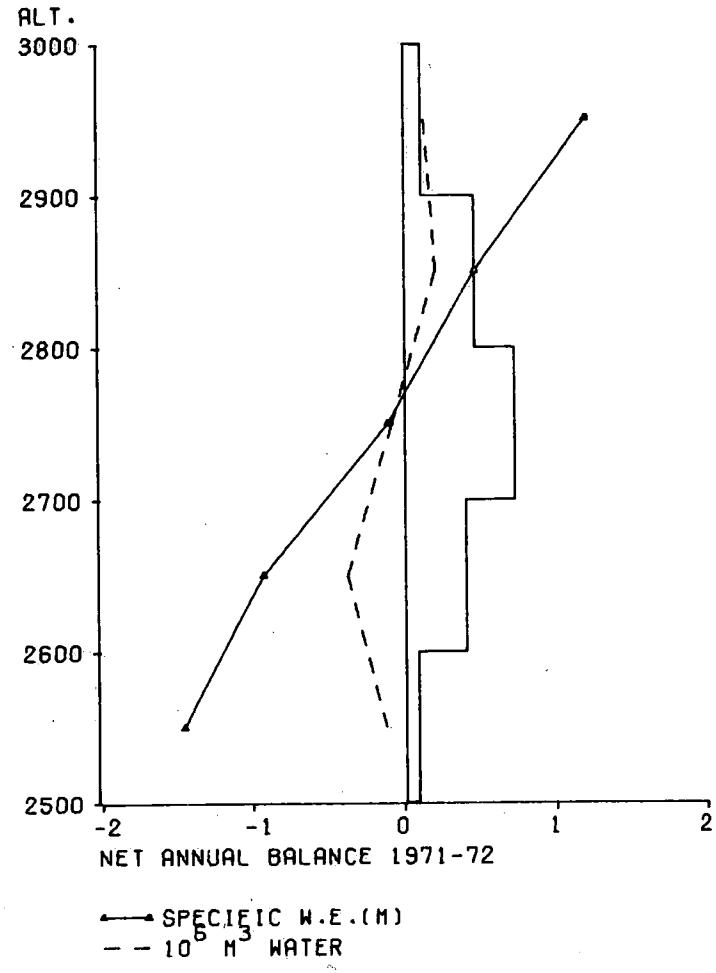
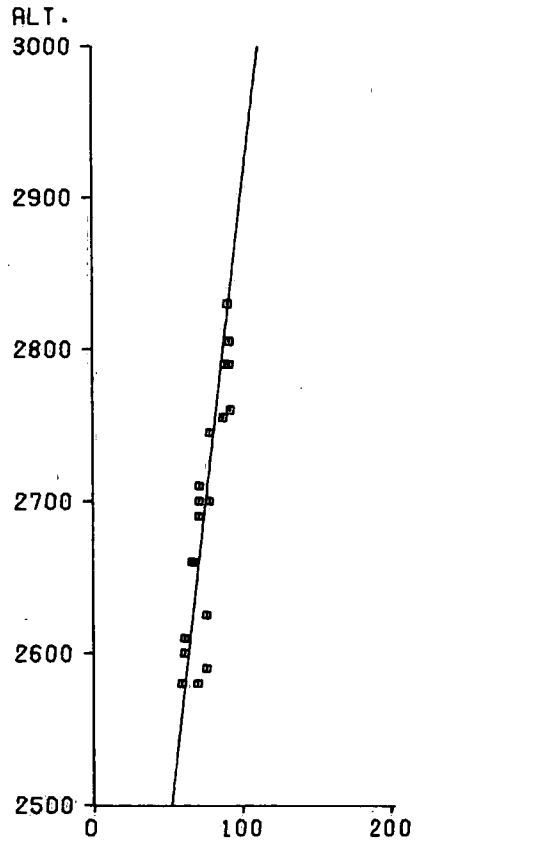


Figure I-32.



NET WINTER BALANCE 1972-73
W.E.=-235.8 +0.1154 *ALT.
CORRELATION COEFFICIENT = 0.851

SNOW DEPTH / ALTITUDE
RELATIONSHIP

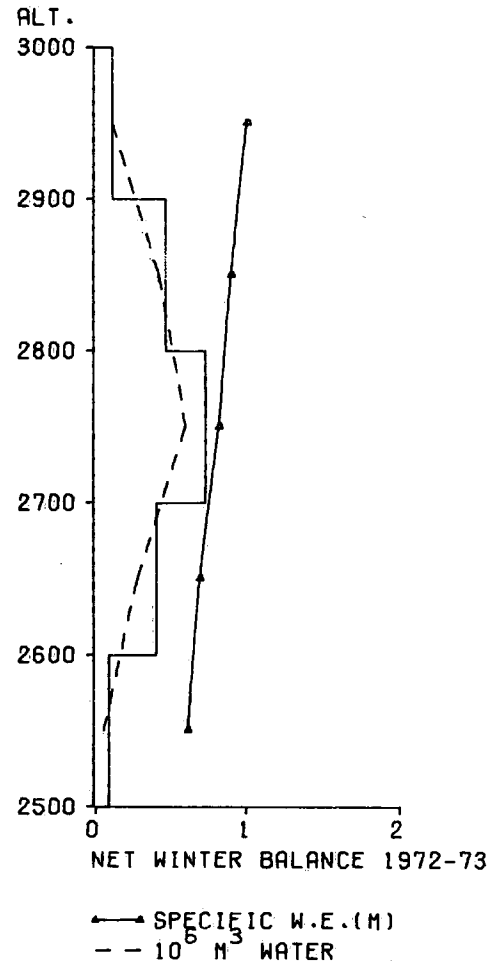
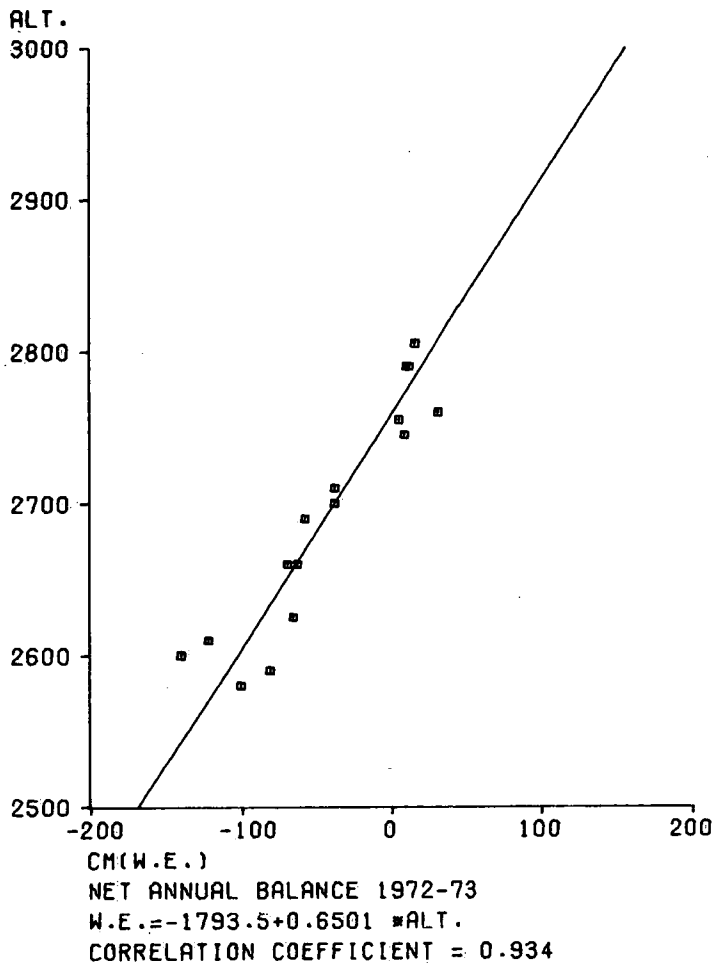


