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WATER RESOURCES BRANCH

THE OCTOBER 1961 FLOOD IN THE NORTH COAST REGION OF BRITISH COLUMBIA

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The October 1961 flood in the North coast region of British Columbia.

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The October 1961 flood in the North coast region of British Columbia.

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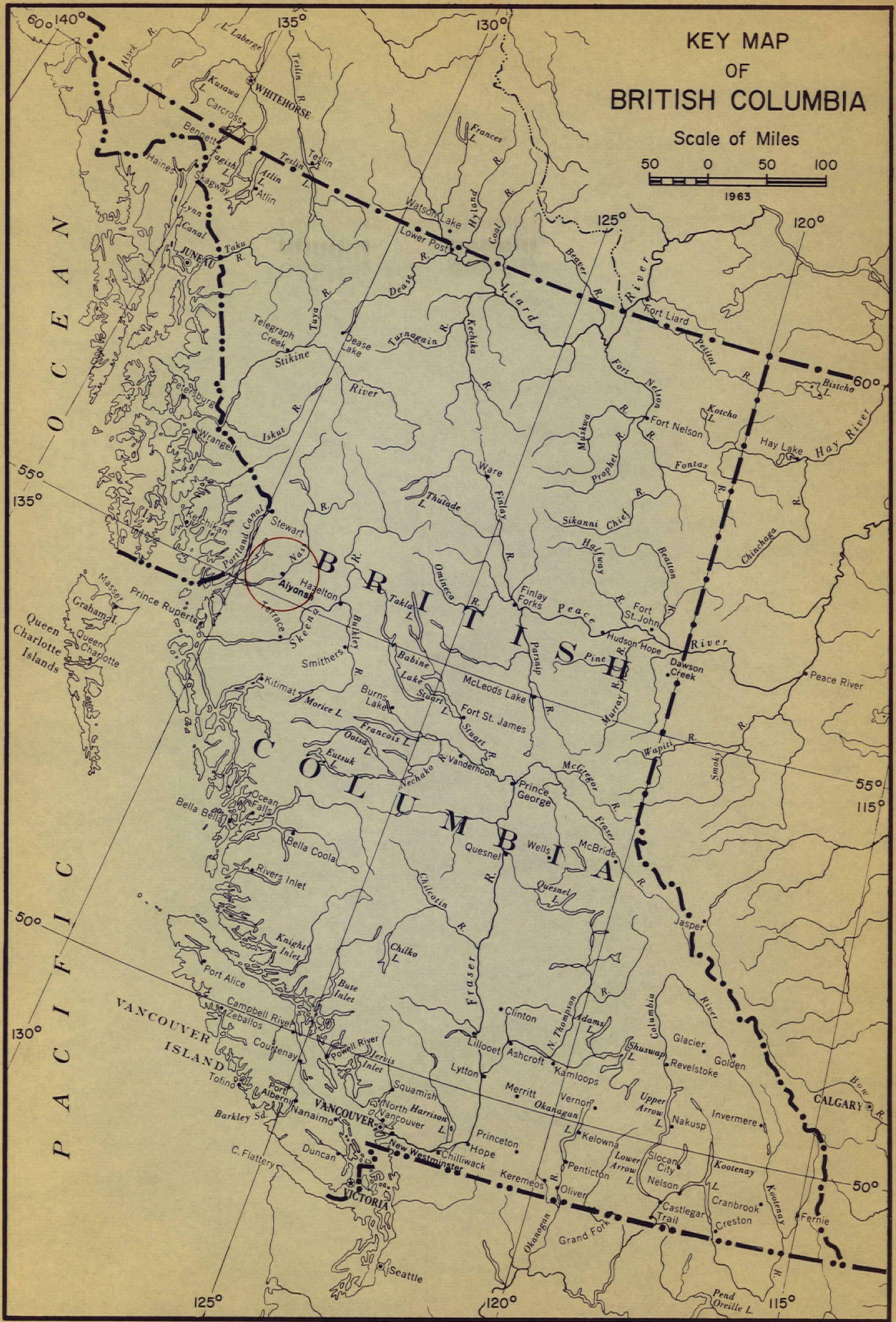
KEY MAP
OF
BRITISH COLUMBIA
Scale of Miles
50 0 50 100
1963
PACIFIC OCEAN
BRITISH COLUMBIA
VANCOUVER ISLAND
Queen Charlotte Islands
WHITEHORSE
JUNEAU
VANCOUVER
VICTORIA
CALGARY
Seattle
Carcross
Bennett
Haines
Skagway
Atlin
Teslin
Watson Lake
Lower Post
Fort Liard
Fort Nelson
Telegraph Creek
Dease Lake
Petersburg
Wrangell
Ketchikan
Stewart
Alyansh
Hazelton
Prince Rupert
Terrace
Masset
Queen Charlotte
Smithers
Kitimat
Burns Lake
Fort St. James
McLeods Lake
Finlay Forks
Fort St. John
Hudson Hope
Dawson Creek
Peace River
Hay Lake
Vanderhoof
Prince George
Quesnel
Wells
McBride
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Ocean Falls
Bella Bella
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Merritt
Vernon
Kelowna
Penticton
Oliver
Keremeos
Grand Forks
Trail
Castlegar
Nelson
Slocan City
Nakusp
Revelstoke
Glacier
Golden
Invermere
Cranbrook
Creston
Fernie
L. Laberge
Kusawa L.
Tagish L.
Atlin L.
Teslin L.
Frances L.
Lynn Canal
Taku R.
Alsek R.
Teslin R.
Hyland R.
Coal R.
Liard
Dease R.
Beaver R.
Turnagain R.
Kechika R.
Tuya R.
Stikine River
Iskut R.
Portland Canal
Nass R.
Skeena
Fort Nelson R.
Petitot R.
Muskwa R.
Prophet R.
Fontas R.
Kotcho L.
Bistcho L.
Hay River
Sikanni Chief R.
Halfway R.
Beatton R.
Chinchaga R.
Thutade L.
Finlay R.
Ware
Omineca R.
Takla L.
Peace River
Pine R.
Parsnip R.
Murray R.
Babine Lake
Bulkley R.
Stuart L.
Stuart R.
Morice L.
Francois L.
Ootsa L.
Eutsuk L.
Nechako R.
Wapiti R.
Smoky R.
McGregor R.
Fraser R.
Quesnel L.
Chilcotin R.
Chilko L.
Fraser R.
Harrison L.
Jervis Inlet
N. Thompson R.
Adams L.
Columbia River
Shuswap L.
Upper Arrow L.
Lower Arrow L.
Okanagan L.
Okanogan R.
Kootenay L.
Kootenay R.
Bow R.
Pend Oreille L.
60°
55°
50°
140°
135°
130°
125°
120°
115°

5670

ACKNOWLEDGMENTS

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Vancouver Public Library, History and Sociological Division, Main Branch, Vancouver, B.C.

THE OCTOBER 1961 FLOOD IN THE NORTH COAST REGION OF BRITISH COLUMBIA

I. SYNOPSIS

On 15 October 1961 the village of Aiyansh, British Columbia, on the Nass River, was severely damaged by a flood of an estimated magnitude of 334,000 cfs, 1/ which is about twice the maximum recorded flow. The frequency of occurrence of such a flood, on the basis of a historical flood record of 84 years, has been estimated as 380 years. 2/ Similar runoff conditions occurred on the Unuk and Iskut Rivers on 15 October 1961. Damage to property in the flood plains of these rivers, however, was very slight as both areas are largely undeveloped. This report, which was prepared by the staff of the British Columbia and Yukon District of the office of the Water Resources Branch, describes in detail the topographical and meteorological conditions which together produced the flood in 1961.

It concludes that flooding was due to the abnormally high precipitation, near gale-force winds, extremely high seasonal temperatures, and rapid snowmelt.

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1 Reference Appendix I.

2 Reference Appendix III.

II. GENERAL DESCRIPTION OF THE FLOOD

1. Nass River

During the period 11 to 16 October 1961, a storm moved across the northern coast of British Columbia with its centre passing over the Nass River Basin. A large part of the village of Aiyansh, which is located approximately 34 miles upstream from the mouth of the Nass River, was inundated, causing severe damage but no loss of life. Several new houses, a new school and generating plant were submerged to a depth of nine feet, and some houses were washed away. Damages to the extent of $250,000 have been estimated by the Indian Affairs Branch. The details are shown in Table 3 of Appendix V. Photographs of damaged property appear on Plates 12 and 13 of the same appendix.

The Nass River reached its peak gauge height of 32.33 feet (equivalent to a computed discharge of 334,000 cfs) on 15 October at approximately 5:00 a.m., according to local residents. (The estimated 1/ previous maximum gauge height was 24.5 feet during the June 1936 flood.) The river level remained steady until 8:00 a.m. on 16 October when it commenced to drop at a rate of about 0.2 foot per hour. (See Appendix II, Plate 3.)

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1 In June 1936 the gauge was located about one and one-half miles downstream from present location and was referenced to a different datum. It is estimated that the flood of 15 October 1961 reached a gauge height of approximately 39 feet referenced to the gauge in use in 1936. The 2 June 1936 flood stage was 29.8 feet referenced to this same gauge.

The following is a newspaper report of the flood published in the 17 October 1961 issue of the Vancouver Sun.

EMERGENCY SUPPLIES RUSHED TO FLOOD-RAVAGED VILLAGES

TERRACE (Staff) - Two tons of emergency supplies are being rushed over rough logging roads today to residents in two flood-ravaged Indian fishing villages.

The supplies, warm clothing and bedding, are for the more than 100 persons left homeless after a wall of water from the Nass River ripped through Aiyansh and Greenville, 55 miles north of here.

Two trucks from the Columbia Cellulose pulp firm are carrying more than 200 boxes containing the supplies.

The vehicles are pushing over logging roads leading to the Nass River where the supplies will be ferried across.

The clothing and bedding were donated by the citizens of Terrace who responded to an appeal for help from the Salvation Army and the United Church.

"The response was terrific. Clothing poured in on us for three hours last night," said Lieut. Jack Cullen of the Salvation Army.

Jack McFarlane, district superintendent of Indian Affairs for the area, said some unions in the Terrace area are considering asking members to give a day's pay to help rebuild the villages.

He said no loss of life was reported.

The flood, caused by heavy rains which melted early snow on the weekend, swept away 17 homes, including two modern $20,000 homes at Aiyansh. About 50 other buildings were threatened.

At Greenville, 25 miles downstream from Aiyansh, churning Nass waters flooded 60 homes and forced several families to flee to higher ground.

The Greenville floods also closed a sawmill, inundated roads and washed away a wharf.

McFarlane, who flew over the stricken area Monday, said debris from Aiyansh had been scattered two miles downstream. He said 15 percent of the village of 500 was destroyed, and another 65 percent heavily damaged.

2. Iskut River

The Iskut River flows through undeveloped territory. The known damage was confined to installations of the Water Resources Branch, and a trapper's cabin. The cableway was damaged and the recorder well was left vulnerable to future high water because of bank erosion in its vicinity. (See Appendix V, Plate 14.) The cabin was moved 200 feet downstream where it wedged in trees and became submerged.

It is estimated that the peak stage occurred about noon on 15 October with an estimated discharge of 280,000 cfs.

