Environment Canada Imaging Cover Page

Report N.: *TEC-830*

SKP Box Number: 672672428

Environment Canada Environnement Canada

Atmospheric Environment Environnement atmosphérique

Technical Memoranda

ALASKA HIGHWAY RAINSTORM OF JULY 15-16, 1974

by

S.T. STOBBE

U.D.C: 551.577.37
ISSN: 0068-7804

TEC 830
9 MARCH 1976

ENVIRONMENT CANADA - ATMOSPHERIC ENVIRONMENT SERVICE
4905 Dufferin Street
Downsview, Ontario

ALASKA HIGHWAY RAINSTORM OF JULY 15-16, 1974

by

S. T. Stobbe

ABSTRACT

The heavy rainstorm of July 15-16, 1974 in a remote area of northeastern British Columbia, resulted in a 10-day closure of the Alaska Highway. In this article, the author examines the synoptic weather features and contributing factors to precipitation in the storm. A short discussion of the return period for such a storm and a verification of the Canadian Meteorological Centre's Quantitative Precipitation Forecast are included.

TEMPÊTE DE PLUIE DES 15 et 16 JUILLET 1974 SUR LA ROUTE DE L'ALASKA

par

S. T. Stobbe

RÉSUMÉ

La violente tempête de pluie qui s'est abattue, les 15 et 16 juillet 1974, sur une région éloignée du nord-est de la Colombie-Britannique a entraîné la fermeture de la route de l'Alaska pendant dix jours. Dans cet article, l'auteur examine les caractéristiques météorologiques synoptiques et les facteurs qui ont contribué aux précipitations lors de la tempête en question. Il étudie brièvement la période de retour d'une tempête semblable et il vérifie la prévision quantitative des précipitations établie par le Centre météorologique canadien.

ALASKA HIGHWAY RAINSTORM OF JULY 15-16, 1974

by

S. T. Stobbe

(Manuscript received January 16, 1975)

1. Introduction

A rainstorm on July 15 and 16, 1974 resulted in a 10-day closure of the southern end of Alaska Highway. Miles of road and numerous bridge approaches were washed out in the flooding that occurred. The centre of the storm was in a remote region west of Fort Nelson near Muncho Lake, where rainfall records date back only a few years. Damage to the Alaska Highway placed the storm in a category seldom experienced in post war history.

2. Synoptic Analysis

Prior to the rain, a 500 mb low had been tracking northeastward at 10-15 kts toward the Queen Charlotte Islands. A weak upper trough circulating around the low had passed over northern B.C. during the morning of July 15. As the upper low approached the B.C. coast, a strong southerly flow developed to the east bringing a very warm airmass into southeastern B.C. and southern Alberta. An upper trough which had been moving slowly eastward in the weak circulation in the southern flank of the low entered the northwestern States, and southwestern B.C. shortly before 0000Z July 16 (Figure 1). At the surface, a front was aligned through Fort Nelson-Fort St. John-Jasper-Castlegar at 1200Z July 15. By 0000Z July 16 a rapidly deepening surface low containing a frontal wave had developed in the vicinity of Jasper (Figure 2). By 1200Z July 16, the 500 mb trough had intensified and was in an east-west line north of Prince George (Figure 3). Also by this time, the frontal wave had occluded and the surface low had reached its maximum depth (Figure 4). The surface low had moved northwestward toward Fort Nelson and was located beneath the upper trough.

Fort Nelson's upper air sounding for 1200Z July 16 shows an airmass with θ_w values of 15-18°C (Figure 5). The hodograph (Figure 6) for the same time portrays the strong easterly circulation. This sounding corresponded to the approximate time of the maximum precipitation intensity at both Watson Lake and Fort Nelson (Figure 7).

The 500 mb analysis for 0000Z July 17 (Figure 8) shows that a secondary low had developed just south of Fort Nelson. The surface low (Figure 9) was under the 500 mb low and had begun filling. Although the original frontal wave had degenerated into a weak trowal between Watson Lake and Whitehorse, a satellite photo taken at 1910Z July 16 (Figure 10) indicates an extensive area of cloud over northern B.C. A northeasterly flow of warm moist air circulated over northern B.C. where it was subjected to orographic and frontal lift. The dome of cold air represented by the old cold low near the Charlottes was considerably colder than the new upper low in the Fort Nelson area. Evidence that the airmass from the Queen Charlotte cold low had reached northern B.C. is shown in dew point temperatures of less than $5^{o}C$ at Dease Lake during the storm. This compares with dew points of $10^{o}C$ in the southern Yukon.

3. Storm Rainfall Analysis and Contributing Factors to Precipitation

All available precipitation records were used to construct the isohyetal map in Figure 11. Rainfall is measured every six hours at first class stations including Watson Lake, Fort Nelson, Dease Lake, Fort St. John, Fort Simpson, Teslin and Footner Lake. Daily precipitation entries for these stations are for the 24 hours ending at 0600 GMT of the following day. Other precipitation records are from climatological stations manned by various governmental or industrial agencies. At climatological stations, daily precipitation entries refer to the 24 hour period ending at approximately 8:00 A.M. local time on the following day. Table 1 is a compilation of daily precipitation records.

Tipping bucket raingauge records were examined in the storm area. These records are useful to determine the rate of precipitation. Records for Watson Lake, Fort Nelson, Ware and Dease Lake, are used in this study. The graph in Figure 7 illustrates the results.

Although not officially published due to the station being abandoned during the storm, a precipitation reading for July 15 is included for Prophet River.

During the construction of Figure 11, some attempt was made to examine factors causing the rainfall. The sparcity of data makes the task of locating the area of heaviest rainfall very difficult. Muncho Lake at Mile 456 of the Alaska Highway was the only climatological station along the 300 mile stretch between Fort Nelson and Lower Post. The placement of the rainfall maximum just southeast of Muncho Lake is largely guesswork supported by the observation that the greatest devastation during the floods occurred near this area.

Rainfall associated with the storm began with a series of heavy thunderstorms in northeastern B. C. and southeastern Yukon during the afternoon of July 15. One and one-half to two inches fell in the Peace River region ahead of the cold front during these storms. The airmass over central Alberta had θ_w values of 18-22°C and was extremely unstable. Some of this very warm air reached the Fort Nelson - Watson Lake area as evidenced by precipitation amounts of about one-half inch in thunderstorms during the evening of July 15.

The main portion of the storm began as the rapidly deepening surface low began recurving toward Fort Nelson. This coincided with the occluding of the wave. As the surface low moved under the upper trough (or upper low centre), northeasterly to easterly winds of 30 to 55 knots developed in the surface - 8000 feet layer at Fort Nelson (Figure 6). The rain at Fort Nelson was accompanied by thunder and lightning indicating the presence of unstable air aloft. Watson Lake's rainfall began about the same time but no thunder or lightning were reported. At Dease Lake, the heavy rain began 3 to 4 hours later than at Watson Lake and Fort Nelson.