Figure I-33.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

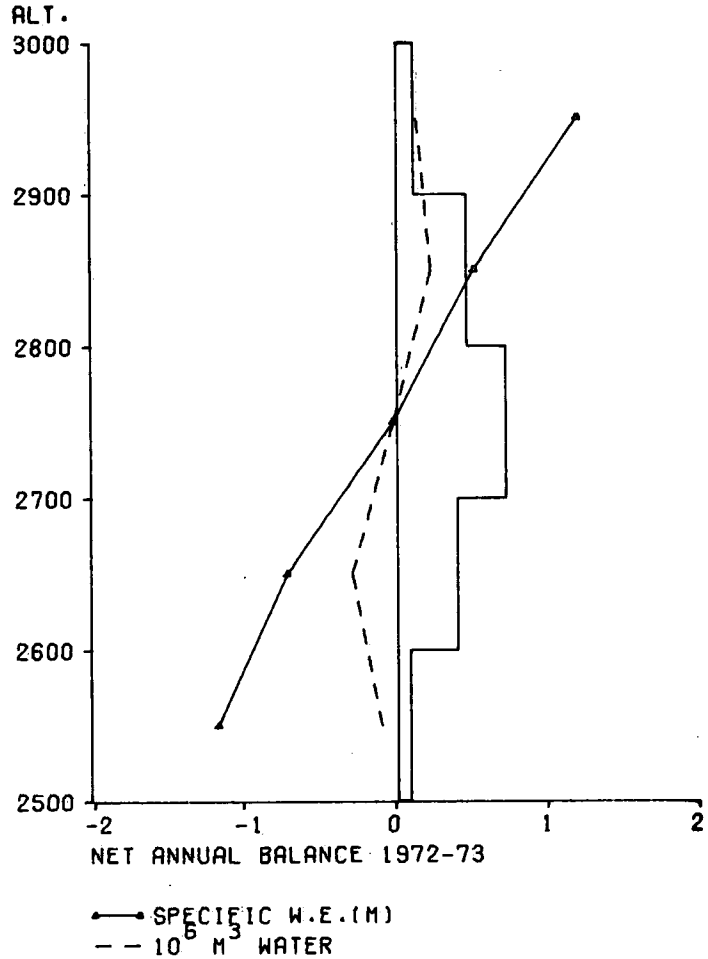
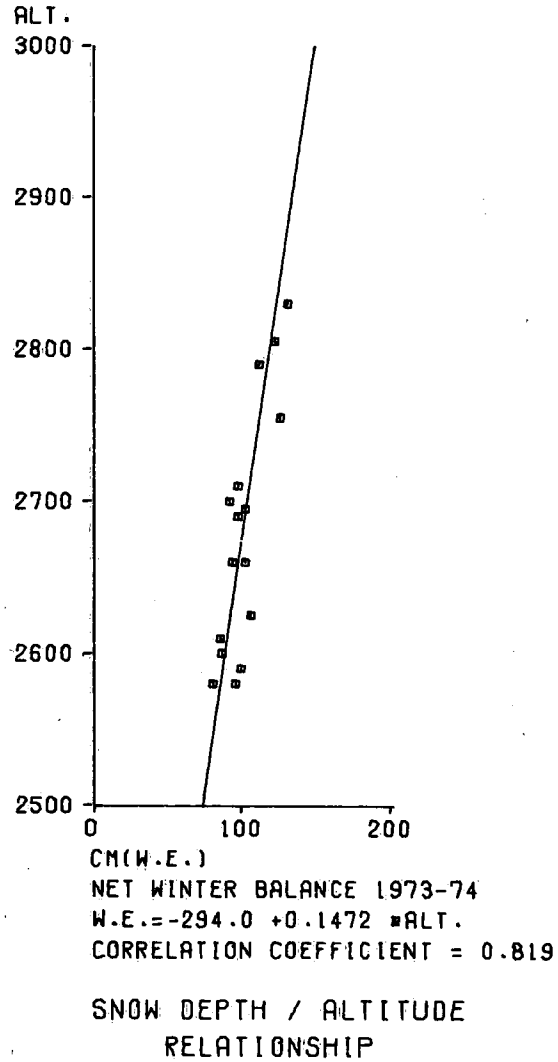


Figure I-34.