3. Unuk River

The Unuk River, like the Iskut, flows through undeveloped country and damage was confined to Water Resources Branch installations. The Water Resources Branch recorder installation was lost, and with it the recorded evidence of the flood.

On 27 October 1961 two stakes spaced some distance apart were set to mark the maximum water level. These reference marks, together with a cross-section of the river channel at each stake, have yet to be surveyed. An estimate of the peak flow of the Unuk will be computed using this information.

4. Other Rivers in the Region

The Stikine River, into which the Iskut River flows, borders the flood region immediately to the north, and although its flow pattern was similar to that of the Nass River, the peak discharge in October 1961 was not unusually high. Flow conditions similar to the Stikine River were recorded on the Skeena River at Usk. (See Appendix II, Plate 4.)

III. PHYSIOGRAPHY OF RIVER BASINS IN THE NORTH COAST REGION

Although unusually large discharges occurred on the Nass, Iskut and Unuk Rivers, these were not the only rivers displaying the effects of the particular meteorological conditions existing from 11 to 16 October.

These effects were noticeable over a fairly wide area, extending from Owikeno Lake (Wannock River) in the south to the Stikine River (at Telegraph Creek) in the north, and east to the Finlay and Parsnip Rivers. (See Appendix II, Plates 4 and 5; Appendix VI, map in pocket.) However, only on the Nass, Iskut, and Unuk were conditions meteorologically and topographically suited to produce floods. Accordingly, the area described in detail is restricted to the drainage basins of these three rivers. 1/

1. Nass River

Length - approx. 210 miles
Drainage Area - 7,800 square miles

The Nass River rises in the Klappan Range of the Skeena Mountains, flows southerly through other ranges of the same system, then through a wide, rolling depression referred to as the Nass Basin. 2/ Finally, for the last 50 miles of its

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1 The physiography of the region is outlined on the map provided in the pocket of this report. For greater details, see maps listed under Reference No. 8.

2 H.S. Bostock, "Physiography of the Canadian Cordillera with Special Reference to the Area North of the Fifty-Fifth Parallel", Department of Mines and Technical Surveys, Memoir #247, Ottawa, 1948, page 46.

course, it traverses to the southwest through the rugged Boundary Range of the Coast Mountains. Its drainage basin lies between latitudes 55° N. and 57° N., and longitudes 128° W. and 130° W. The drainage area upstream from Aiyansh covers an area of 6,940 square miles.

Topographically, the river can be divided into three main sections.

(a) The first section is from its source on the western slopes of Mount Gunanoot in the Klappan Range, through the Skeena Mountains to the Nass Basin. The gradient is steep, the river dropping from 6000 to 1250 feet in a distance of 60 miles. Its tributaries in this area originate in the Oweegee and Strata Ranges in the west, and the Groundhog Range in the east. The whole area consists of distinct ranges trending to the northwest, divided by broad, deep valleys, while there is an extremely high concentration of major folds, averaging four per mile. For the most part, the mountains consist of sedimentary rocks (slaty argillite and shale) but the valleys are made up of unconsolidated glacial and fluvial deposits such as clay, till, peat and muskeg. 1/ Throughout the Skeena Mountains, small icefields and glaciers are found, ranging up to three miles in length, and the slopes are heavily wooded to elevations up to 4500 feet.

(b) The second section is through a wide depression known as the Nass Basin which is bounded by the Skeena Mountains on the east and north, the Coast Mountains on the west, and the

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1 Department of Mines and Technical Surveys, Stikine River Area, Map No. 9, 1947, Ottawa, 1948.

Hazelton Mountains on the south. The gradient is flatter through this section, the river dropping from 1250 feet to an elevation of 50 feet in a distance of 100 miles. On all sides, except for a heavily-glaciated area to the north containing the Bell-Irving River, the mountains rise steeply above this heavily-wooded region. Geologically, the region is similar to the Skeena Mountains with, however, a greater predominance of glacial and fluvial deposits in a more gently-rolling configuration. Most of the area is below 5000 feet, but Mount Madely, in the northern section, rises to 5883 feet.

(c) The third section is through the Coast Mountains, the river dropping from an elevation of 50 feet to sea level. In this final 50 miles of its course, the Nass River cuts through the Nass Range of the Coast Mountains by way of an extremely narrow, deep valley. The area consists primarily of volcanic rock, with minor quantities of sediments.

The mountains rapidly increase in height north of the Nass, with Mount Pattullo being the highest peak at 8951 feet. The icefields and glaciers also increase in size and occurrence, a major one of these being the Cambria Snowfield, located just to the east of Stewart, B.C.

Major Tributaries of the Nass River

The Nass River has nine major tributaries. The characteristics of each are detailed in the following table. The table indicates distances of the confluence of each tributary from the mouth of the Nass River, description of source, and headwater mountains.

Tributary	Distance of Confluence from Mouth of Nass River miles	Description of Source	Headwater Mountains
Tseax	34	Source at Lava Lake to south of Nass River. Lake itself has source in glacier on Alder Peak (elev. 7382 feet).	Coast Mountains
Kwinatahl	44	Source in substantial glacier to west of Aiyansh.	Coast Mountains
Tchutin	52	Lake and glacier fed.	Coast Mountains
Kinskuch	54	One of the larger tributaries. Source at Kinskuch Lake, directly fed by glacier on Lavender Peak (elev. 7620 feet).	Coast Mountains
Cranberry	57	Ranks with the Bell-Irving as major tributary. Has Kiteen River as tributary. Both rise in Nass Range.	Hazelton Mountains
White	91	Has numerous glacier-fed creeks and has its own source in the Cambria Glacier.	Coast Mountains
Meziadin	96	Source in Meziadin Lake, located close to northern Cambria Range.	Coast Mountains
Bell-Irving	109	The major tributary of the Nass. Rises close to source of Nass in Klappan Range, meeting main river just above Meziadin River confluence. Has a large glacier-fed tributary in the Bowser.	Skeena and Coast Mountains
Taylor	129	Source in the Oweegee Range with its own tributary, the West Taylor, flowing from the Strata Range.	Skeena Mountains

2. Iskut River

Length - approx. 160 miles
Drainage Area - 3,630 square miles

The Iskut River has its source in the interconnected Eddontenajon and Kinaskan Lakes, which lie on the Klastline Plateau, the southwest subdivision of the Stikine Plateau. For the first 100 miles of its course, the Iskut River travels almost due south to a point 15 miles downstream from its confluence with the Ningunsaw River, where it turns and flows west for 60 miles to join the Stikine River. Except for its extreme upper reaches in the Klastline Plateau, the Iskut drainage basin is completely contained in the Coast Mountains. The Iskut Valley floor upstream from the Ningunsaw confluence is about four miles wide and consists mainly of unconsolidated glacial and fluvial clay and other sediments. Downstream from this confluence, the valley reduces in width to about one and one-half miles. This part of the valley is composed of volcanic rocks while to the south of the river there is a predominance of sedimentary rock with igneous intrusions.

The Iskut River has three tributaries of consequence: namely, the Jekill River, flowing northwesterly from a glacier on Mount Lewis Cass to join the Iskut 18 miles from its confluence with the Stikine; the Ningunsaw River, originating in the glaciers around Mount Alger to the east of the Iskut, and joining it about 75 miles from the Stikine; and the Little Iskut River, flowing eastward from the glaciers of the Spectrum Range to join the Iskut some 120 miles from the mouth.

About 2000 feet of the river's 4000-foot drop in elevation occurs in the first 70 miles from its source; a further drop of 1000 feet occurs in the next 30 miles; and the final drop of 1000 feet occurs in the final 60 miles to the Stikine River.

3. Unuk River

Length - approx. 60 miles
Drainage Area - 990 square miles

The 60-mile-long Unuk River is the shortest of the three rivers under consideration. It is wholly contained in the Coast Mountains, and runs through an area immediately to the south of the Iskut River, displaying many of the physiographic and topographic features of the Lower Iskut drainage basin with, however, a much more rugged lower section. This lower part is characterized by three canyons. The first of these is at the confluence of the Blue River in the Alaska Panhandle of the United States, and the second and third canyons are in Canada 23 and 26 miles, respectively, from the Unuk's mouth. Generally, the mountains are in the 4000 to 5000-foot range. The valley is V-shaped in its southern half while being more U-shaped in its northern half. The entire area is heavily wooded up to an elevation of about 2500 feet. As with the Iskut and Nass Rivers, the Unuk flows in unconsolidated glacial and fluvial sediments, although the principal rocks of the area are of volcanic origin.

In its upper portion the Unuk River has many tributary creeks, most of which, like the Unuk, are glacial fed. Its main tributary, the South Unuk River, flows north from glaciers atop

the twin peaks of Willibert and Pearson, near the International Boundary, to join the Unuk about 40 miles from its mouth.

IV. CLIMATOLOGICAL CONDITIONS

The following description of climatological conditions is not intended to be a precise account of those prevailing in the Nass-Iskut area during the period 1 to 16 October 1961, but rather should be considered as a guide. Only limited data are available from meteorological stations in the area under study. However, by correlating these data with those from other observation points within a reasonable proximity, it has been possible to obtain an understanding of the meteorological conditions which produced the high runoff, and to trace the series of events leading up to the flood.

In order to "set the scene" for the storm of the 14th to the 16th of October, the period from the 1st to the 16th will be examined, and for this purpose the period is divided into five phases which correspond approximately to the major developments of the weather system up to the 16th. 1/ An additional factor which contributed to the heavy runoff was the early snow which had accumulated at the higher elevations prior to the 1st of October. 2/

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1 For detailed meteorological information, see Appendix IV, Table 2 - "Temperatures and Precipitation Data".

2 Unfortunately no record of snow conditions in the Nass, Iskut and Unuk River Basins is available. The natives at Aiyansh did remark that after the flood there was no snow left on the mountains visible from Aiyansh.

Phase 1 - 1-4 October

A high-pressure area, almost stationary over southern British Columbia and the Pacific, caused the northward movement of a series of low-pressure systems which forced a series of warm air masses up the Nass-Iskut Valleys, resulting in unseasonally high temperatures. The warm air, on meeting the cold air masses of the low-pressure areas and the Coast Mountains, caused heavy rains and strong winds; e.g., at Wrangell 1.44", 2.11", and 3.17" of rain were recorded on the 1st, 2nd, and 3rd, respectively, while at Prince Rupert 1.09", 0.71", and 1.93" of rain were recorded with accompanying southeasterly winds of up to 28 m.p.h.

Phase 2 - 5-7 October

The development of this high-pressure area forced the low-pressure zone still farther north and caused an improvement in weather conditions on the north coast. Precipitation was light and scattered, the wind dropped to mere gusts, while temperatures stayed about normal (modified by localized conditions).

Phase 3 - 8-10 October

A new low-pressure area, positioned over central Alaska, gradually eased to the southeast to maintain the low-pressure complex over northern British Columbia, specifically to the west of the Nass-Iskut area. Heavy precipitation occurred on the 8th for most stations, but declined on the 9th and 10th. Normal temperatures and winds of moderate force from the south-east were recorded.