Factors causing the precipitation in the storm (not necessarily in order of importance) appear to be orographic, frontal, airmass instability and large scale vertical motion due to vorticity and thickness advection. A factor which is more indirect but which causes greatly increased vertical motion and rainfall is the latent heat release when condensation occurs.

In order to rate each factor as a cause of precipitation in this storm, it is best to estimate the vertical motion produced by each factor. Using a method described by Harley et al (1969) to determine spot values of vertical velocity and precipitation rate, some figures were obtained for the July 15-16 storm. Since 1200Z July 16 was approximately the time of maximum precipitation in the storm area, 500 mb and surface charts and upper air data for this time were used as a basis for computations.

The large scale vertical velocity at the 600 mb level is given by an adaptation of Penner's (1963) equation:

$$-\omega_6 = \frac{100}{f^2}\left(\frac{0.13}{2.65} A_{\zeta_a} + 0.0012\ A_h\right) \qquad (1)$$

where ω_6 = large scale vertical velocities at 600 mb, in 10^{-3} mb / sec

$f = 2\Omega \sin\phi$, the Coriolis parameter in $10^{-5}\ sec^{-1}$

A_{ζ_a} = advection of absolute vorticity in $10^{-5} sec^{-1}$

A_h = advection of 1000-500 mb thickness in m/3 hours.

Using the advection scale of Ferguson (1963) on the 161200Z 500 mb charts in the vicinity of Fort Nelson, a value of 52 units was obtained for vorticity advection and 26 units for the 1000-500 mb thickness advection. Substitution in equation (1) yields $\omega_6 = -3.7 \times 10^{-3}$mb/sec.

To determine the orographic vertical velocity, ω_m, the geostrophic wind and the 1000 foot topographical contour spacing in the area immediately west of Fort Nelson were estimated. Figures of 40 knots and 20 nm were derived. Since winds were perpendicular to the topographical contours, ω_m could be easily read from Harley's Chart 6 giving a value of -9×10^{-3} mb/sec. Using Harley's Chart 8 and interposing values obtained previously, the total vertical velocity $\omega_6 + \omega_m + \omega_H$ (latent heat term) was read as -30×10^{-3} mb/sec. A precipitable water content of .80 in was taken from Chart 9 after inserting values of 5600 meters for the 1000-500 mb thickness and an average elevation of 1500 feet for the Fort Nelson area. The resulting precipitation rate was about 1.2 inches/6 hours.

The figure for the precipitation rate of 1.2 inches/6 hours is about twice the maximum 6 hour precipitation at Fort Nelson as taken from recording raingauge records. There may be several reasons for the difference. One is that instability was present and its effect is highly variable. Secondly, the 1000 foot topographical contour spacing was estimated for the area immediately west of Fort Nelson and may not be applicable for the site itself. Interestingly enough, precipitation rates of over an inch/6 hours were recorded at both Watson Lake and Dease Lake.

Applying the results of the preceding computations to the storm area as a whole, some conclusions can be reached. The release of latent heat was the major contributor to vertical motion. This factor depended on the availability of a very warm airmass. The rapid occlusion process over northern Alberta pinched off the warm airmass very quickly east of Fort Nelson, but to the west the warm airmass remained 6-12 hours longer.

Orographic vertical motion contributed about a third of the total in the Fort Nelson estimate. Nearer the Rockies, the orographic component may have been larger still as the steepness of the slope increased. The area most likely affected would have been immediately east of Muncho

Lake, north of the 10,000' Churchill Peak.

Although seemingly insignificant, the contribution to the vertical motion due to large scale process was nevertheless important in the early stages of the storm. In order to release latent heat, the airmass had to be brought to saturation. This was likely accomplished in most part by the large scale processes of vorticity and thickness advection.

Vertical motion due to fronts was not considered in the Fort Nelson estimate. However, the Polar and Maritime fronts were involved in the storm. In the Peace region, about 2 inches of rain fell in prefrontal thunderstorms. Over-running of Maritime tropical air on the maritime frontal surface may have been a major producer of rain in the area south of the Alaska Highway. Frontal ascent seems to be the only plausible reason for the heavy precipitation rates at Dease Lake. Dease Lake is located west of the Cassiar Mountains and would have been subjected to a downslope flow.

4. Return Period

The lack of precipitation records in the storm area makes the task of estimating a return period for such a storm very difficult. Also the extreme variability of terrain does not allow the transposition of long term records from established stations to remote areas.

One indication of the intensity of the rainfall was that total precipitation at Watson Lake from 7 A.M. PST July 15 to 7 A.M. PST July 16, of 1.79 inches equalled the greatest 24 hour precipitation ever recorded at the site.

Another indication of the severity of the event is provided in Figures 12 and 13. The Alaska Highway was built in the early forties and such destruction has not been experienced in its approximate forty years of existence.

5. Verification of CMC QPF Package

Package based on 151200Z data

The precipitation forecast was for amounts in excess of 1.5 inches over northeastern B.C. The forecast for the 24 hour period ending 161200Z for Watson Lake for about 0.75 inches and the actual occurrence was 1.15 inches, for Fort Nelson 1.5 inches and the actual 0.99 inches.

Package based on 160000Z data

The precipitation forecast was for amounts ranging from 0.50 to 4.00 inches for the Alaska Highway between miles 0 and 600. Actual rainfalls for the 24 hour period ending 170000Z were 1.66 at Watson Lake, 1.43 inches at Fort Nelson and likely higher between these locations.

6. Conclusions

a) The July 15-16, 1974 rainstorm involved the northward motion of a breakoff upper low and an associated frontal wave into northeastern B.C. This triggered the development of a surface low which tracked northward to the vicinity of Fort Nelson before filling. The warm airmass had θ_w values of 15-20°C.

b) The main factors producing vertical motion and rainfall were:

(1) Release of latent heat of condensation - due to its warmness and moisture content, the airmass could release large amounts of heat.

(2) Orographic ascent - winds 50 knots were present at levels from the surface to over 10 thousand feet in a direction perpendicular to the northern B.C. Rockies.

(3) Large scale ascent appeared to be responsible for the initial development of precipitation.

(4) Instability was present and may have resulted in local variations in intensity.

(5) Cold maritime air over northern B.C. could have been a factor in prolonging heavy rainfalls in northern B.C. in non-upslope areas.

c) A return period for a similar storm to this one could not be ascertained due to insufficient records. The storm produced one of the heaviest 24 hour rainfalls in Watson Lake's 36 year history.

d) The quantitative precipitation forecast (QPF) chart produced by the Canadian Meteorological Center (CMC) verified very well for the storm.

e) As an aid in predicting future rainstorms in the area, the pre-storm synoptic situation had the following characteristics:

(1) Slow-moving or stationary upper low off the B.C. coast and a strong upper ridge over Alberta.

(2) Strengthening southerly flow at 500 mbs over B.C.

(3) An intense upper trough captured in the flow.

(4) High θ_w values over eastern B.C. or Alberta (surface θ_w values of greater than 15°C.