SNOW DEPTH / ALTITUDE
RELATIONSHIP

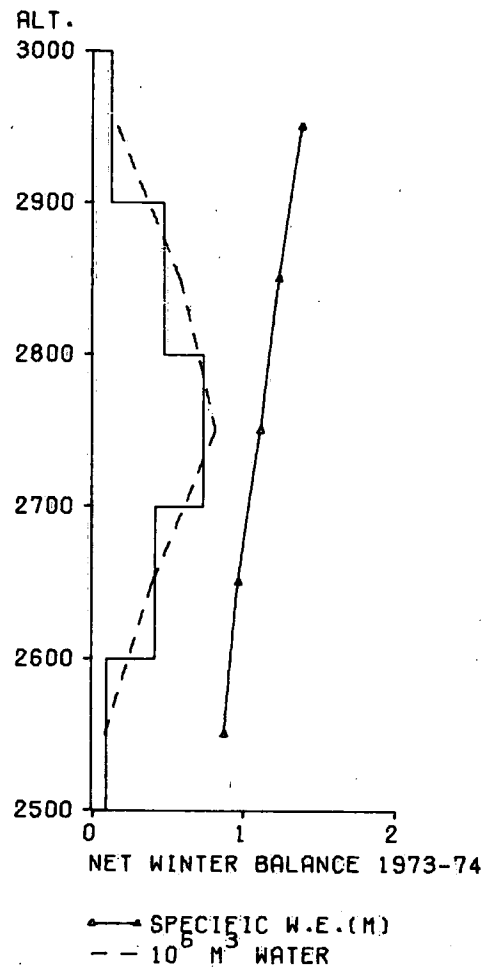
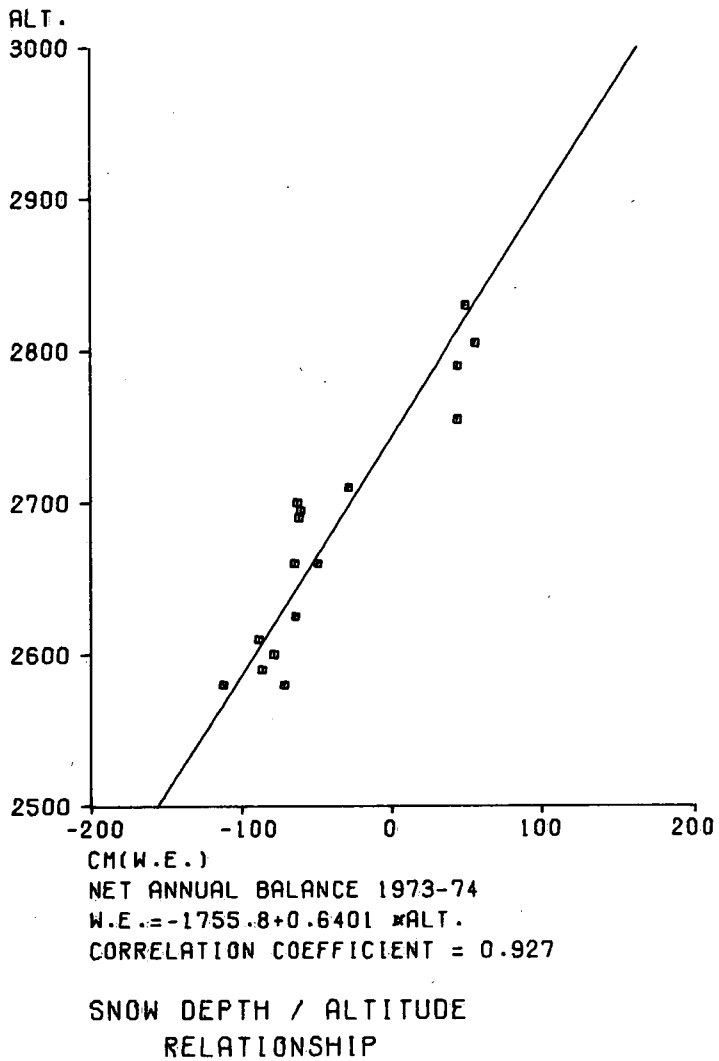


Figure I-35.


ALT.
3000
2900
2800
2700
2600
2500
-200
-100
0
100
200
CM(W.E.)
NET ANNUAL BALANCE 1973-74
W.E.=-1755.8+0.6401 *ALT.
CORRELATION COEFFICIENT = 0.927
SNOW DEPTH / ALTITUDE
RELATIONSHIP

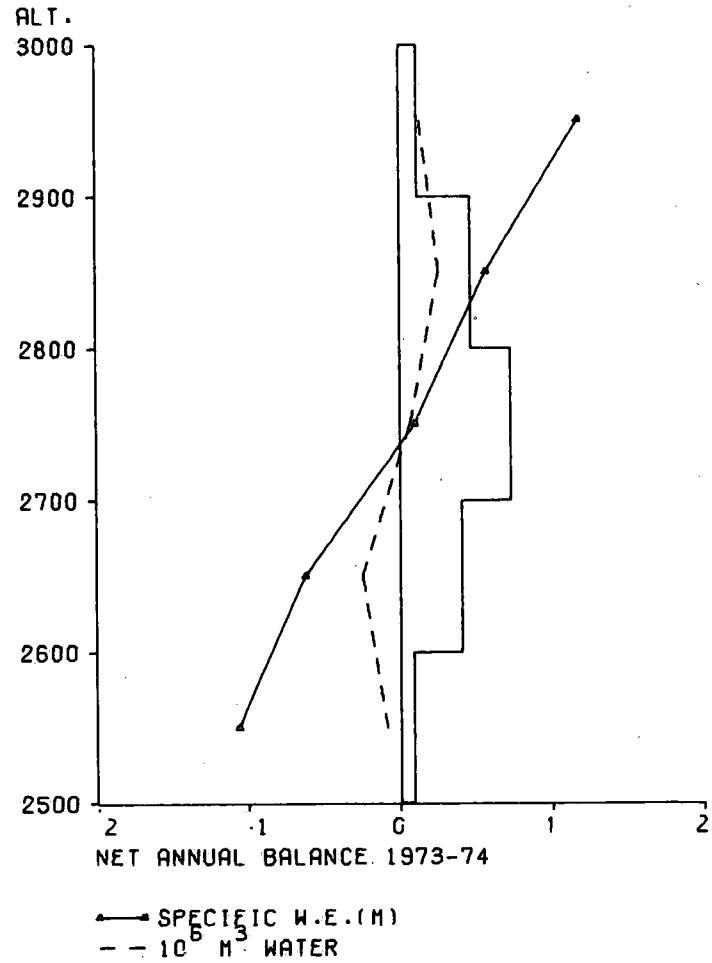

ALT.
3000
2900
2800
2700
2600
2500
2
-1
0
1
2
NET ANNUAL BALANCE 1973-74
SPECIFIC W.E.(M)
10^6 M^3 WATER

Figure I-36.

Table I-1. Ram River Glacier, mass balance, 1965-66.