Phase 4 - 11-15 October

A still larger low-pressure area appeared over northern British Columbia during the 10th and 11th, setting up a complex system of warm and cold fronts. 1/ This low-pressure area was contained by a ridge of three high-pressure zones stretching from the northern mid-Pacific, through the western and northwest states up to the eastern Mackenzie Basin and Arctic Ocean. Wind velocity increased during the 12th and by the 13th had grown to half-gale; e.g., on the 12th Ketchikan had variable south-southeast winds gusting to 40 knots, while Prince Rupert reported southeast winds of up to 35 m.p.h. on the 13th and 14th, with a mean hourly speed (on the basis of 24 hours record per day) of 25.5 and 28.2 m.p.h., respectively, and rainfalls of 0.37", 0.24", 1.68", and 1.02" from the 11th to 14th inclusive. Stewart, farther to the north and closer to the Nass-Iskut area, recorded precipitation on the same days; viz., 1.37", 4.97", 7.00" and 2.25", respectively.

The dominance of a large warm-air mass, which traversed the region with accompanying south to southeasterly winds, served to keep temperatures, both maximum and minimum, above normal, culminating on the 14th with peak temperatures for the interior regions. Some examples follow with their long-term means for comparison.

Station	14 Oct. 61 Maximum Temperature °F.	Long-Term Average of October Extreme Maximum Temperatures °F.
Aiyansh	70	-
New Hazelton	74	62.6
Kitimat	67	59.9
Terrace	65	61.7

1 See Appendix IV, Climatological Data, "Meteorological Charts, 12 October - 16 October 1961", Plates 7-11.

These temperatures contrast with the near-to-normal maximum temperature of 36° F. occurring at Telegraph Creek which was well to the north of the warm front.

Phase 5 - 16 October

By late evening of the 15th, conditions eased considerably. The low-pressure system moved off as the blocking high to the east relented, resulting in a gradual return to more normal temperatures and a sharp decrease in precipitation. (See Appendix IV, Table 2.)

V. CONCLUSIONS

1. The flooding on the Nass, Unuk and Iskut Rivers was due to several factors:

   (a) The nature of the topography. The rivers are located in the Coast Mountain region which is characterized by fairly high mountains with steep-sloped valleys, and glaciers.

   (b) Early snowfall.

   (c) An almost-stationary high-pressure zone which settled over southern British Columbia, forcing a series of low-pressure zones over the Nass, Iskut, Unuk Basins.

   (d) Heavy precipitation, high temperatures, and near gale-force winds which, together, caused rapid melt of the snow.

2. The property damage resulting from the high stage on the Nass River, at Greenville and Aiyansh, was particularly aggravated in the latter case by the location of the village - on a flat river bench, in a narrow section of valley, immediately upstream from a series of constricting canyons.

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1. H.S. Bostock, "Physiography of the Canadian Cordillera with Special Reference to the Area North of the Fifty-Fifth Parallel", Department of Mines and Technical Surveys, Memoir #247, Ottawa, 1948.

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3. A.V. White, "Water Powers of British Columbia", Commission on Conservation, Ottawa, 1919.

4. U.S. Geological Survey, "Stream Gaging Procedure", Water Supply Paper No. 888, Washington, D.C., 1945.

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6. J.W.W. Moeran, McCullagh of Aiyansh, Marshall-Prologue, London, 1923.

7. Edward Sapir, "A Sketch of the Social Organization of Nass River Indians", Geological Survey of Canada Museum Bulletin #19, Anthropological Series #7, Ottawa, 1915.

8. Maps

Department of Lands, Forests and Water Resources, Surveys and Mapping Branch, Victoria, B.C.

103P - Nass River - 1953

Department of Mines and Technical Surveys, Surveys and Mapping Branch, Ottawa.

104A - Bowser Lake - 1954
104B - Iskut River - 1955
104G - Telegraph Creek - 1954
104H - Spatsizi - 1954

LIST OF APPENDICES

APPENDIX I

COMPUTATION OF PEAK DISCHARGE OF NASS RIVER AT AIYANSH, B.C., 15 OCTOBER 1961, BY SLOPE-AREA METHOD

Notes on Computation

Plate 1 Plan of River Section Used in Application of Slope-Area Method

Plate 2 Cross-Sections 1 and 2 Used in Application of Slope-Area Method

COMPUTATION OF PEAK DISCHARGE OF NASS RIVER AT AIYANSH, B.C., 15 OCTOBER 1961, BY SLOPE-AREA METHOD

Theory

The slope-area method of measuring the discharge of a stream consists of the determination of three basic factors:

1. Area of an average cross-section of a straight reach of channel of known length.
2. Slope of the water surface in that reach.
3. Character of the streambed and banks such that a roughness factor may be allotted.

On determining these, the mean velocity of the stream may be computed by the Chezy Formula; viz.,

$$V = C\sqrt{RS}$$

where V is mean velocity in feet per second,

C is coefficient dependent on the roughness factor and the hydraulic radius of the section,

R is the hydraulic radius in feet,

S is slope of water surface.

Multiplying the obtained mean velocity, V, by the area of the average cross-section gives the desired discharge.

Method

A relatively straight section of the Nass River some two miles upstream from Aiyansh was chosen for the application of the slope-area method of computing discharge. The reach was 737 feet long on a slight curve. 1/ Soundings of the end sections

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1 See Plate 1.

revealed close agreement in their respective cross-sectional areas (within 4 percent). Section 1 was 450 feet wide while Section 2 was 414 feet wide. 1/ Levels were run on 22 October 1961, at and between the two sections, to reference the high-water marks of 15 October 1961 and the water level of 22 October 1961. On 26 November 1961 the two cross-sections were surveyed. From this information drawings of the two cross-sections, scale 1" = 10', were plotted, and their respective areas computed by planimeter. The average of the two was taken as the mean area of the reach (16,654 square feet).

The hydraulic radius, R, being the ratio,

$$\frac{\text{area of cross-section}}{\text{wetted perimeter of cross-section}}$$

was computed. S, the slope of the water surface, was derived directly from the survey notes.

The coefficient, C, was calculated using two methods:

(1) Using Kutter's formula,

$$C = \frac{41.65 + \frac{1.811}{n} + \frac{0.00281}{S}}{1 + \left(41.65 + \frac{0.00281}{S}\right)\frac{n}{\sqrt{R}}}$$

Where n = roughness factor of the streambed (selected from a table of values according to those characteristics found on the Nass River at the section examined), 2/ S and R are as defined previously.

---

1 See Plates 1 and 2.

2 Table of Values, Reference No. 4, page 83.

The value selected for n was 0.033, corresponding to a natural stream channel, having clean, straight banks, full stage and no rifts or deep pools. S equalled 0.001818 and R (mean of values obtained from sections 1 and 2) equalled 35.40 feet.

(2) Using Mannings formula,

$$C = \frac{1.486}{n} R^{\frac{1}{6}}$$

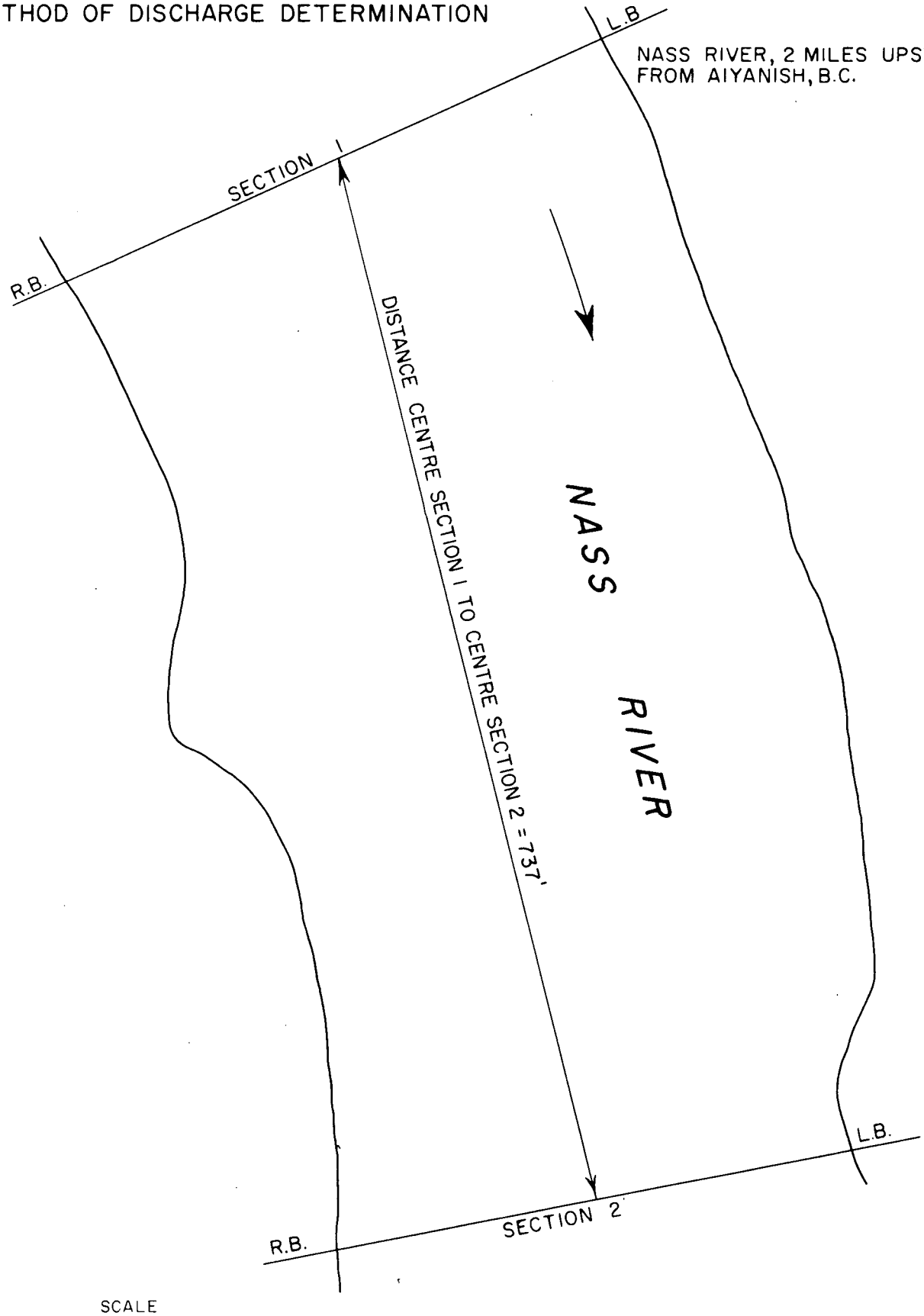
Applying these formulae, two results for C were obtained - 79.10 and 81.59, respectively. Substitution of these in Chezy's expression gave two values for V, the mean velocity through the section; viz., 20.07 f.p.s. and 20.70 f.p.s., respectively. Multiplying these by the mean cross-sectional area produced the final results; viz.,

$$Q_1 = 334,200 \text{ cfs}$$

$$Q_2 = 344,700 \text{ cfs}$$

These values are in close agreement and the figure of 334,000 cfs has been adopted for the estimate of peak flow of the Nass River at Aiyansh.