APPROVED,

J. R. H. Noble
Assistant Deputy Minister
Atmospheric Environment Service

References

1. Ferguson, H. L., 1963: A Geostrophic Advection Scale for Polar Stereographic Charts. Canada, Department of Transport, Meteorological Branch, Technical Circular Series, CIR-3847, TEC 473.

2. Harley, W.S., Dragert, H., Rutherford, I.D., 1964: The Determination of Spot Values of Vertical Velocity and Precipitation Rate. Canada, Department of Transport, Meteorological Branch, Technical Circular Series CIR-4139, TEC 544.

3. Penner, C.M., 1963: An Operational Method For the Determination of Vertical Velocities. Journal of Applied Meteorology, Vol. 2, No. 2, pp. 235-41.

TABLE 1

Precipitation amounts observed at AES stations

Station	Date		Total
	July 15	July 16	
Synoptic			
Fort Nelson	.28	1.23	1.51
Watson Lake	.67	1.30	1.97
Dease Lake	.25	1.36	1.61
Fort St. John	1.72	.39	2.11
Teslin	.38	.48	.86
Fort Simpson	Nil	.02	.02
Footner Lake	Nil	.34	.34
Climatological			
Muncho Lake	2.03	1.85	3.88
Pink Mountain	2.39	.50	2.89
Prophet River	3.15	Msg.	3.15(?)
Wonowon	2.42	.04	2.46
Hudson Hope	1.64	Tr	1.64
St. Ware	.63	.42	1.05
Ingenika Point	.67	.26	.93
Fort Liard	.13	.52	.65
Lower Post	1.72	.17	1.89
Good Hope Lake	.83	1.78	2.61
Tuchitua	.93	Nil	.93
Cassiar	.39	1.88	2.27
Kiniskan Lake	Nil	1.05	1.05
Telegraph Creek	.06	.51	.57
Swift River	.61	.47	1.08
Tungsten	.02	Nil	.02