Elevation, m a.s.l.	Area, km^2	Winter balance Total $10^6 m^3$	Winter balance Specific m	Net annual balance Total $10^6 m^3$	Net annual balance Specific m
2900–3000	0.11	0.17	1.53	+0.17	+1.52
2800–2900	0.46	0.58	1.25	+0.32	+0.70
2700–2800	0.73	0.75	1.03	+0.05	+0.07
2600–2700	0.41	0.30	0.74	-0.32	-0.77
2500–2600	0.09	0.05	0.56	-0.12	-1.34
Whole glacier	1.80	1.85	1.03	+0.11	+0.06

Table I-2. Ram River Glacier, mass balance, 1966-67.

Elevation, m a.s.l.	Area, km^2	Winter balance Total $10^6 m^3$	Winter balance Specific m	Net annual balance Total $10^6 m^3$	Net annual balance Specific m
2900–3000	0.11	0.14	1.24	+0.09	+0.83
2800–2900	0.46	0.49	1.06	-0.09	-0.19
2700–2800	0.73	0.66	0.90	-0.74	-1.02
2600–2700	0.41	0.30	0.73	-0.84	-2.05
2500–2600	0.09	0.06	0.62	-0.24	-2.71
Whole glacier	1.80	1.64	0.91	-1.84	-1.02

Table I-3. Ram River Glacier, mass balance, 1967-68.

Elevation, m a.s.l.	Area, km^2	Winter balance Total $10^6 m^3$	Winter balance Specific m	Net annual balance Total $10^6 m^3$	Net annual balance Specific m
2900–3000	0.11	0.14	1.24	+0.14	+1.24
2800–2900	0.46	0.50	1.08	+0.40	+0.86
2700–2800	0.73	0.69	0.95	+0.28	+0.39
2600–2700	0.41	0.32	0.79	-0.09	-0.22
2500–2600	0.09	0.06	0.70	-0.06	-0.62
Whole glacier	1.80	1.71	0.95	+0.67	+0.37

Table I-4. Ram River Glacier, mass balance, 1968-69.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.13	1.19	+0.13	+1.19
2800–2900	0.46	0.45	0.98	+0.22	+0.47
2700–2800	0.73	0.61	0.84	-0.15	-0.20
2600–2700	0.41	0.25	0.60	-0.48	-1.17
2500–2600	0.09	0.04	0.47	-0.16	-1.78
Whole glacier	1.80	1.48	0.82	-0.44	-0.24

Table I-5. Ram River Glacier, mass balance, 1969-70.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.10	0.93	-0.03	-0.30
2800–2900	0.46	0.37	0.80	-0.49	-1.06
2700–2800	0.73	0.51	0.70	-1.21	-1.66
2600–2700	0.41	0.24	0.58	-0.95	-2.32
2500–2600	0.09	0.05	0.52	-0.24	-2.71
Whole glacier	1.80	1.26	0.70	-2.93	-1.63

Table I-6. Ram River Glacier, mass balance, 1970-71.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.10	0.95	+0.01	+0.10
2800–2900	0.46	0.40	0.86	-0.21	-0.46
2700–2800	0.73	0.59	0.81	-0.51	-0.87
2600–2700	0.41	0.27	0.65	-0.67	-1.63
2500–2600	0.09	0.05	0.55	-0.11	-2.11
Whole glacier	1.80	1.40	0.78	-1.69	-0.94

Table I-7. Ram River Glacier, mass balance, 1971-72.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.16	1.41	+0.13	+1.20
2800–2900	0.46	0.56	1.22	+0.22	+0.47
2700–2800	0.73	0.79	1.08	-0.07	-0.10
2600–2700	0.41	0.35	0.86	-0.38	-0.93
2500–2600	0.09	0.06	0.72	-0.13	-1.46
Whole glacier	1.80	1.93	1.07	-0.23	-0.13

Table I-8. Ram River Glacier, mass balance, 1972-73.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.11	1.01	+0.11	+1.01
2800–2900	0.46	0.41	0.90	+0.24	+0.52
2700–2800	0.73	0.60	0.82	-0.01	-0.02
2600–2700	0.41	0.28	0.69	-0.30	-0.72
2500–2600	0.09	0.06	0.62	-0.11	-1.18
Whole glacier	1.80	1.46	0.81	-0.07	-0.04

Table I-9. Ram River Glacier, mass balance, 1973-74.

Elevation, m a.s.l.	Area, km^2	Winter balance		Net annual balance	
		Total $10^6 m^3$	Specific m	Total $10^6 m^3$	Specific m
2900–3000	0.11	0.15	1.38	+0.13	+1.17
2800–2900	0.46	0.57	1.23	+0.26	+0.56
2700–2800	0.73	0.81	1.11	+0.07	+0.10
2600–2700	0.41	0.39	0.96	-0.26	-0.63
2500–2600	0.09	0.08	0.87	-0.10	-1.07
Whole glacier	1.80	2.00	1.11	+0.11	+0.06