PLAN OF RIVER SECTION USED IN APPLICATION OF SLOPE-AREA METHOD OF DISCHARGE DETERMINATION

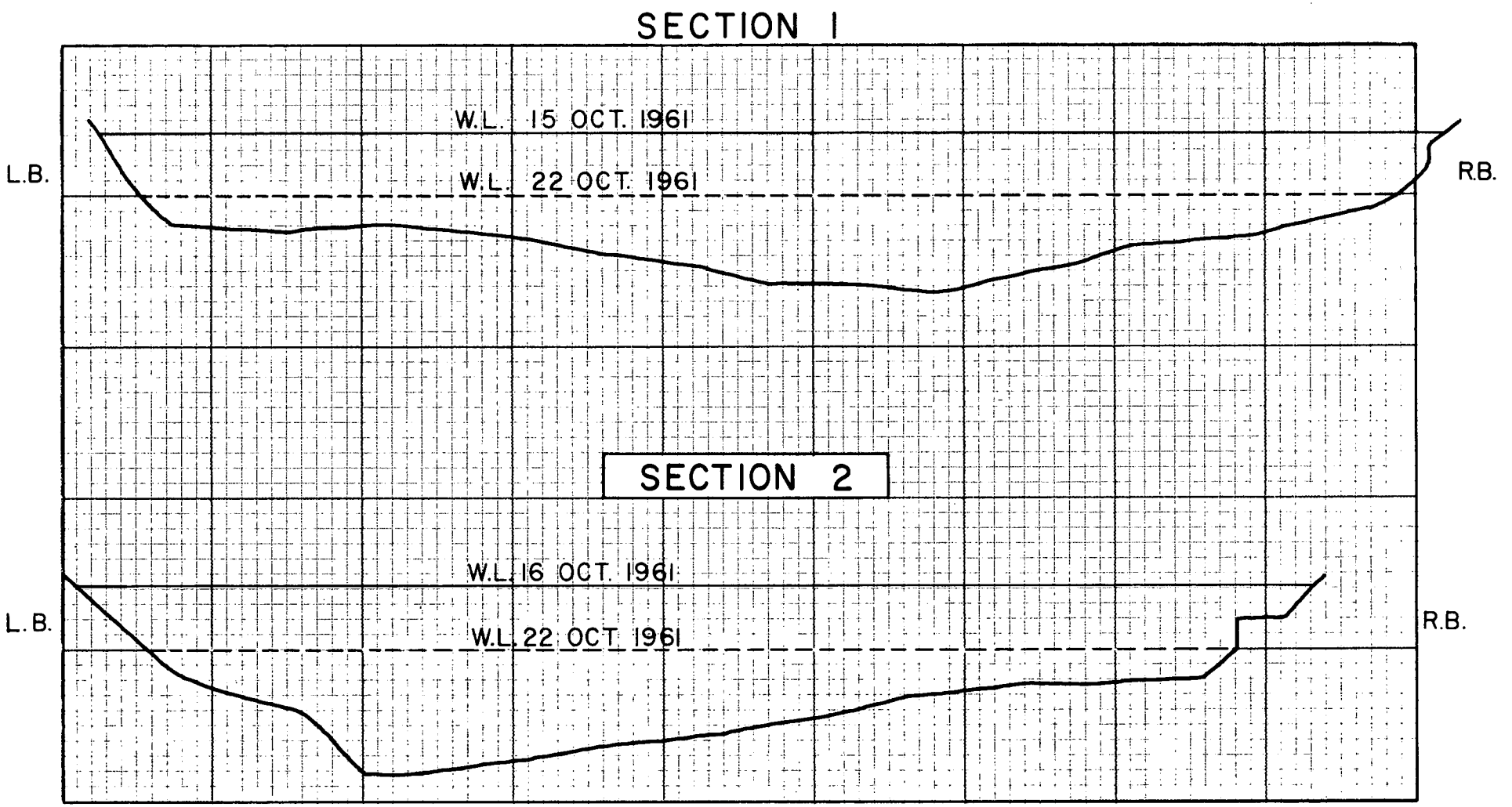


SURVEYED: 26 NOV. 1961
BY: G.W.C.

PLATE 1

NASS RIVER TWO MILES UPSTREAM FROM AIYANISH, B.C.

CROSS-SECTIONS OF RIVER USED IN APPLICATION OF SLOPE-AREA METHOD OF DISCHARGE DETERMINATION



SCALE
10 30 50
0 20 40
FEET

PLATE 2

APPENDIX II

HYDROGRAPHS - OCTOBER 1961

Plate 3 Nass and Iskut Rivers

Plate 4 Coastal Rivers

Plate 5 Interior Rivers

Plotted according to Water Resources Branch records for those stations having their respective locations as noted on each plate.

HYDROGRAPHS
FOR
NASS AND ISKUT RIVERS.

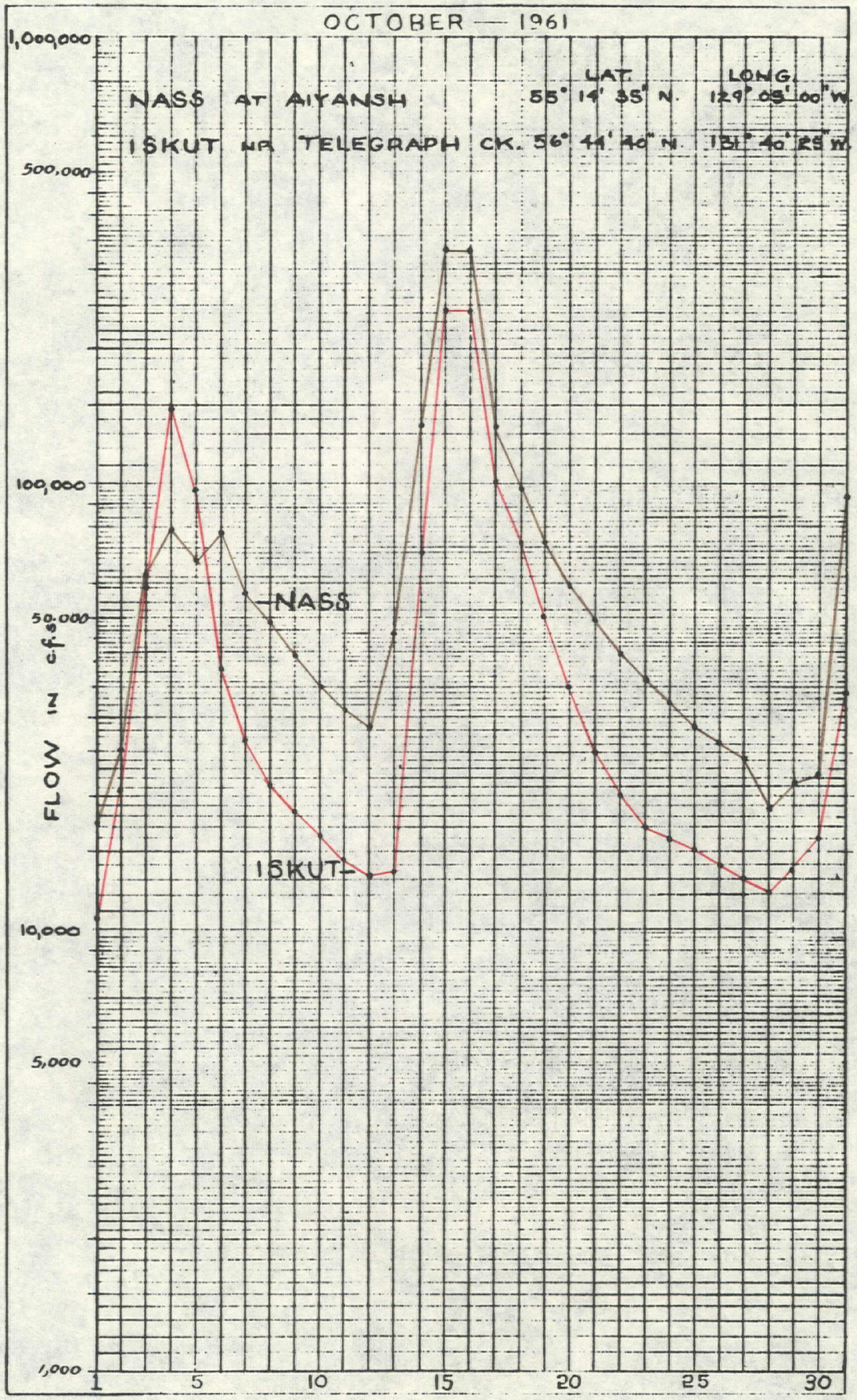


Plate 3

HYDROGRAPHS
FOR
COASTAL RIVERS

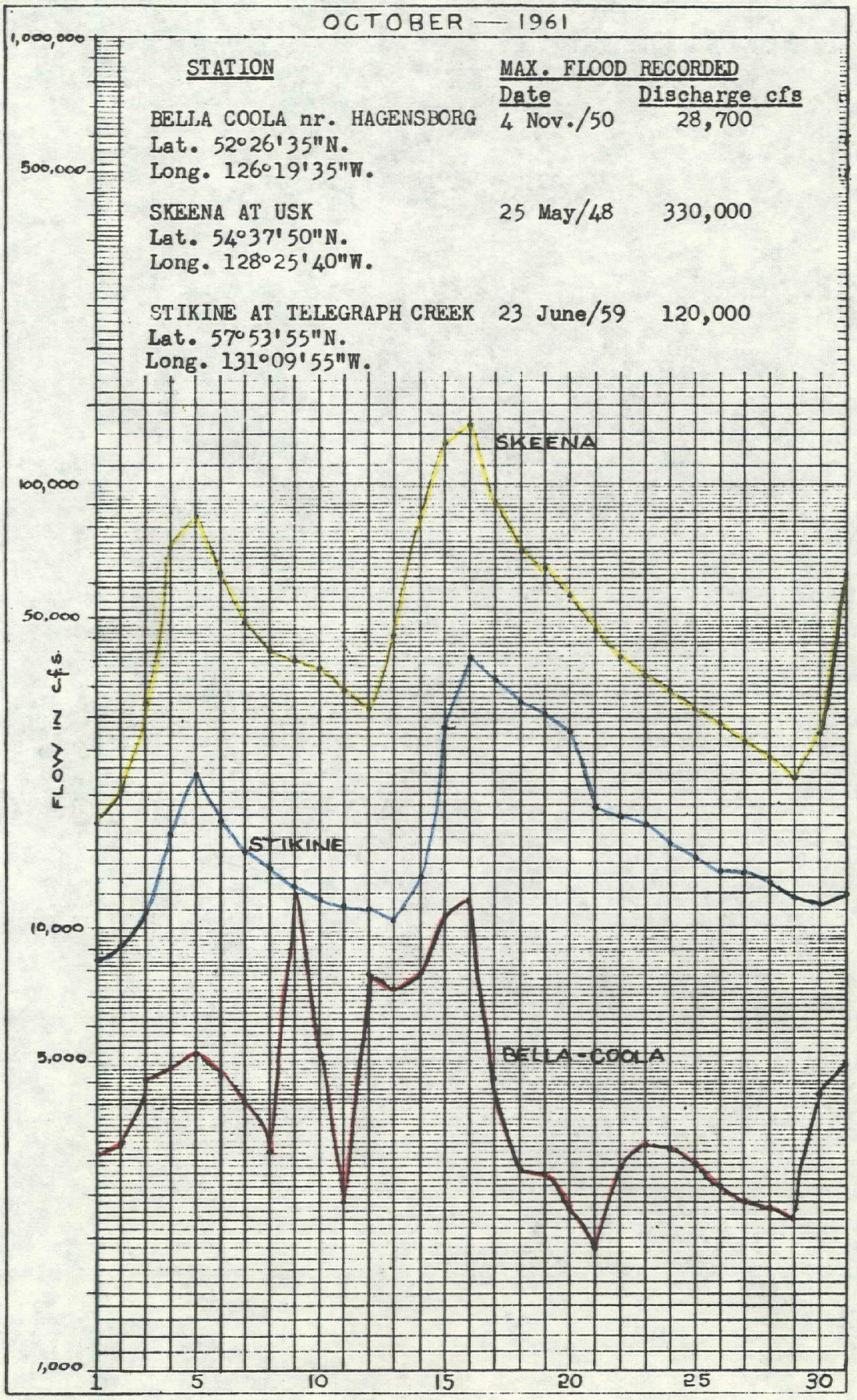


Plate 4

HYDROGRAPHS
FOR
INTERIOR RIVERS.