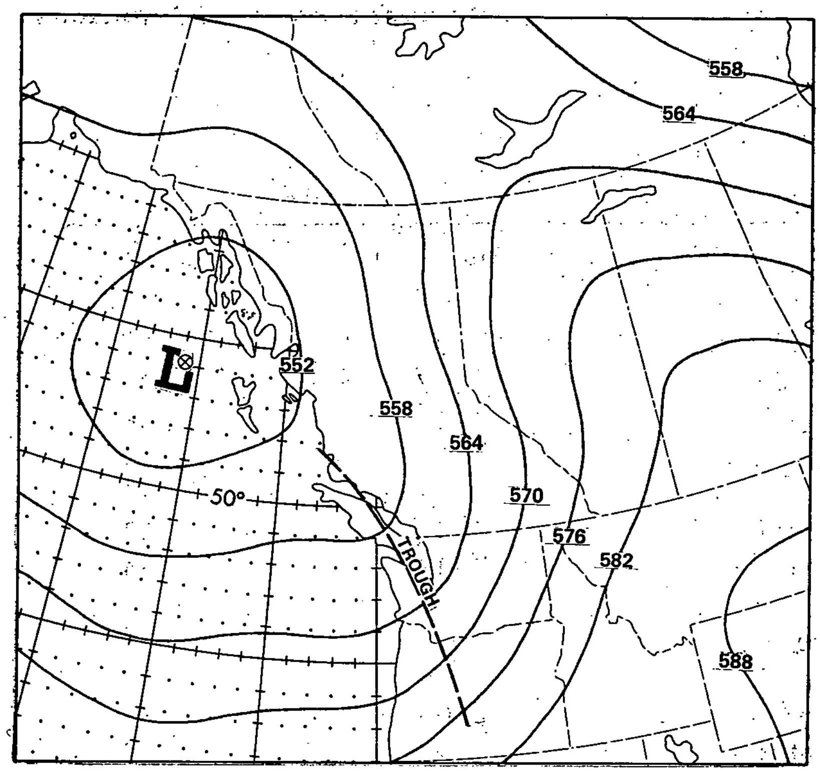

Figure 1 500 mb Analysis 0000Z - July 16, 1974

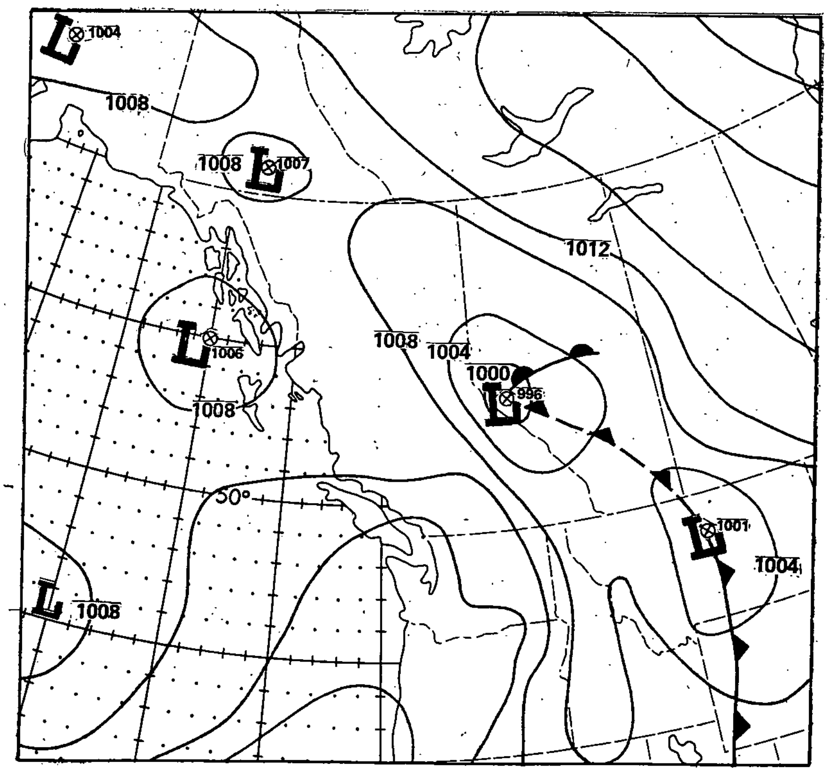

Figure 2 Surface Analysis 0000Z - July 16, 1974

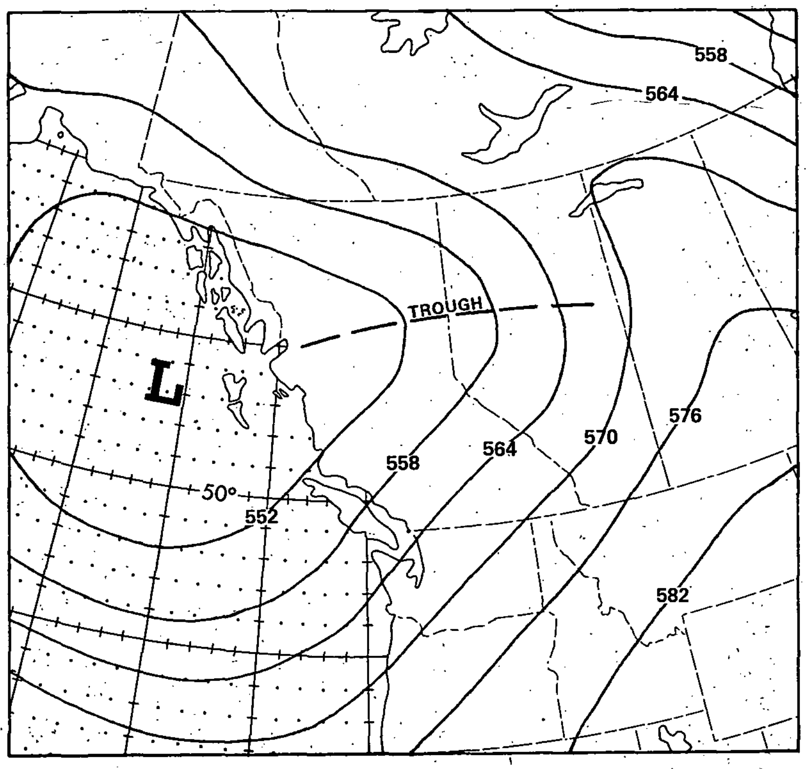

Figure 3 500 mb Analysis 1200Z - July 16, 1974

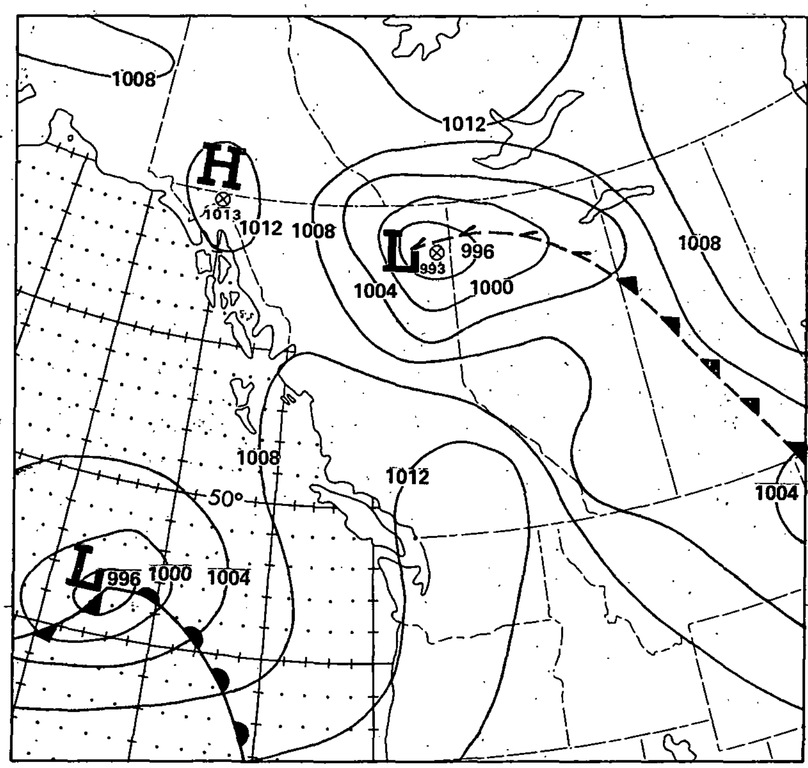