Appendix II

Meteorological and hydrological summaries

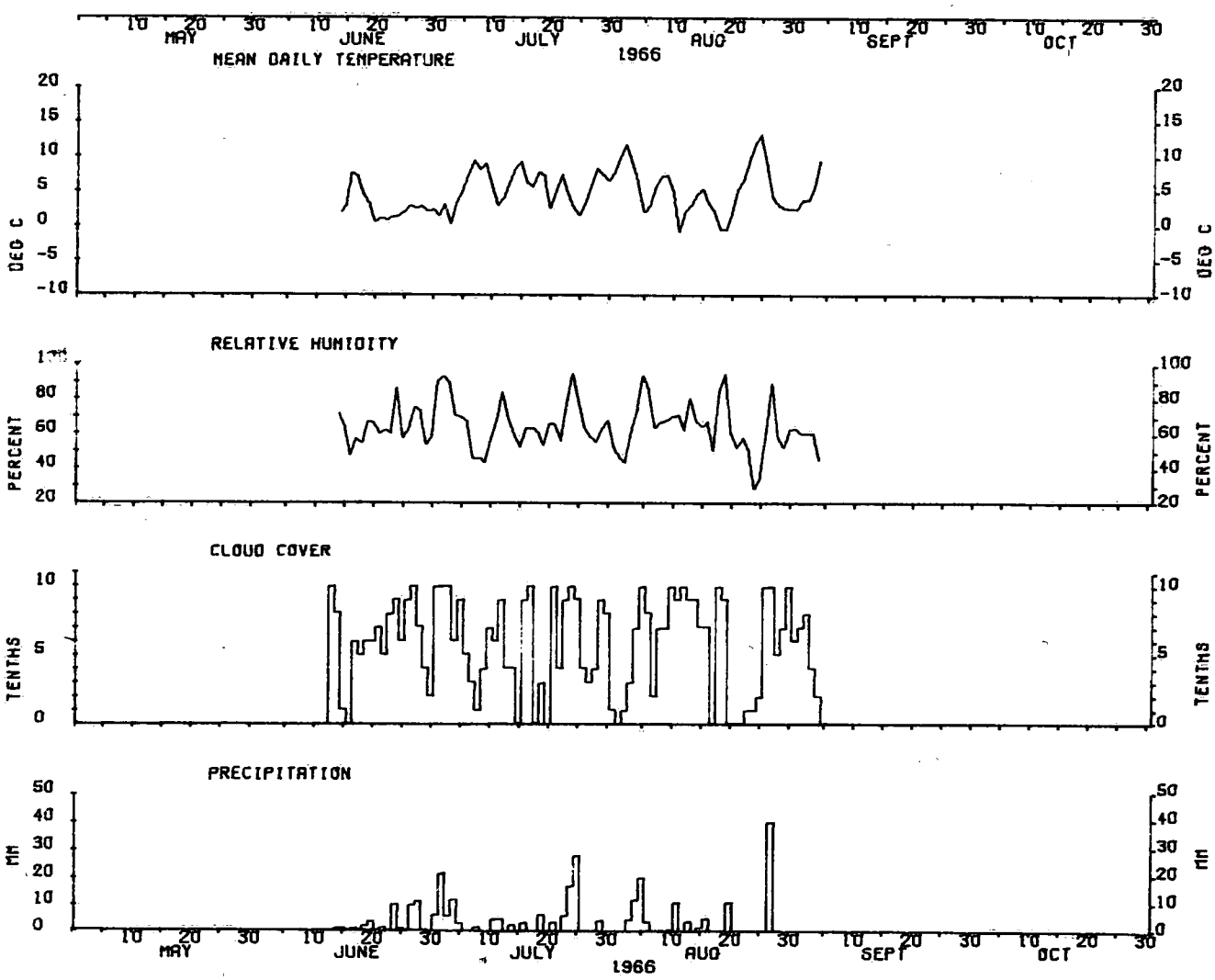


Figure II-1. Ram River Glacier, 1966.

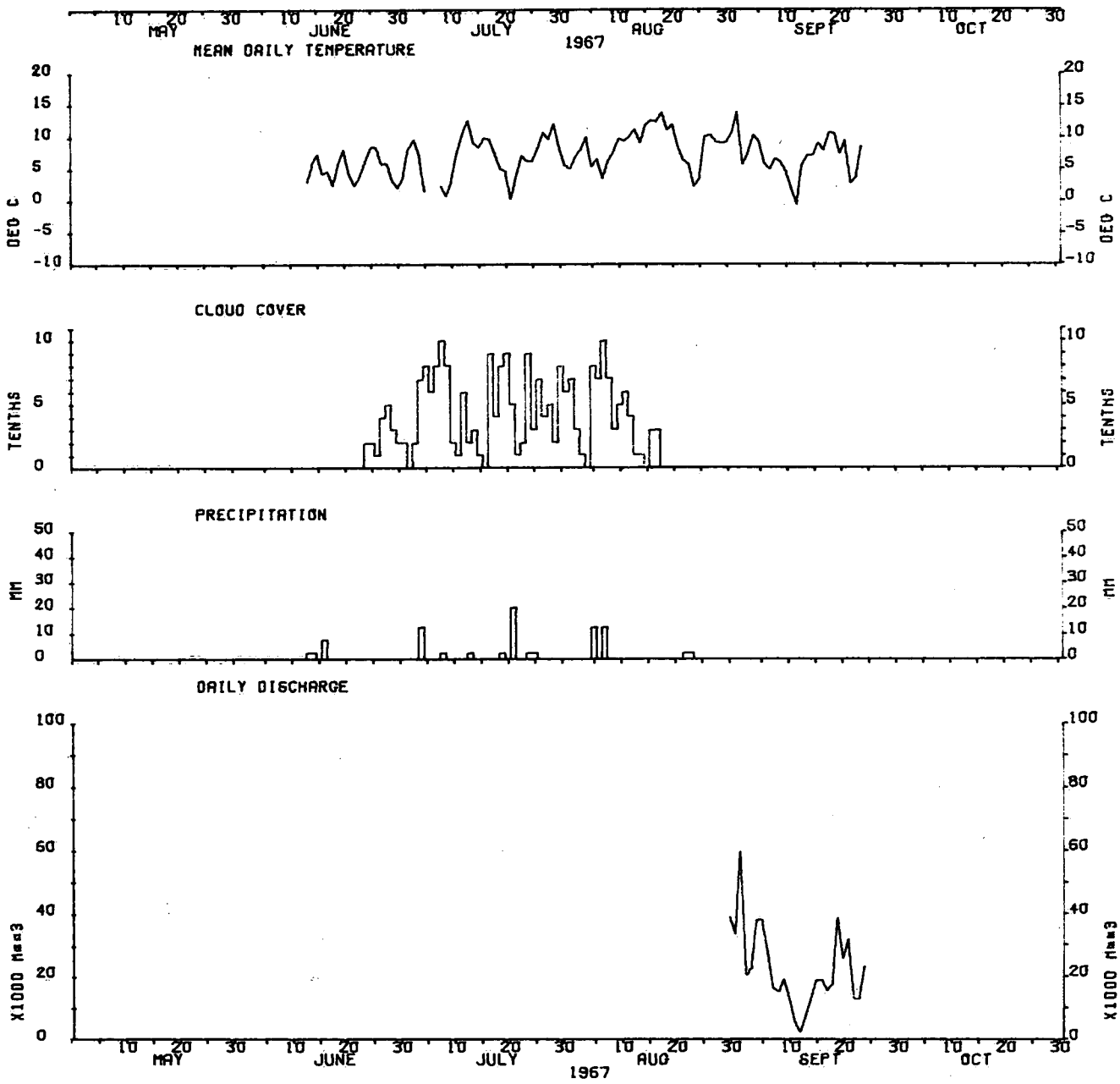


Figure II-2. Ram River Glacier, 1967.