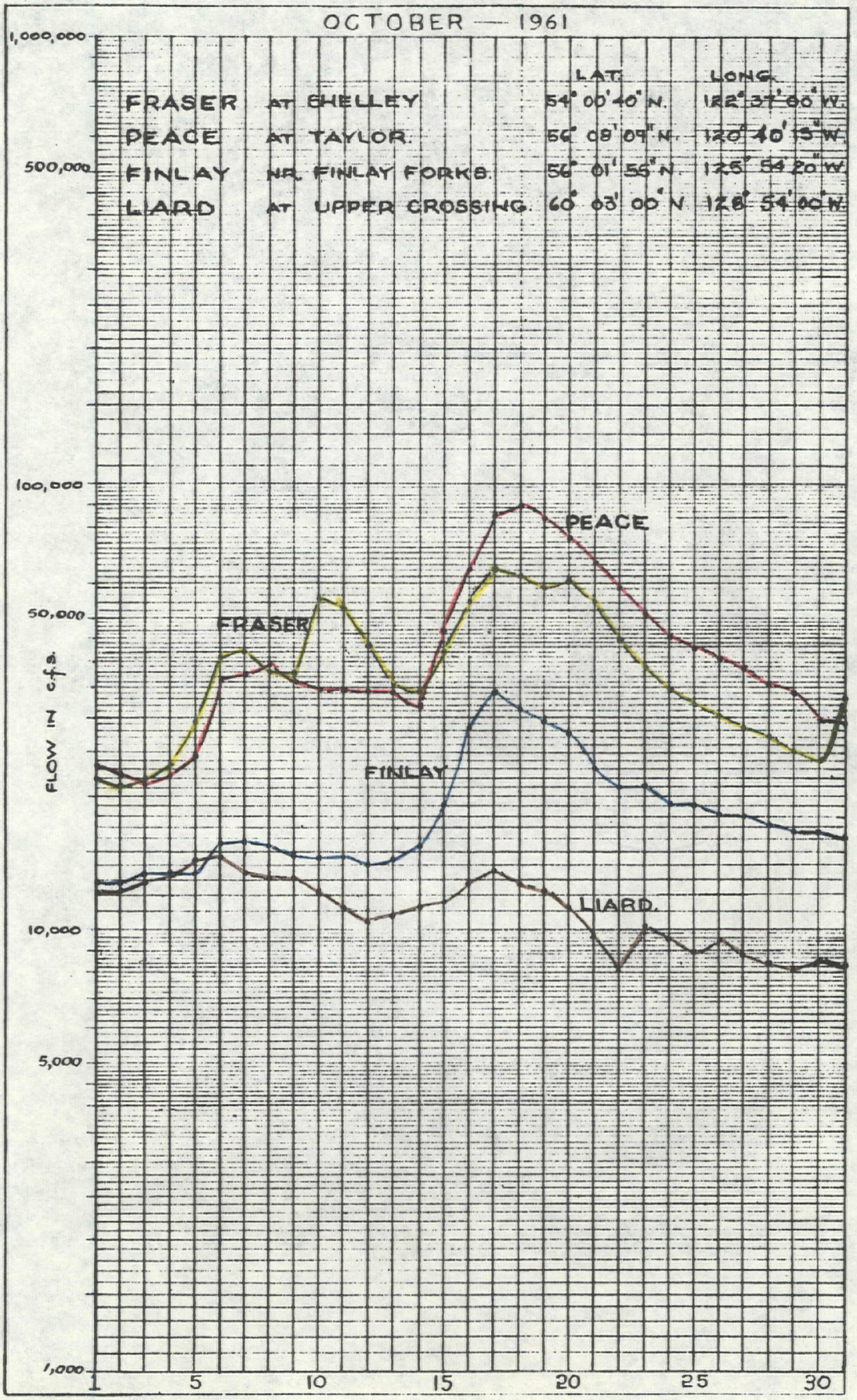


Plate 5

APPENDIX III

FLOOD-FREQUENCY CURVE

Notes on Frequency Curve

Plate 6 Frequency Curve

Table 1 Adjustment of 84-Year Historical Record Using Modified Benson Method

NOTES ON FREQUENCY CURVE

Record of flood discharges for the Nass River is available only for November 1917 and from 1929 to date. Compiling a frequency curve from this record necessitated using a statistical method whereby a reasonable curve could be obtained. The method employed is that described in the U.S.G.S. publication, "Flood Frequency Analyses", Paper No. 1543-A, pages 17-18. The modified formula for adjusting recurrence intervals due to lack of record, according to Benson, viz.,

$$m_1 = A + \frac{H - A}{T - A} (m - A)$$

is used in the basic formula,

$$t = \frac{H + 1}{m_1}$$

where m = order number, where the highest flood is 1, the second highest 2, and for all floods, both those for period of record and those from the historical record;

m_1 = order number of floods below base of historical record and those from the historical record;

A = number of annual floods equalling or exceeding the lowest historical flood;

H = length of the historical record in years;

T = the total number of items, historical and recent, in the array;

t = adjusted recurrence interval.

It may be noted in Table 1 that the 15 October 1961 flood has been plotted on the basis of 84 years. According to

Moeran 1/ and Sapir 2/ the old village of Aiyansh was inhabited in 1878. It was at this time that attempts were first made to establish an Anglican Mission at the village. It is not known how long Old Aiyansh had been in existence previous to 1878. In November 1917 a flood inundated the old village and the natives migrated to the present (1961) Aiyansh a few miles upstream from Old Aiyansh. It is assumed, therefore, that the distribution of floods over the period 1878 to 1917 was such that no particular year had a flood greater than that of 1917, 3/ i.e., 172,000 cfs, since this was the first-noted flood of consequence over that period.

The curve drawn shows that the flood of 15 October 1961 has a frequency of occurrence of once in 380 years; i.e., it has a probability of approximately 0.26 percent of occurring each year. However, it must be recognized that this estimate is based on a small sample of record. It will change as additional records accumulate.

---

1 J.W.W. Moeran, McCullagh of Aiyansh, Marshall-Prologue, London, 1923.

2 Edward Sapir, "A Sketch of the Social Organization of Nass River Indians", Geological Survey of Canada Museum Bulletin #19, Anthropological Series #7, Ottawa, 1915.

3 See Table 1.

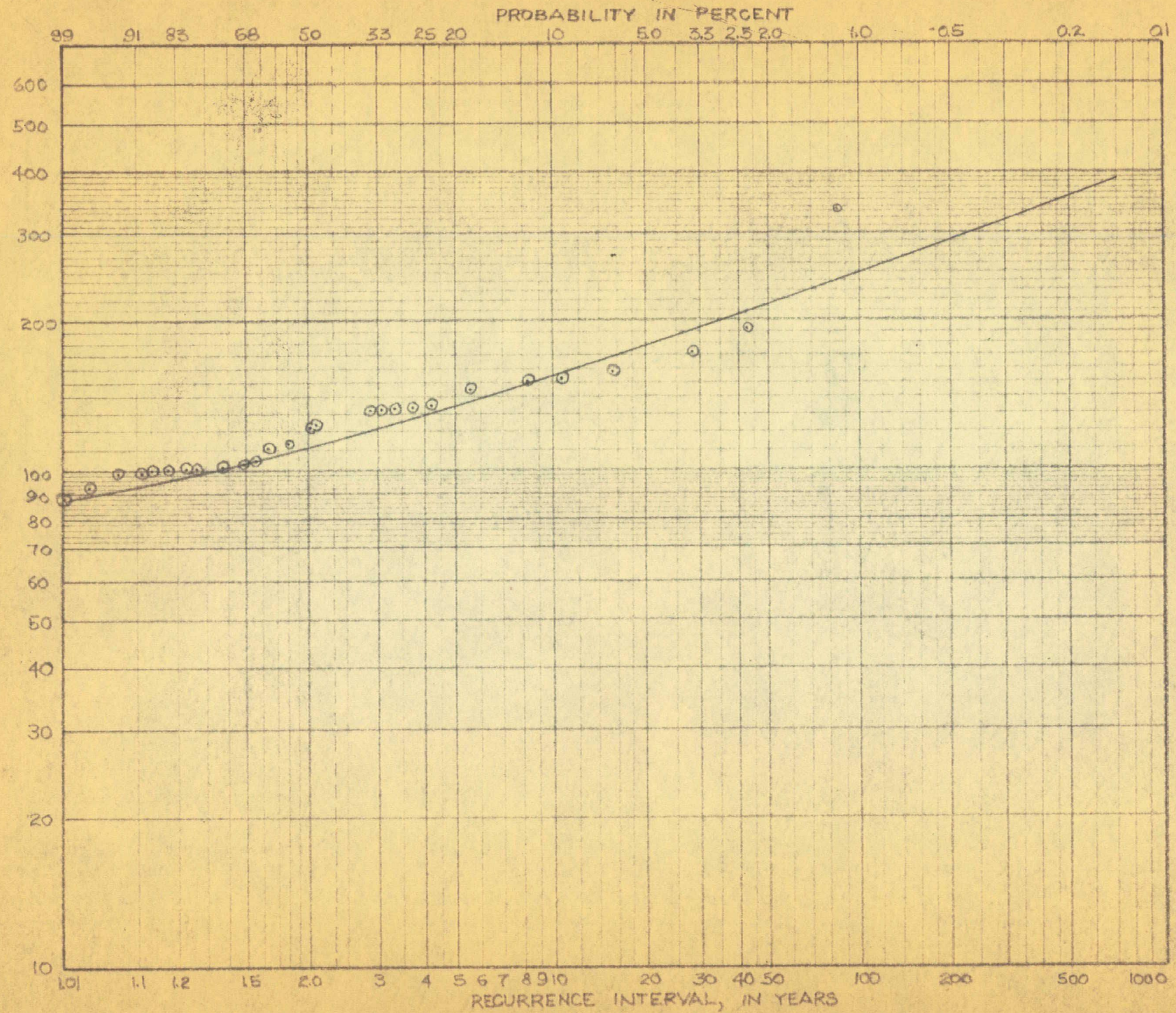


Plate 6

FREQUENCY CURVE
FOR PERIOD
1878-1962

DRAWN A.R.W
DATE 17 JULY '62
CHECKED R.O.