Figure 4 Surface Analysis 1200Z - July 16, 1974

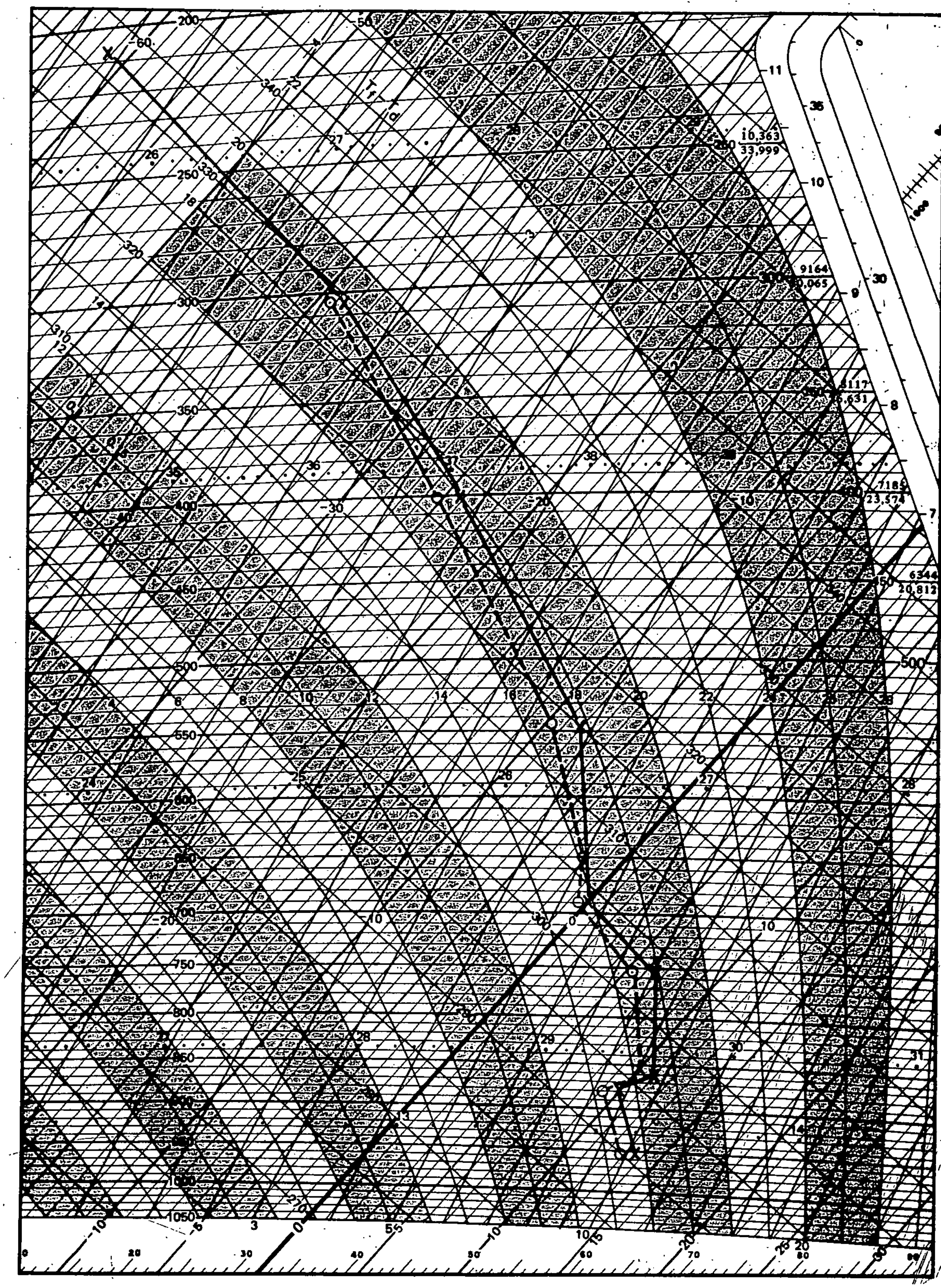

Figure 5 Fort Nelson Tephigram 1200Z - July 16, 1974

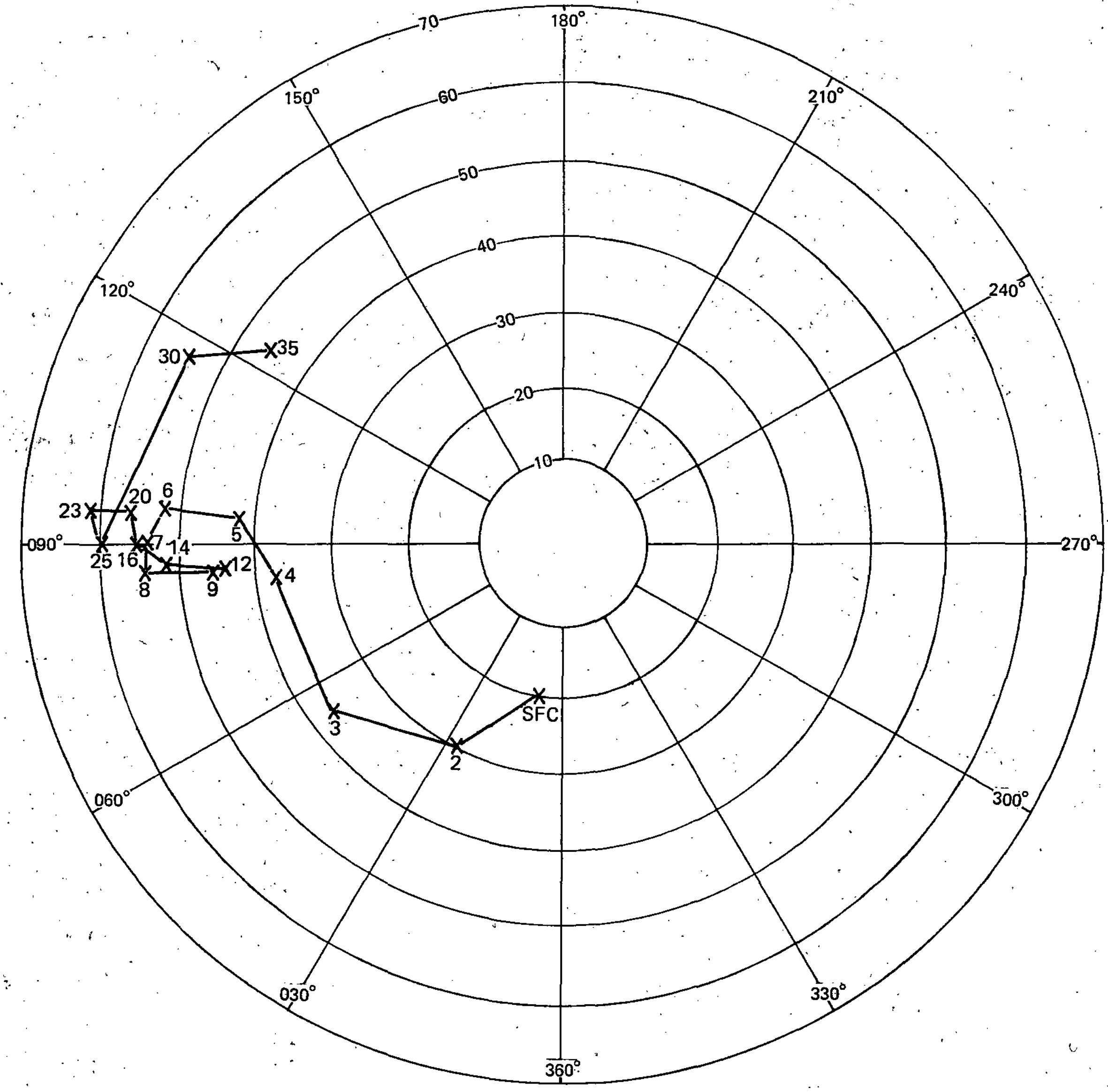

Figure 6 Fort Nelson HODOGRAPH 1200Z - July 16, 1974
(Spokes indicate wind direction true, concentric rings wind speed in knots, labelled heights in thousands of feet ASL)