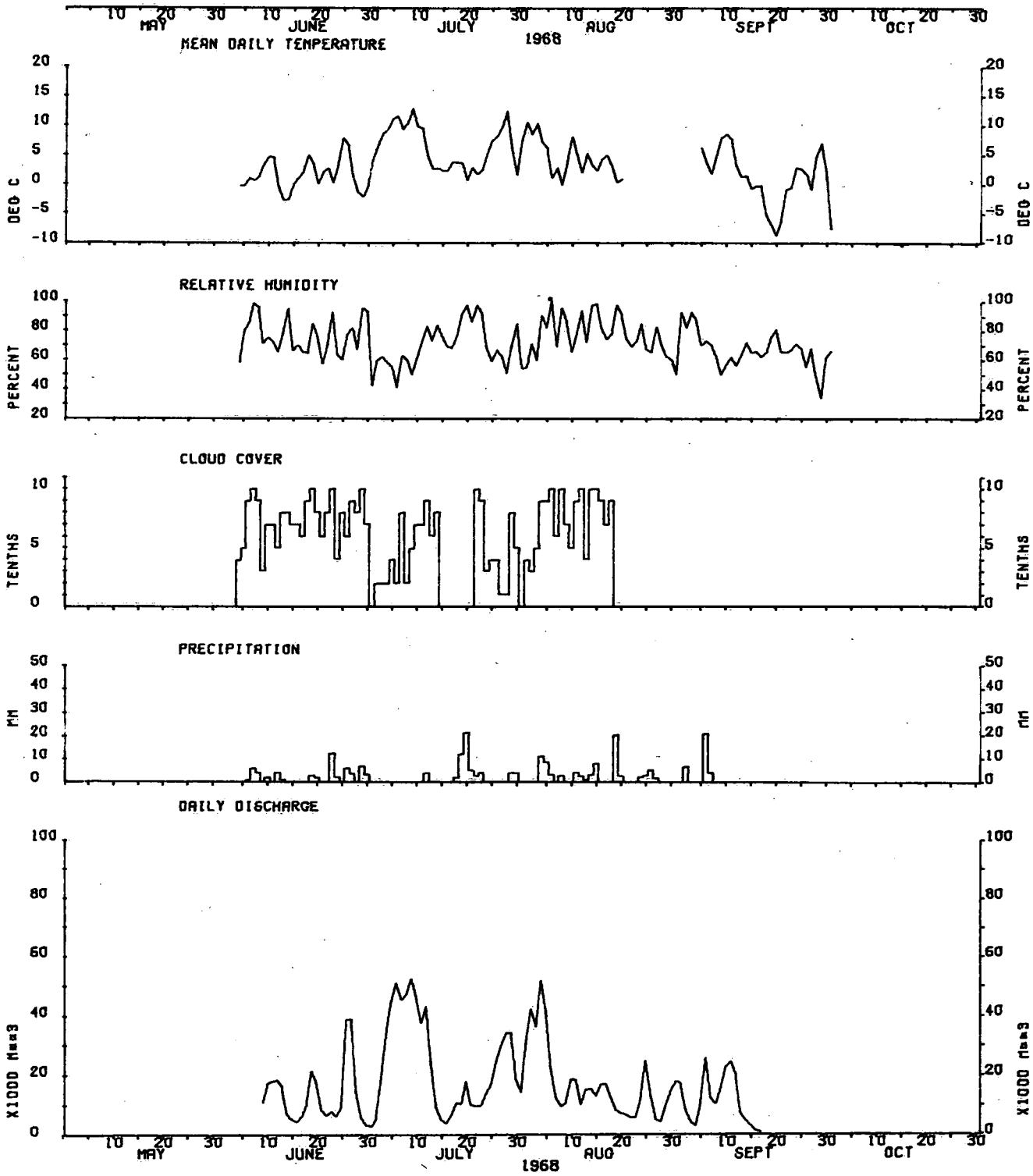


Figure II-3. Ram River Glacier, 1968.