NASSR
AT AIYANSH

TABLE 1

NASS RIVER AT AIYANSH

Adjustment of 84-Year Historical Record
Using Modified Benson Method

Date of Record day/month/year	Maximum Daily Flow 1000 cfs	Order Number m	m-3	$m_1 = 3+\frac{81}{33}(m-3)$	$t = \frac{84+1}{m_1}$
15 Oct. 1961	334	1		1	85
2 June 1936	192	2		2	42.5
* Nov. 1917	172	3		3	28.33
29 May 1948	158	4	1	5.45	15.60
18 June 1931	154	5	2	7.91	10.73
8 June 1961	151	6	3	10.36	8.21
1950	145e	7	4	12.82	6.63
18 July 1960	145	8	5	15.27	5.57
1954	137e	9	6	17.73	4.79
29 May 1958	135	10	7	20.18	4.21
13 Nov. 1934	134	11	8	22.64	3.75
20 May 1957	134	12	9	25.09	3.39
10 June 1937	133	13	10	27.60	3.08
1 July 1939	132	14	11	30.00	2.83
1946	128e	15	12	32.45	2.62
1955	126e	16	13	34.91	2.44
1953	125e	17	14	37.36	2.28
30 May 1947	123	18	15	39.82	2.14
12 June 1941	121	19	16	42.27	2.01
1951	116e	20	17	44.73	1.90
26 May 1942	114	21	18	47.18	1.80
1952	114e	22	19	49.64	1.71
13 June 1932	111	23	20	52.09	1.63
29 May 1945	105	24	21	54.54	1.56
14 June 1940	104	25	22	57.00	1.49
~~20 June~~ 1956	104e	26	23	59.45	1.43
11 June 1930	102	27	24	61.91	1.37
1928	101e	28	25	64.36	1.32
20 June 1944	101	29	26	66.82	1.27
22 June 1959	101	30	27	69.27	1.23
26 June 1938	100	31	28	71.73	1.18
23 June 1943	100	32	29	74.18	1.14
15 July 1935	98.8	33	30	76.64	1.11
25 June 1933	98.6	34	31	79.09	1.07
12 June 1929	93.1	35	32	81.54	1.04
23 May 1949	88	36	33	84.00	1.01

Notes: e - Estimated by correlating with Skeena River at Usk. Used in obtaining order number only.
* - Earliest referenced flood mark. Discharge obtained by interpolating with 1936 flood.

APPENDIX IV

CLIMATOLOGICAL DATA

Table 2	Temperatures and Precipitation Data
Plates 7-11	Meteorological Charts, 12 October to 16 October 1961

TEMPERATURES AND PRECIPITATION DATA

1 TO 20 OCTOBER 1961

STATION	DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MAX. & MIN. MEANS	1-31 OCTOBER LONG-TERM MAX. & MIN. MEANS	PERIOD OF RECORD RECORD MAX.** 24-HR. PCPN.
AIYANSH	Max.											46*	40*	44*	70*									
	Min.																							
	Prm.	1.13	1.13	1.31		.37		.77	1.11		.04		.84	.18	.86	.02	.19	1.27	.20					3.70 24/12/47
ALICE ARM	Max.	56	58	54	52	46	45	50	38	41	43	42	45	46	45	42	45	44	45	42	44	46.5	45.3	3.77
	Min.	40	41	45	42	37	39	35	30	33	34	33	37	40	38	39	37	38	25	30	29	37.2	34.9	1/2/54
	Prm.	.84	4.10	4.66	.47	.41	.45		1.09	.16			2.31	3.42	3.84	.31	.42	.94						
ATLETTE (U.S.)	Max.	51	53	55	58	49	55	47	52	49	48	50	52	55	56	52	46	55	51	52	49	51.9		
	Min.	38	41	42	46	43	46	35	41	46	48	38	43	49	42	43	46	45	43	39	34	43.5		
	Prm.	1.13	1.39	1.76	.08	1.26	.02	.53	1.64	.24	.60	.32	.64	2.68	3.25	.04	.18	.39	.70					
BEAVER FALLS (U.S.)	Max.	54	55	57	57	54	54	48	49	47	46	46	51	54	59	55	47	53	52	49	48	51.8		
	Min.	46	38	42	47	43	46	46	46	42	41	38	39	46	48	45	46	42	45	38	32	43.1		
	Prm.	2.29	2.09	4.83	1.91	.99	.38		1.85	.24	.73	1.64	.91	3.27	4.20	1.35	.20	1.09	2.43	.09				
GERMANSEN LANDING	Max.	58	58	64	57	52	52	43	39	38	30	32	37	63	65	46	45	48	43	36	30	46.0	43.7	2.11
	Min.	36	41	49	36	27	32	29	31	31	24	25	27	32	51	41	27	38	32	25	12	32.2	27.5	19/4/51
	Prm.				.09	.63			.14	.05	.10			.37					.10	.07			
HUSTON	Max.	59	62	64	59	52	45	46	48	47	45	48	45	68	71	58	55	56	56	38	37	53.0	49.8	1.43
	Min.	31	36	46	48	37	36	38	42	26	29	29	20	40	45	35	21	34	31	28	12	32.2	28.7	30/8/60
	Prm.			.05	.31	.07		.07	.55				.26		.31				.05	.05				
KETCHIKAN (U.S.)	Max.	55	56	56	58	58	57	54	51	50	47	47	53	55	61	57	56	52	52	54	52	54.1		
	Min.	50	51	51	48	45	46	48	46	47	42	42	41	41	43	46	42	41	47	39	32	43.4		
	Prm.	1.60	1.26	3.45	1.55	.66	.15		1.95	.22	1.04	.94	1.18	2.89	4.78	2.54	.09	.94	1.23	.03				
KITIMAT	Max.	57	62	58	59	50	52	47	47	47	47	45	48	63	67	51	50	50	49	50	46	52.8	50.6	7.29
	Min.	44	52	52	43	47	41	39	39	46	39	45	39	37	56	47	38	39	44	40	33	42.5	40.8	16/3/60
	Prm.	.44	1.29	2.88	.25	.65	TR	1.54	1.18	1.02	.09	.10	4.09	.79	1.70	.57	.22	.78	.84	.02				
MASSET	Max.	59	59	61	60	51	56	54	51	50	53	54	57	58	56	51	50	57	51	50	49	54.4	55.1	2.61
	Min.	32	33	55	50	43	43	46	43	41	42	38	41	49	55	41	36	45	45	42	35	44.8	41.1	20/10/58
	Prm.	.07	.24	.34	.07	.54	.30	1.36		.21	.46	.38	1.33	1.67		.06	.32				.16			
NEW HAZELTON	Max.	62	65	60	59	53	49	46	43	47	49	50	44	55	54	53	50	53	51	46	40	53.0	49.8	2.20
	Min.	48	48	50	49	33	38	35	37	36	33	33	31	37	47	42	31	37	37	38	23	38.2	29.6	25/10/35
	Prm.			.87		.35		.25	.66			.11	.92		.39			.15	.02					
PRINCE GEORGE	Max.	53	61	57	65	49	43	47	50	46	35	45	45	50	69	62	47	45	44	40	34	49.9	50.2	2.08
	Min.	37	39	46	45	36	32	26	29	32	26	29	24	45	56	45	31	28	38	26	21	34.1	31.5	13/7/32
	Prm.			.01	.01	.20	.07	TR	.73	.30	.27	TR	.08	.94		.17	.01	TR	.25	TR				
PRINCE RUPERT	Max.	57	57	57	56	53	52	48	50	48	46	50	54	60	61	54	48	50	49	54	49	52.7	52.8	5.55
	Min.	50	52	52	45	46	46	39	42	41	41	39	44	47	53	46	39	43	41	38	33	43.2	42.6	11/10/53
	Prm.	1.09	.71	1.93	1.13	.84	.43	.15	2.51	.20	.20	.37	.24	1.68	1.02	.27	.14	.23	2.24	.07				
STEWART	Max.	44	42	43	43	45	46	44	43	48	50	45	44	42	42	41	42	43	42	41	40	43.5	47.5	5.71
	Min.	38	39	46	43	41	42	46	38	46	40	43	40	36	38	37	38	43	40	37	37	39.3	36.2	10/9/57
	Prm.	.78		3.00	3.73	2.05	.21				1.60	1.37	4.97	7.00	2.25	.45			.76	.37				
TELEGRAPH CREEK	Max.	54	58	53	52	54	55	44	45	44	39	43	36	39	36	42	48	54	50	42	37	46.8	47.6	1.76
	Min.	45	41	46	44	22	36	38	32	29	28	25	30	38	31	30	32	34	33	20	20	29.3	30.2	4/12/54
	Prm.	.07	.39	.83	.11			.29	.08				.02	.93	.75	1.21	.40	.05	.67					
TERRACE	Max.	53	60	55	55	48	52	45	42	47	45	45	42	60	65	54	46	49	46	47	42	50.4	50.1	4.59
	Min.	48	51	51	47	43	48	37	37	39	37	39	32	41	56	41	38	41	42	35	30	41.2	38.8	1/12/33
	Prm.	.14	.05	1.37	.88	.12	TR	.02	.88	.04	.08	.03	.40	1.07	.02	.97		.01	.56					
WANDERLL (U.S.)	Max.	55	56	59	58	50	52	47	47	48	48	46	48	48	57	55	44	47	48	46	46	50.3		
	Min.	43	45	38	46	41	35	35	39	34	37	37	36	43	48	43	38	38	40	31	26	39.6		
	Prm.	1.44	2.11	3.17	.23	.12	.09	.02	.71	.12	.55	.18	.15	.90	2.60	1.26	.20	.34	1.25	.08	.01			

TABLE 2

Information supplied by Department of Transport or United States Weather Bureau. *Unofficial readings obtained by gauge reader. **Prior to October 1961.

PLATES 7 - 11

METEOROLOGICAL CHARTS

12 OCTOBER TO 16 OCTOBER 1961

The following surface charts are excerpts from the 1200 hours editions of Form 9211 (station - Vancouver Airport) prepared and published by the Department of Transport, Meteorological Branch, Canada.

A front, distinguishing warm and cold-air masses, is denoted by a line, on one side of which solid triangles represent the warm area, and on the opposing side, solid semi-circular symbols represent the cold area.

The Nass-Unuk-Iskut River Basins are approximately outlined by a red dotted line.