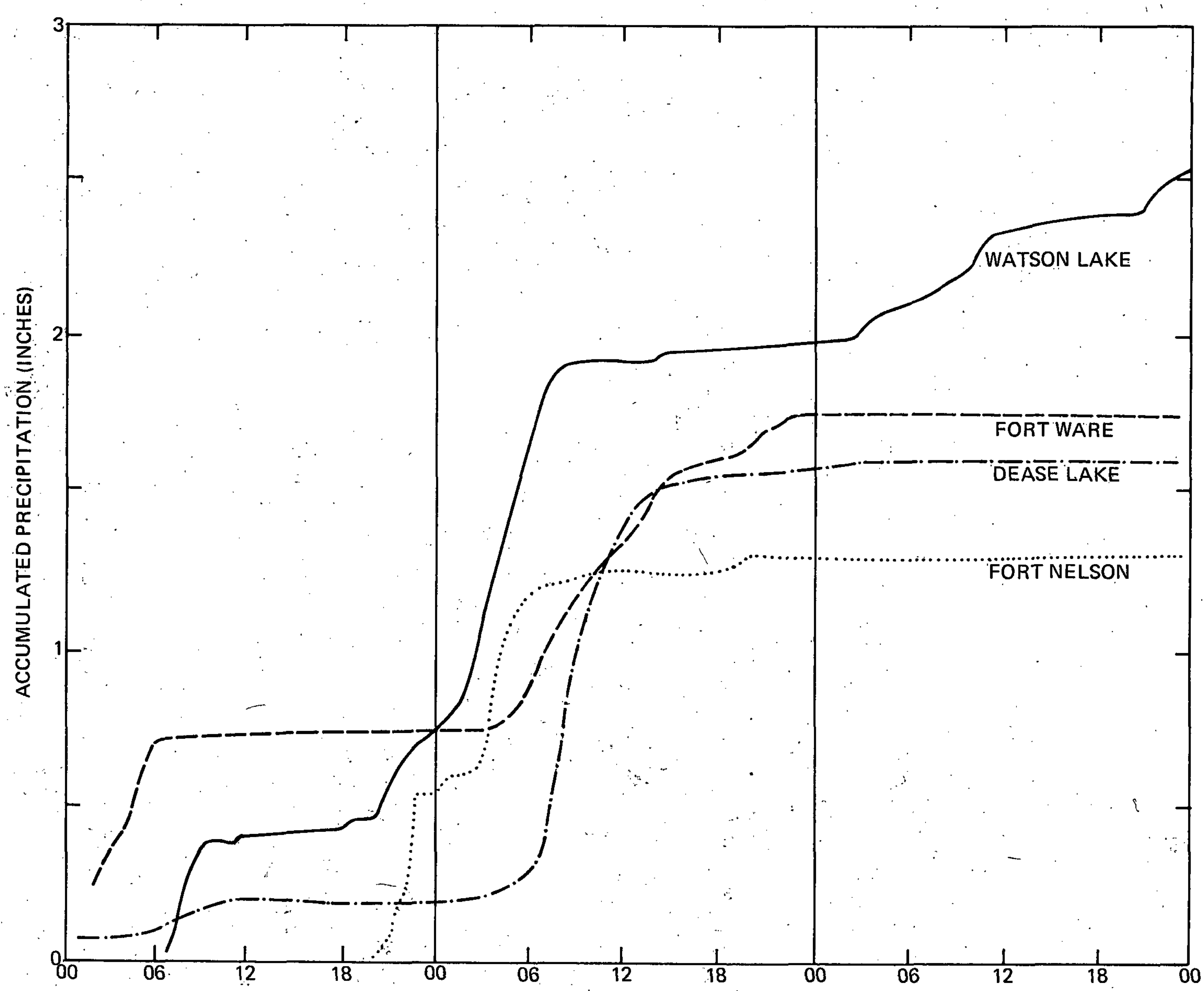

Figure 7 Mass curves for four observation sites in storm areas

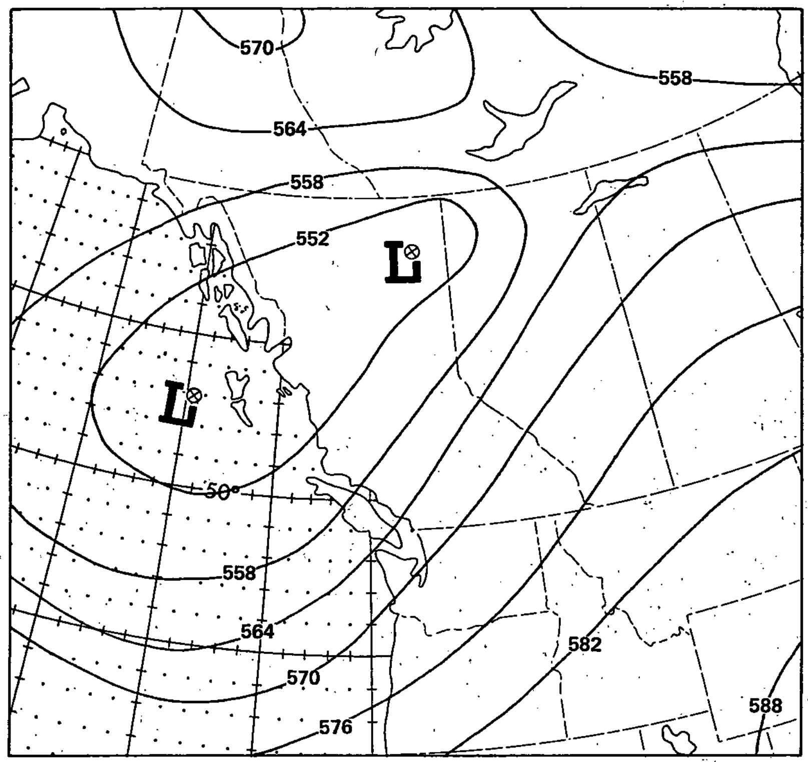

Figure 8 - 500 mb Analysis 0000Z - July 17, 1974

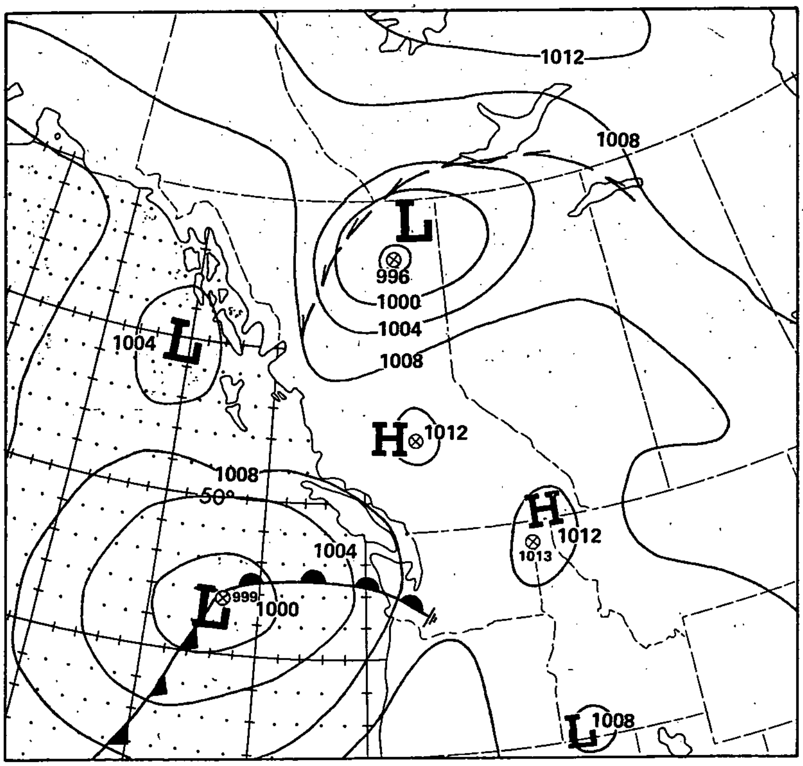

Figure 9 Surface Analysis 0000Z - July 17, 1974

Figure 10 Essa 8 Satellite photograph 1910Z (1110 PST) July 16, 1974 Heaviest rains had ended 12 hours previously at Fort Nelson and Watson Lake but were just ending at Dease Lake and Fort Ware.