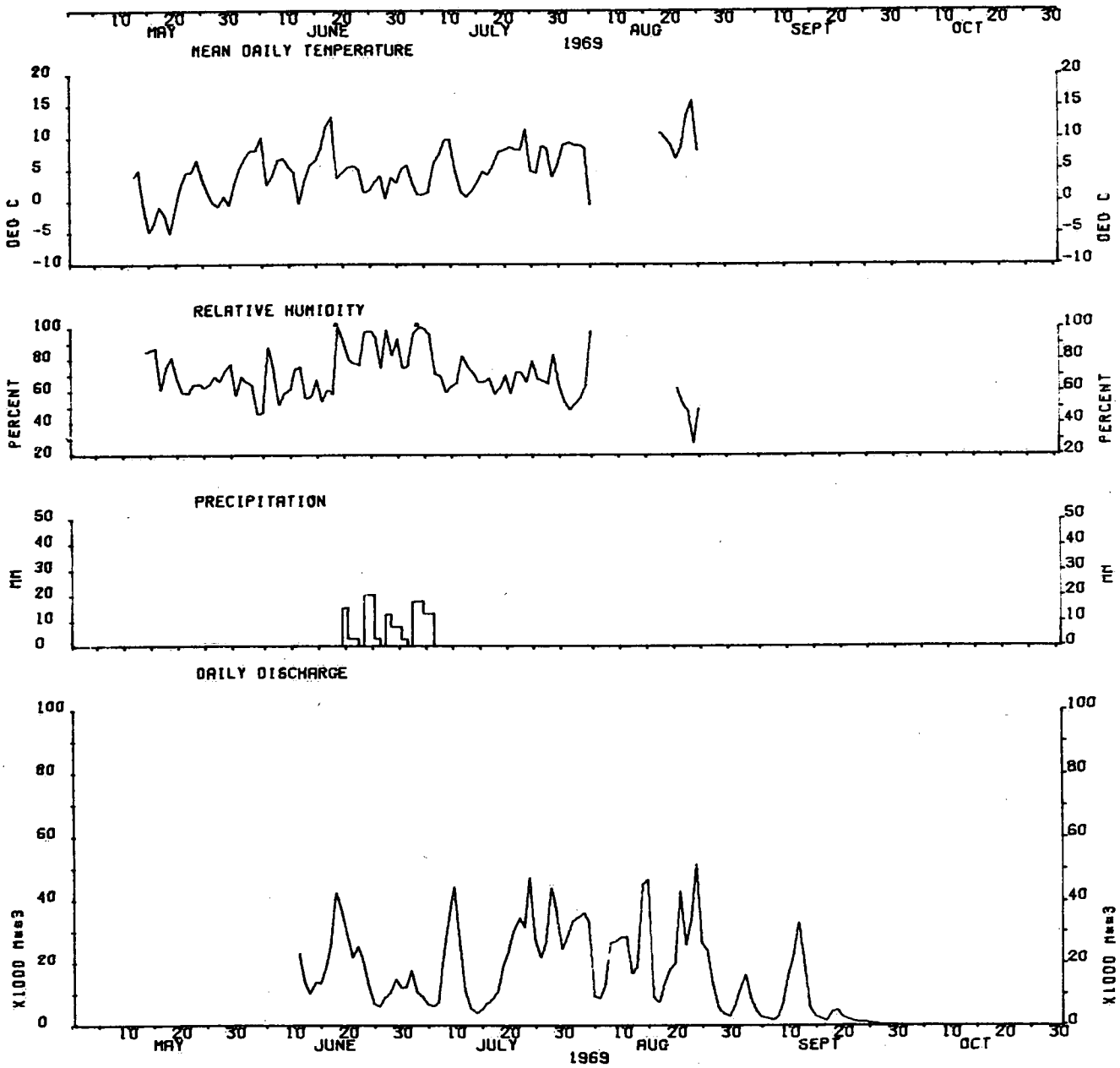


Figure II-4. Ram River Glacier, 1969.

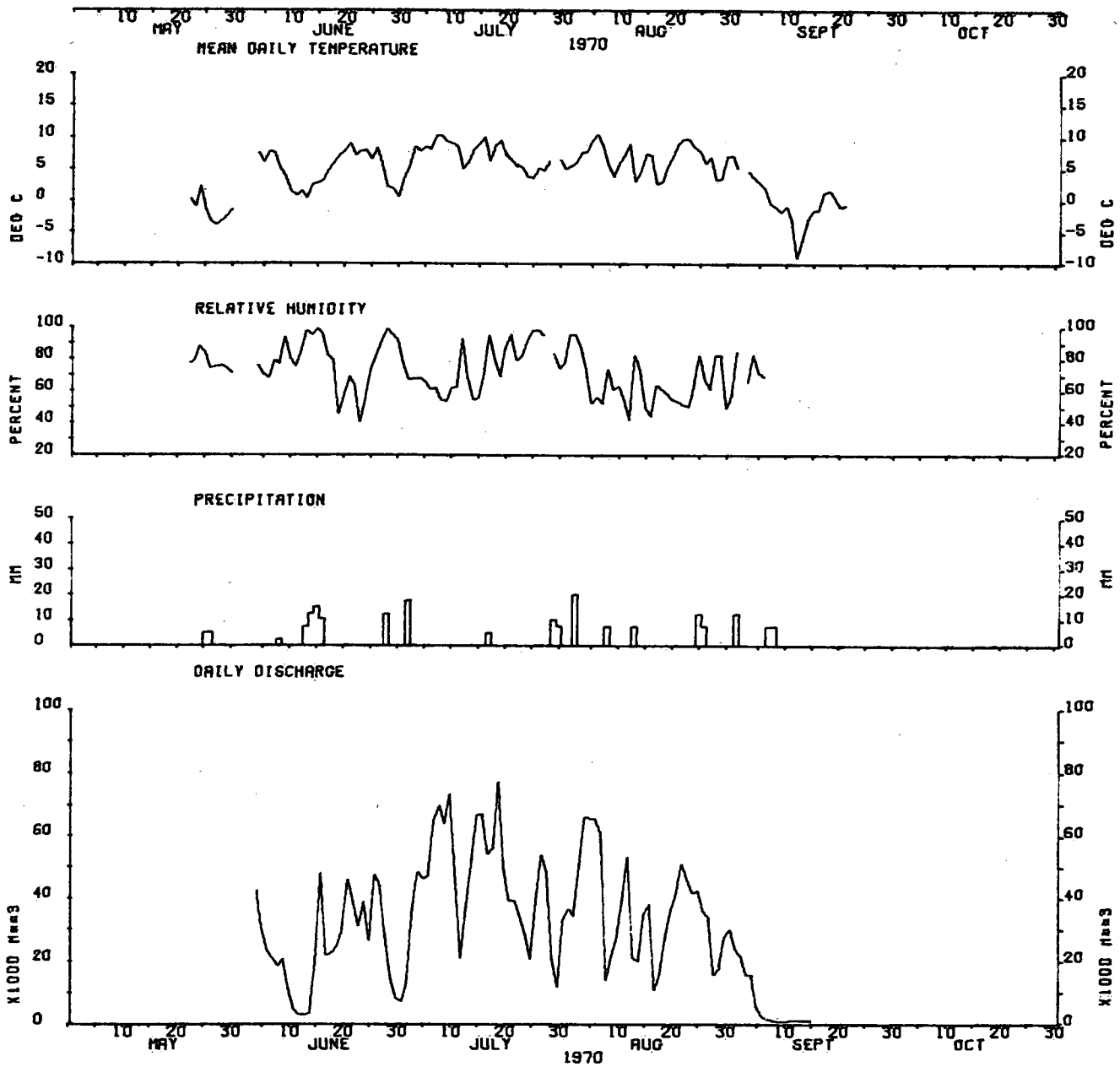


Figure II-5. Ram River Glacier, 1970.