12 OCT 1961.

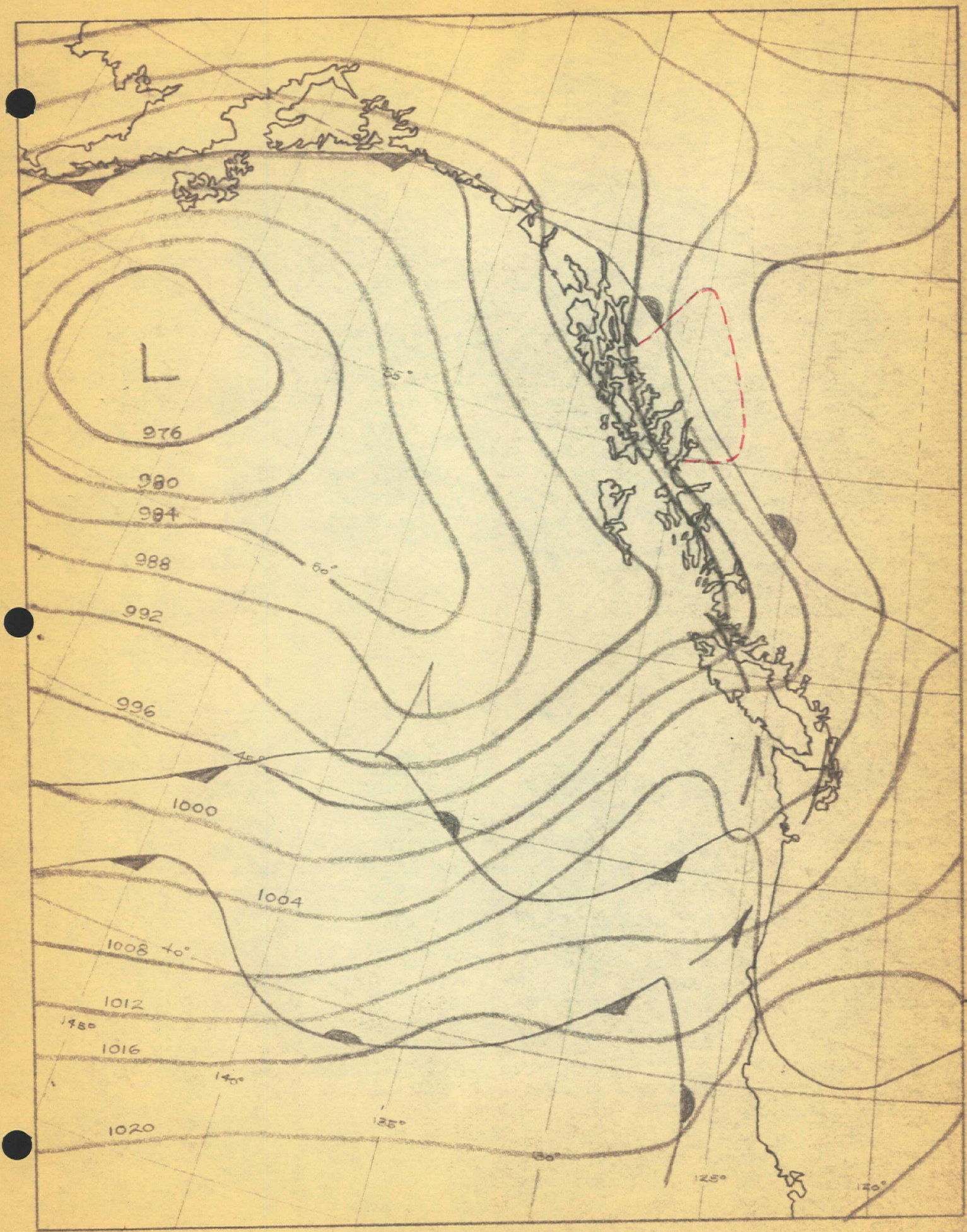


Plate 7

13 OCT. 1961.

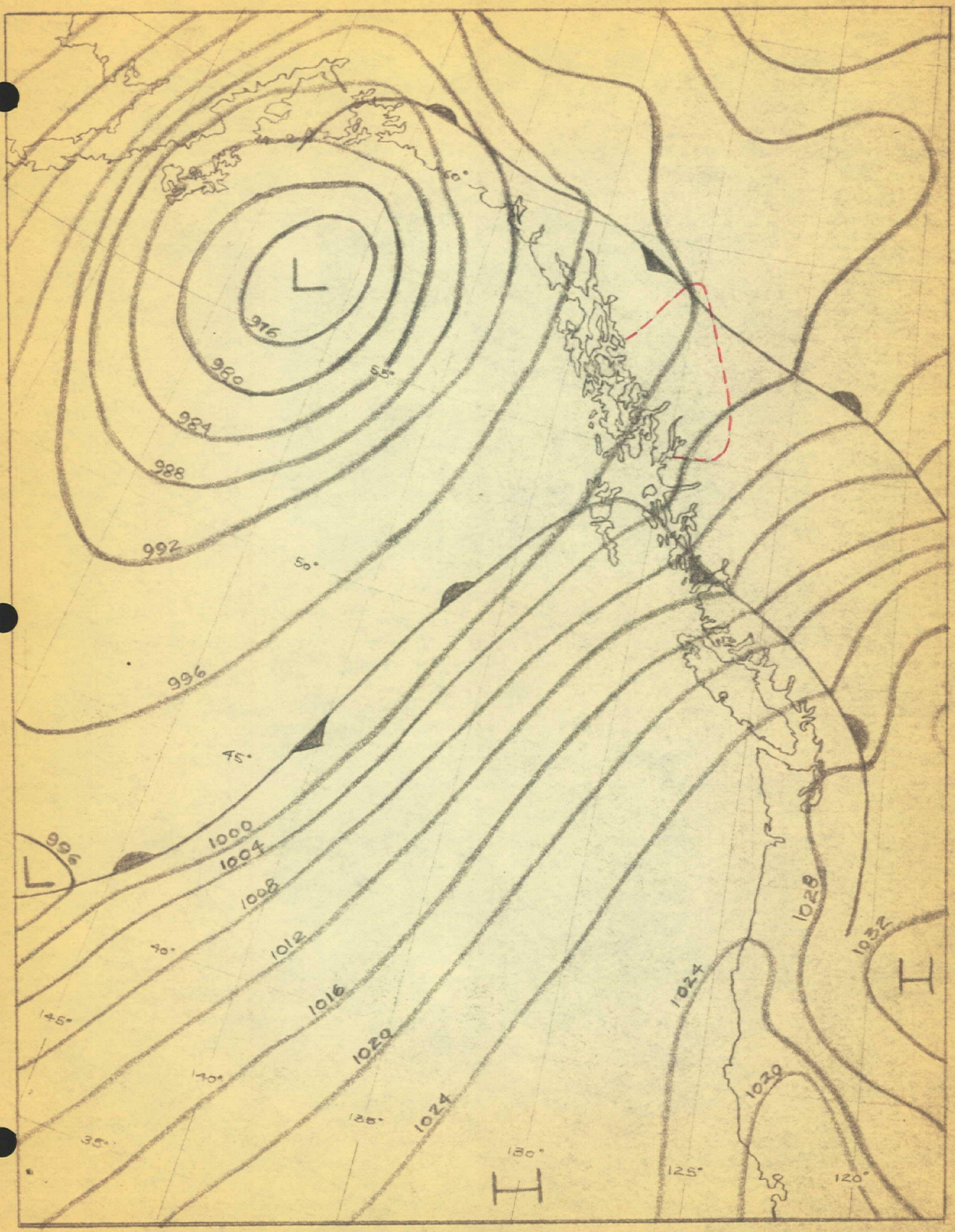


Plate 8

14 OCT. 1961

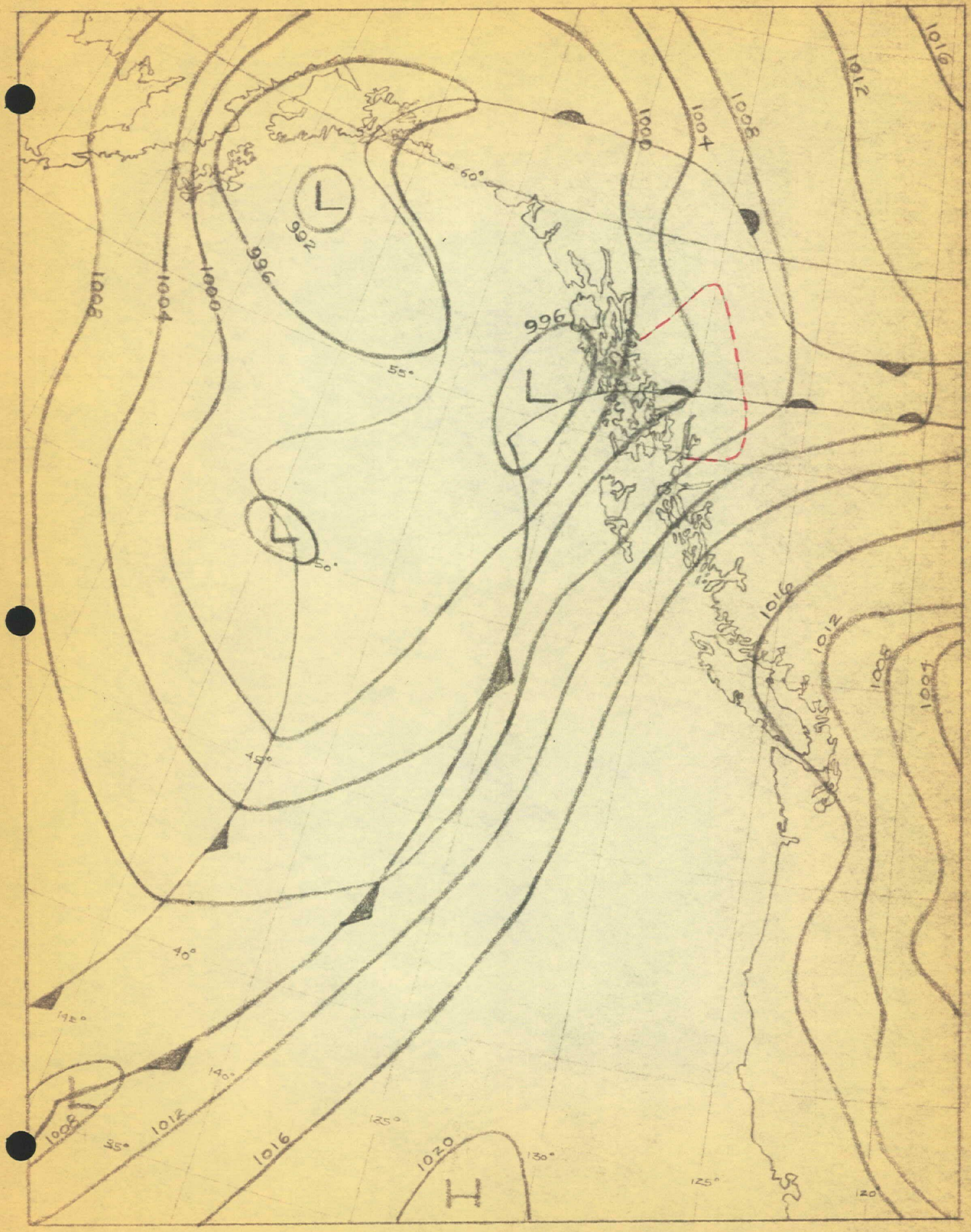


Plate 9

15 OCT. 1961.

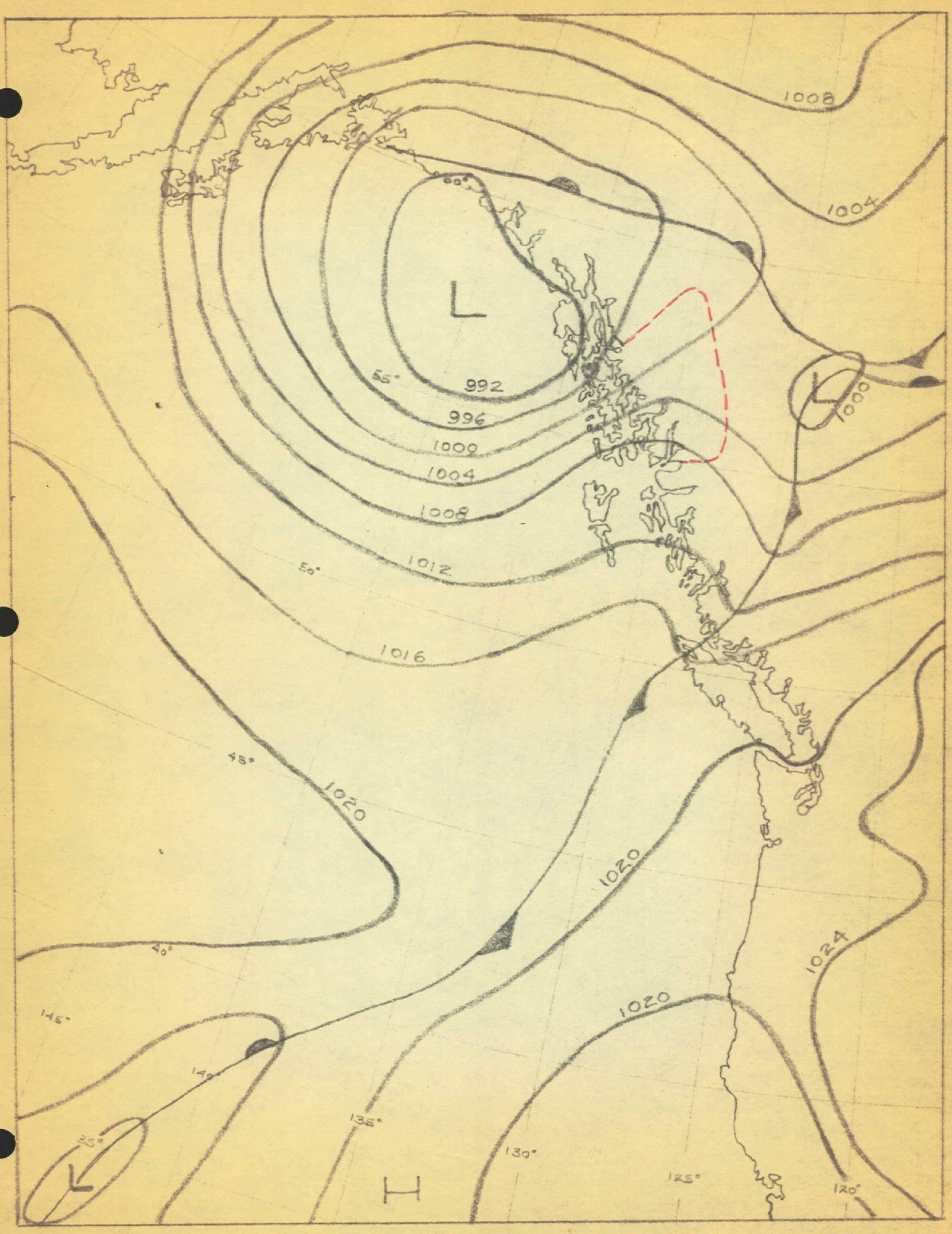


Plate 10

16 OCT 1961.

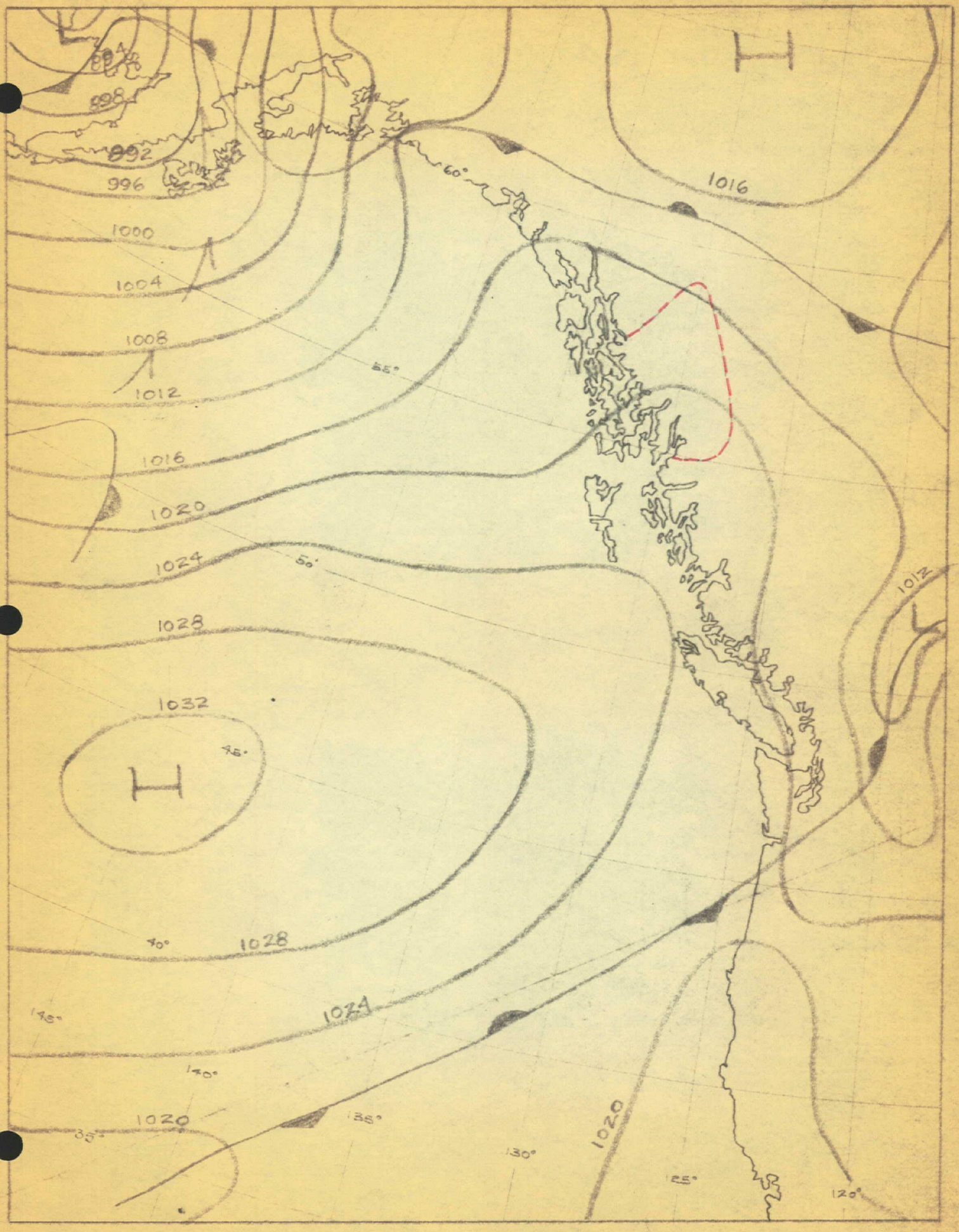


Plate 11

APPENDIX V

FLOOD DAMAGE

Table 3	Estimated Value of Flood Losses at Aiyansh
Plates 12-14	Photographs of Flood Damage on Nass River at Aiyansh and on Iskut River near Gauging Station

TABLE 3

ESTIMATED VALUE OF FLOOD LOSSES
AT AIYANSH, 15 OCTOBER 1961

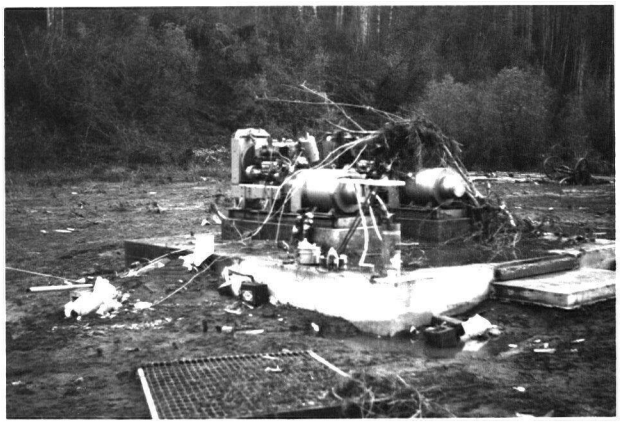
Government property excluding Indian health services	$ 76,000
Indian health services	55,000
Homes destroyed	50,000
Damage to 30 homes	50,000
Community hall repairs	7,000
Sawmill	6,000
Winter food supplies	10,000