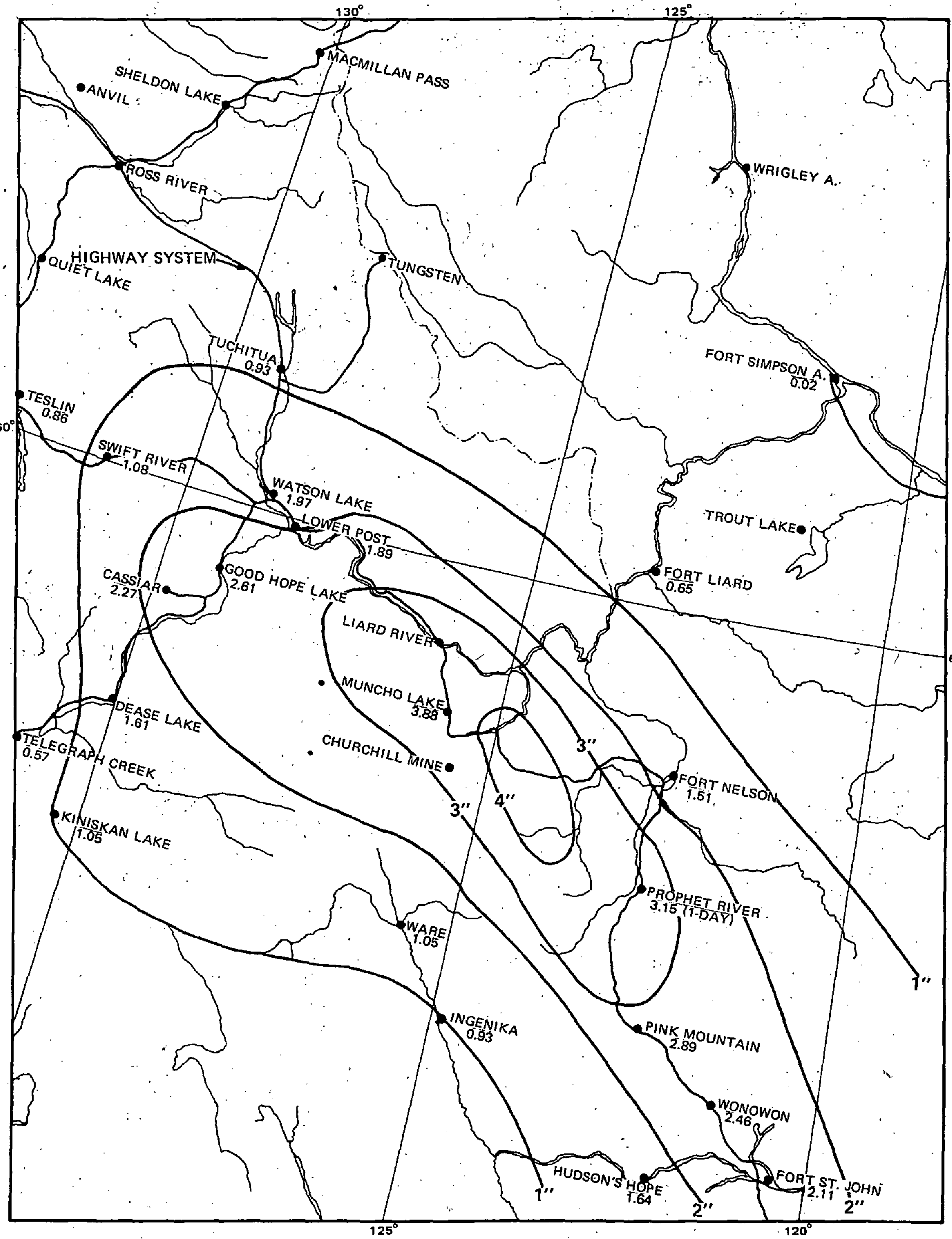

Figure 11 Isohyetal analysis for the period 0800 PDT July 15-0800 PDT July 17 except at AES synoptic stations where precipitation values are for the period 2300 PDT July 14-2300 PDT July 16.

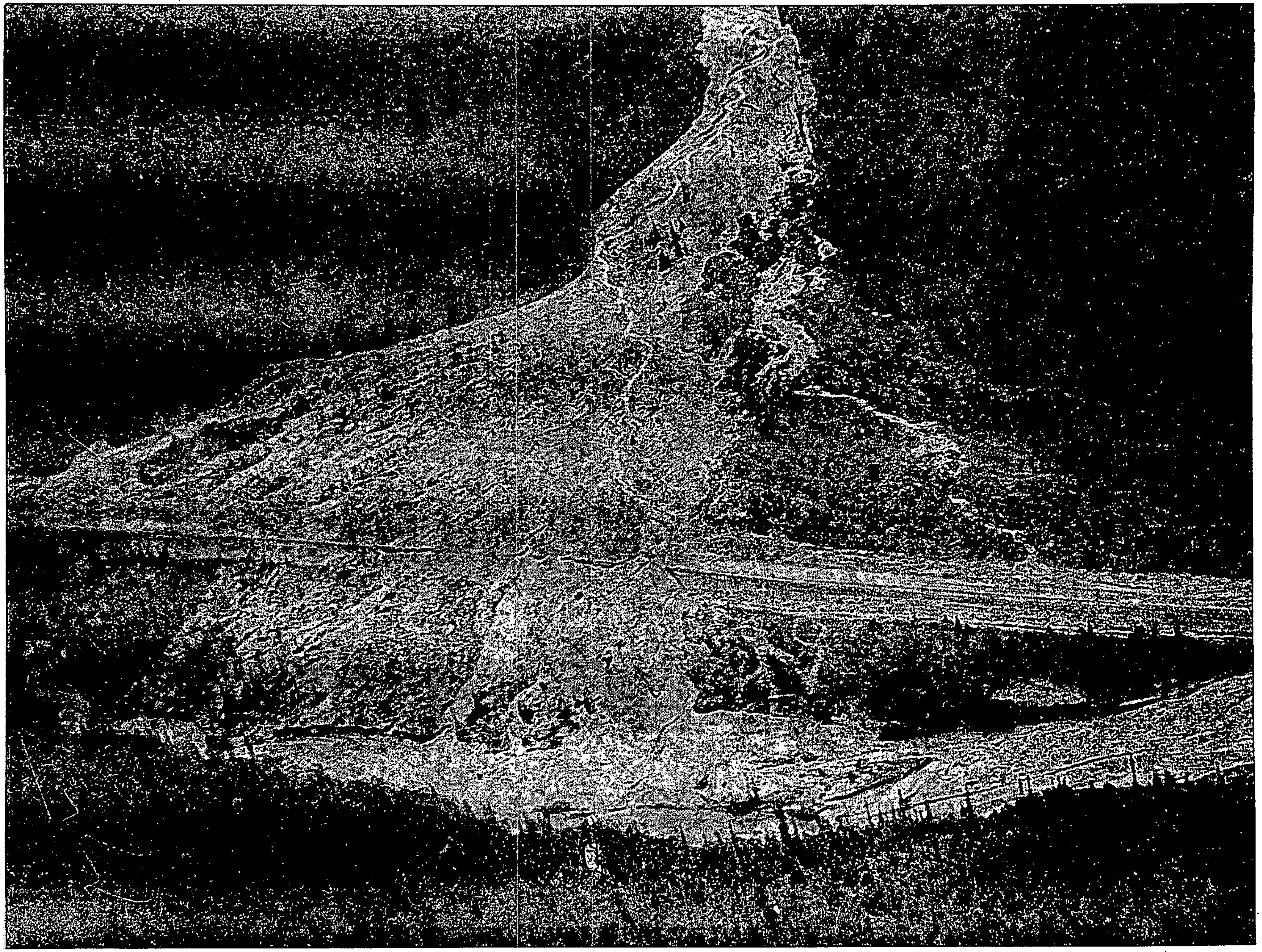

Figure 12 Wash-out on Alaska Highway near Muncho Lake, B. C.
July, 1974 (Whitehorse Star Photo)