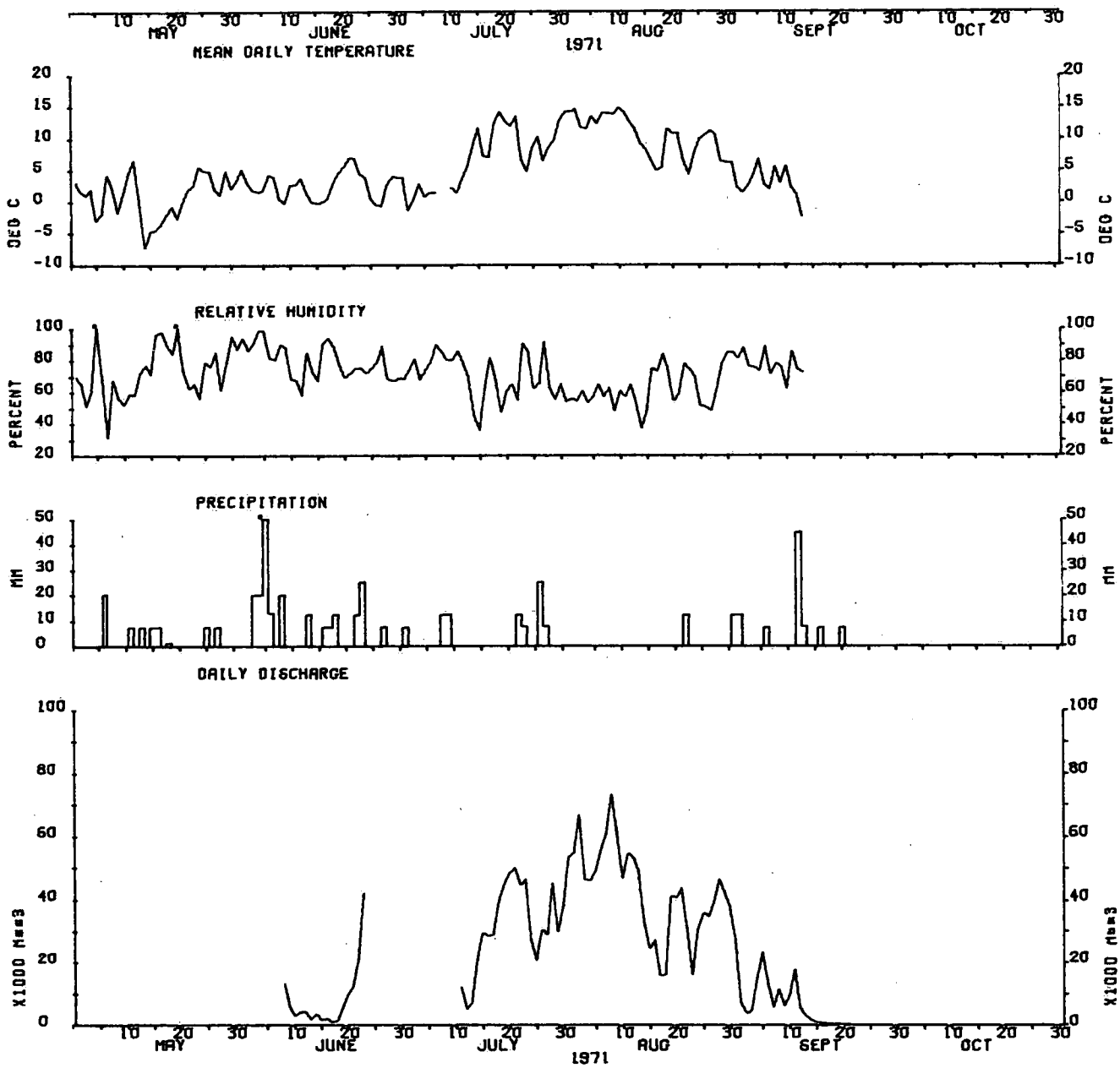


Figure II-6. Ram River Glacier, 1971.

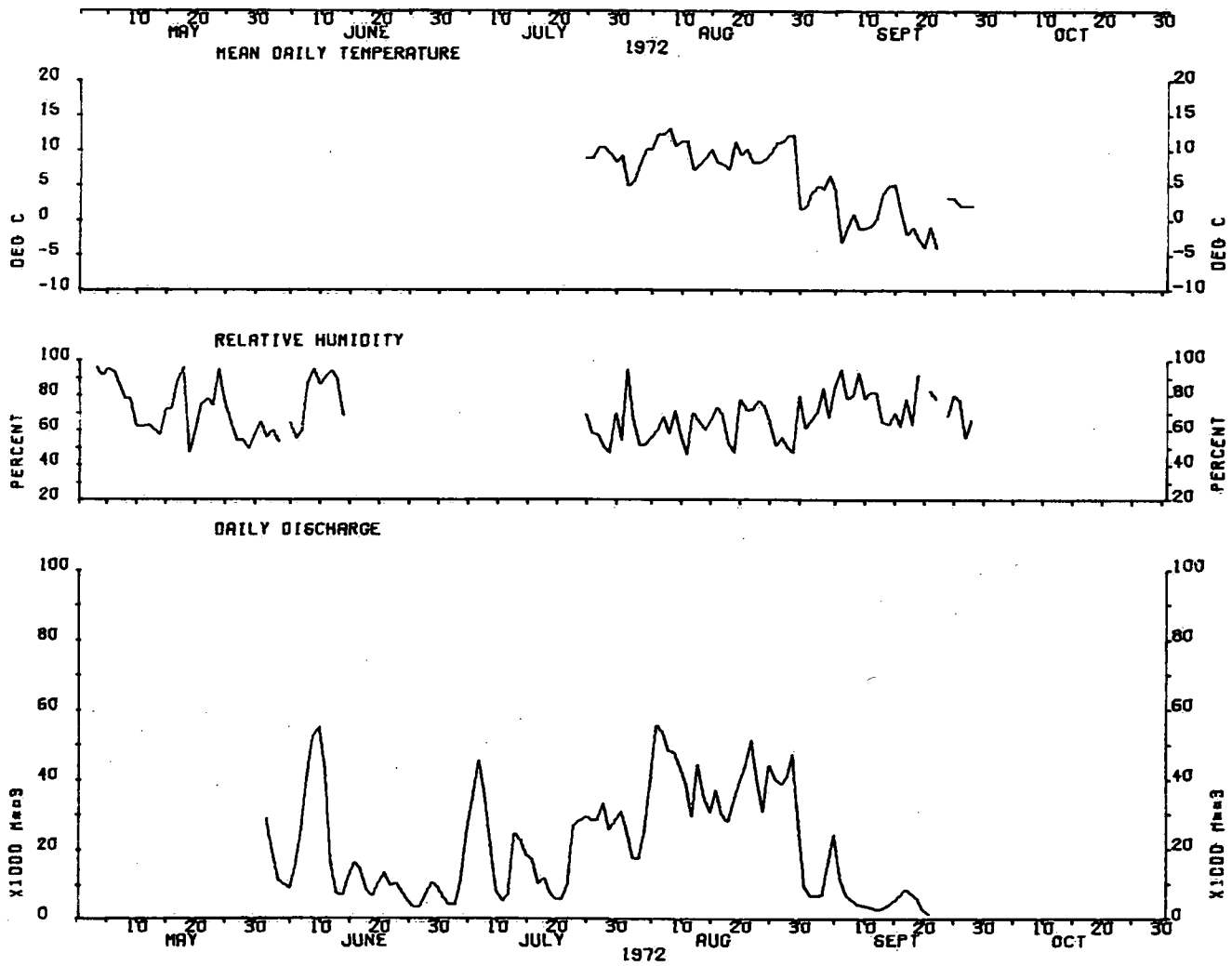


Figure II-7. Ram River Glacier, 1972.