Personal equipment - power saws, boats, etc.	5,000
Teachers' personal losses	6,000
TOTAL	$252,000

Information obtained from Indian Affairs Branch,
Department of Citizenship and Immigration,
Vancouver, B.C.

FLOOD DAMAGE AT AIYANSH NEAR MOUTH OF
NASS RIVER 18 OCTOBER 1961

SEP 64

Old house in front of Y.M.C.A. building was situated where depression shows in left-hand foreground of picture.



SEP 64

Village power plant.

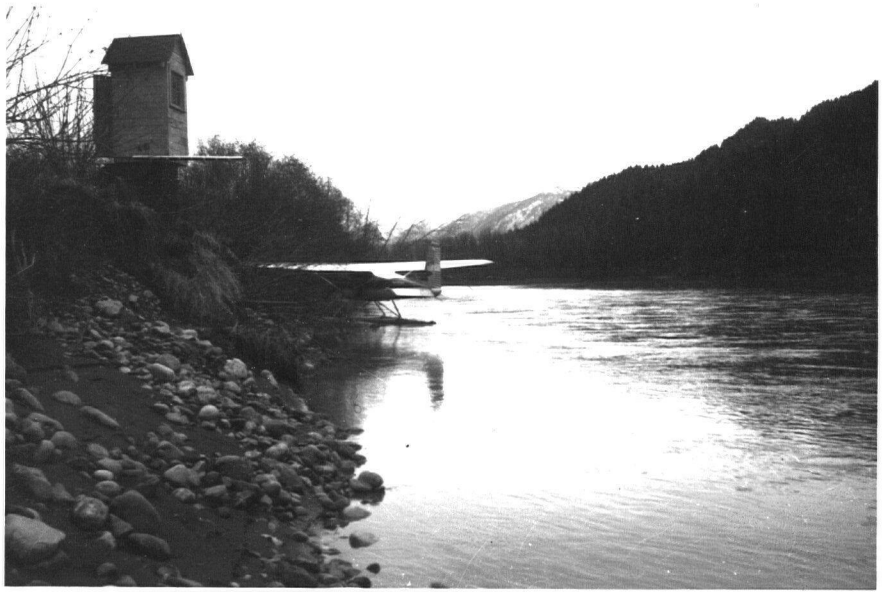
FLOOD DAMAGE AT AIYANSH NEAR MOUTH OF
NASS RIVER 18 OCTOBER 1961

SEP 64

Interior of classroom in new school.
Note silt deposits and water-level mark
above the windows and blackboard.

SEP 64

FLOOD DAMAGE TO RECORDER STATION
ISKUT RIVER 24 OCTOBER 1961



Looking upstream, showing undercut right bank.

Looking downstream, arrow indicates high-water level, 15 October 1961.