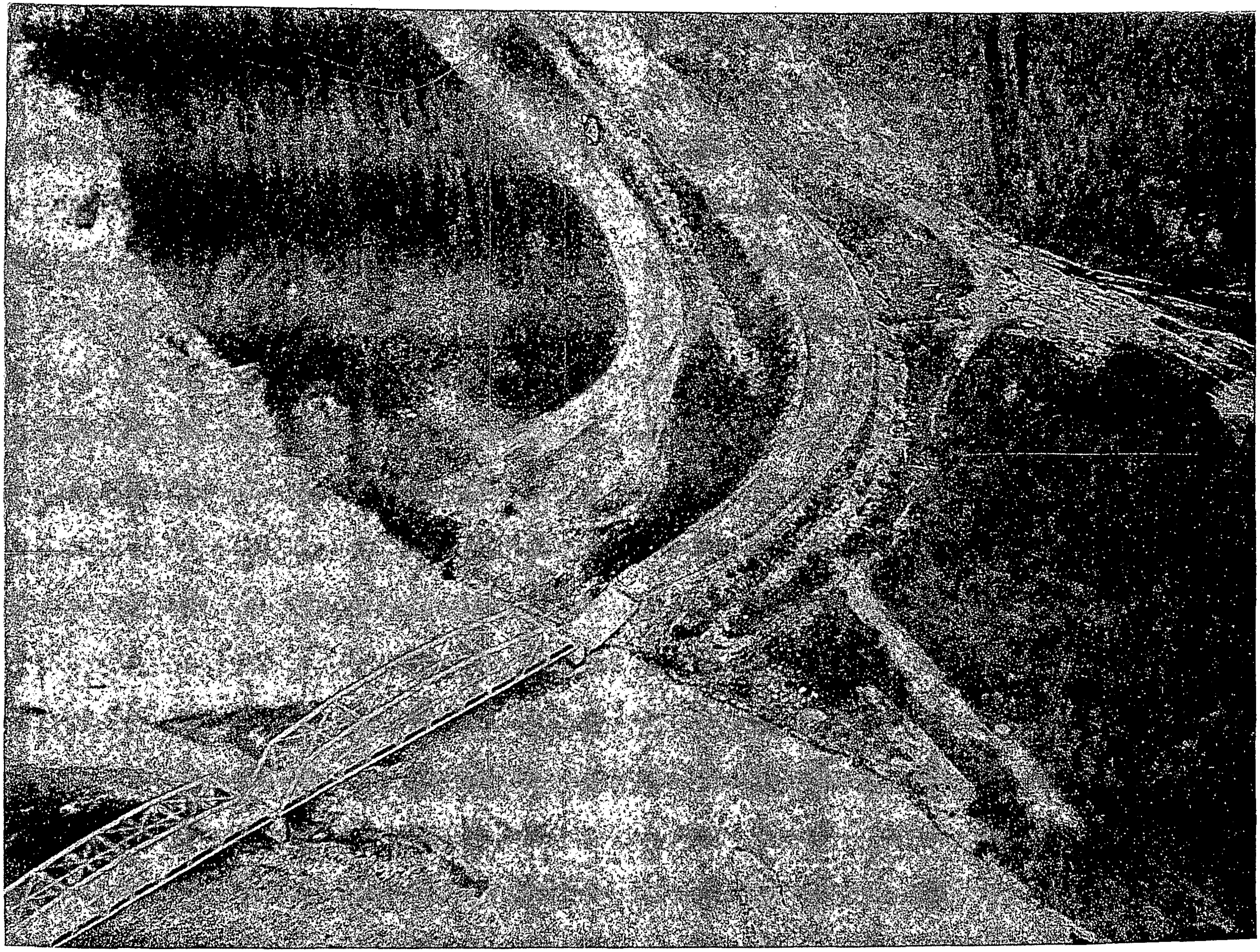

Figure 13 Washed-out bridge approach at Racing River, British Columbia, July, 1974 (Whitehorse Star Photo)

TEC 830 — UDC: 551.557.37
9 March 1976 — ISSN 0068-7804

CANADA

Environment - Atmospheric Environment Service
4905 Dufferin Street, Downsview, Ontario

Alaska Highway Rainstorm of July 15-16, 1974
by S. T. Stobbe

7 pps. 13 figs. 3 refs. 1 table

Subject References: 1. Rainstorm
2. Alaska Highway

TEC 830 — UDC: 551.557.37
9 March 1976 — ISSN 0068-7804

CANADA

Environment - Atmospheric Environment Service
4905 Dufferin Street, Downsview, Ontario

Alaska Highway Rainstorm of July 15-16, 1974
by S. T. Stobbe

7 pps. 13 figs. 3 refs. 1 table

Subject References: 1. Rainstorm
2. Alaska Highway

TEC 830 — UDC: 551.537.37
9 March 1976 — ISSN 0068-7804

CANADA

Environment - Atmospheric Environment Service
4905 Dufferin Street, Downsview, Ontario

Alaska Highway Rainstorm of July 15-16, 1974
by S. T. Stobbe

7 pps. 13 figs. 3 refs. 1 table

Subject References: 1. Rainstorm
2. Alaska Highway

TEC 830 — UDC: 551.537.37
9 March 1976 — ISSN 0068-7804

CANADA

Environment - Atmospheric Environment Service
4905 Dufferin Street, Downsview, Ontario

Alaska Highway Rainstorm of July 15-16, 1974
by S. T. Stobbe

7 pps. 13 figs. 3 refs. 1 table

Subject References: 1. Rainstorm
2. Alaska Highway

ABSTRACT: The heavy rainstorm of July 15-16 1974 in a remote area of northeastern British Columbia, resulted in a 10-day closure of the Alaska Highway. In this article, the author examines the synoptic weather features and contributing factors to precipitation in the storm. A short discussion of the return period for such a storm and a verification of the Canadian Meteorological Centre's Quantitative Precipitation Forecast are included.

ABSTRACT: The heavy rainstorm of July 15-16 1974 in a remote area of northeastern British Columbia, resulted in a 10-day closure of the Alaska Highway. In this article, the author examines the synoptic weather features and contributing factors to precipitation in the storm. A short discussion of the return period for such a storm and a verification of the Canadian Meteorological Centre's Quantitative Precipitation Forecast are included.

ABSTRACT: The heavy rainstorm of July 15-16 1974 in a remote area of northeastern British Columbia, resulted in a 10-day closure of the Alaska Highway. In this article, the author examines the synoptic weather features and contributing factors to precipitation in the storm. A short discussion of the return period for such a storm and a verification of the Canadian Meteorological Centre's Quantitative Precipitation Forecast are included.

ABSTRACT: The heavy rainstorm of July 15-16 1974 in a remote area of northeastern British Columbia, resulted in a 10-day closure of the Alaska Highway. In this article, the author examines the synoptic weather features and contributing factors to precipitation in the storm. A short discussion of the return period for such a storm and a verification of the Canadian Meteorological Centre's Quantitative Precipitation Forecast are included.