# *Short Papers and Notes*

## UNUSUAL WEATHER AND RIVER BANK EROSION IN THE DELTA OF THE COLVILLE RIVER, ALASKA*

The delta of the Colville River, located about half-way between Barrow and Barter Island on the arctic coast of Alaska (Fig. 1B), is characterized by typical arctic maritime weather and climate. Winters are long, cold, and windy; summers are short, cool, and windy, with frequent fog and light rain. The weather of the summer of 1961 was unusual in at least two aspects: rainfall was more abundant, and westerly winds were more frequent and stronger than normal. The only full-time resident of the area recalls only one summer with more rain during the last 50 years.

The importance of these abnormal weather conditions was made evident in several ways, economic as well as physical. The local resident fishes with gill nets in the 500-foot-wide west branch of the Colville River at Nigilik (Fig. 1C). During the summer of 1961 only about one-half of a normal catch was taken, primarily because of frequent high water and excessive muddiness which both affect the movements of fish. In addition, the great amounts of trash (mainly willow sticks and peat shreds) brought down by the high water necessitated frequent net cleaning. Repeated rain and fog hampered sun drying of even the reduced catch.

Another result of the summer floods and of the waves generated by high westerly winds was a great amount of erosion along the east banks of the several branches in the delta. This type of bank erosion was especially great during the severest storm of the summer, which occurred between July 30 and August 2 (Fig. 2 shows a bank that had been quite smooth 3 days before this storm). In addition, as the river level dropped to a more normal stage, undercutting of varying magnitude became visible along almost the entire right bank.[1] Visual observation suggested a correlation between the amount of undercutting and the fetch available to southwesterly winds as well as with the composition of the river banks. The eastern distributary is sufficiently wide for waves of considerable magnitude to be generated on it except in the parts obstructed by islands. Maximum undercutting, as much as 25 to 30 feet (Fig. 3), was seen in the least protected sandy banks, whereas the most highly protected peat banks showed the least. Erosion of banks along the narrow winding western distributaries was equally variable. Where straight reaches coincided with the wind direction, erosion was especially great.

From the standpoint of our study, which included a consideration of bank morphology and erosional processes, the "unusual" weather was most helpful. As the frequency of such weather conditions must be very important in affecting the rate of bank erosion, the following cursory investigation was made of their periods of occurrence.

The only weather records available from the delta of the Colville River are those the authors kept during the summer of 1961 of daily temperature extremes, precipitation types, and wind direction and records of temperature and wind for June and July, 1956.[2] The nearest stations with records for widely varying periods are Barrow and Barter Island on the coast, and Umiat and Anaktuvuk Pass inland (Fig. 1B). Although these stations are far from the delta, an analysis of their records should allow useful conclusions to be drawn in connection with weather influences on geological processes operating in the delta.[3]

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For river bank erosion (as well as for summer fishing) the weather conditions in summer are important. The river ice usually breaks up during the first 2 weeks of June and re-forms in early October. Therefore, only the weather of the 4 months from June to September is here considered. The weather elements of temperature, precipitation, and wind are the most important.

**Temperature**

Throughout the 4 "summer" months, temperatures may go below freezing but not to the extent of refreezing the river. In 1961 the monthly average temperature at Barrow ranged from 33.8°F. in September to 38.2°F. in July. Barter Island had a slightly higher range, from 33.1°F. for September to 40.6°F. in July. At both stations the monthly average varied less than 4°F.

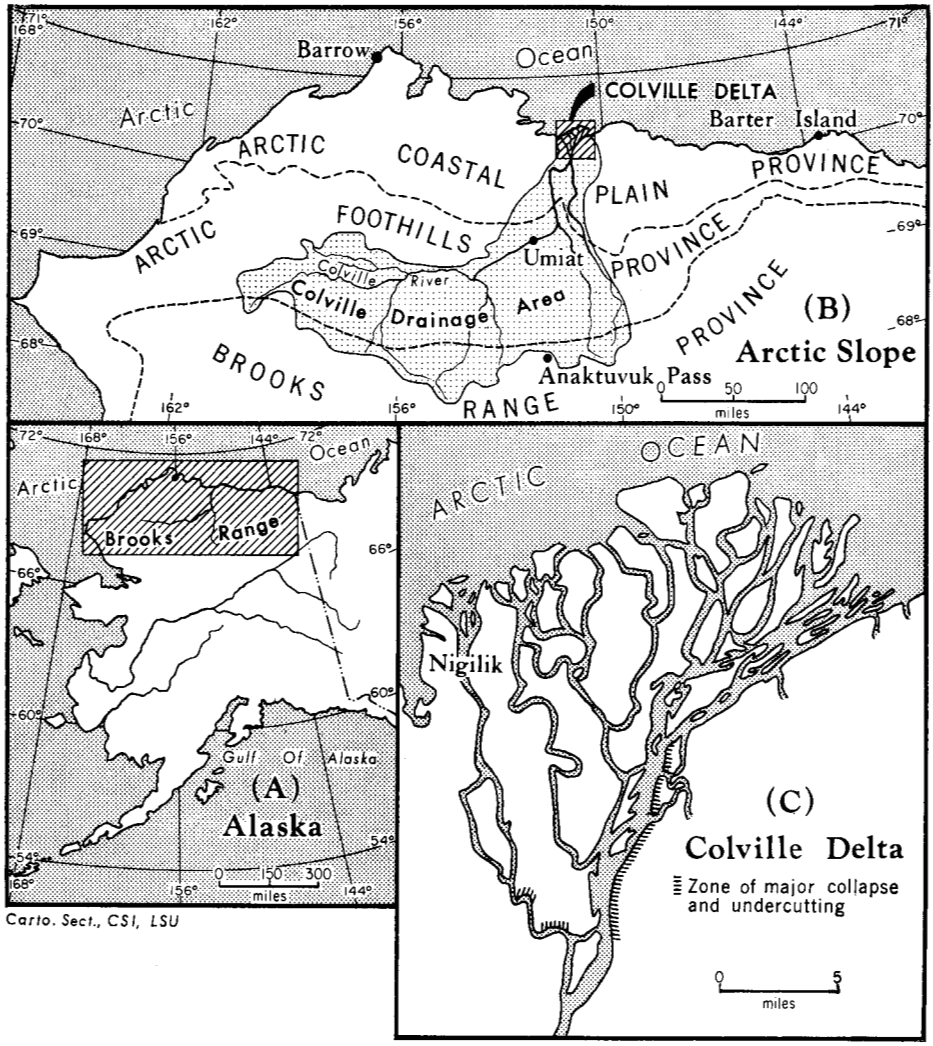


**Fig. 1.** Location maps.

from the long-term averages given in Climatological Summaries of the Weather Bureau.

For flooding of the river, temperature is especially significant during the early part of summer, for it determines the rate at which the snow melts and, therefore, the rate of runoff in the watershed of the river (Fig. 1B). Apparently, some of the floods in June were caused by abnormally high temperatures. Although the average temperature for June was only slightly higher than normal, the maximum temperatures recorded at both Barrow and Barter Island were high. Indeed,

Fig. 2. Collapse of right bank through action of high waves generated by westerly winds.

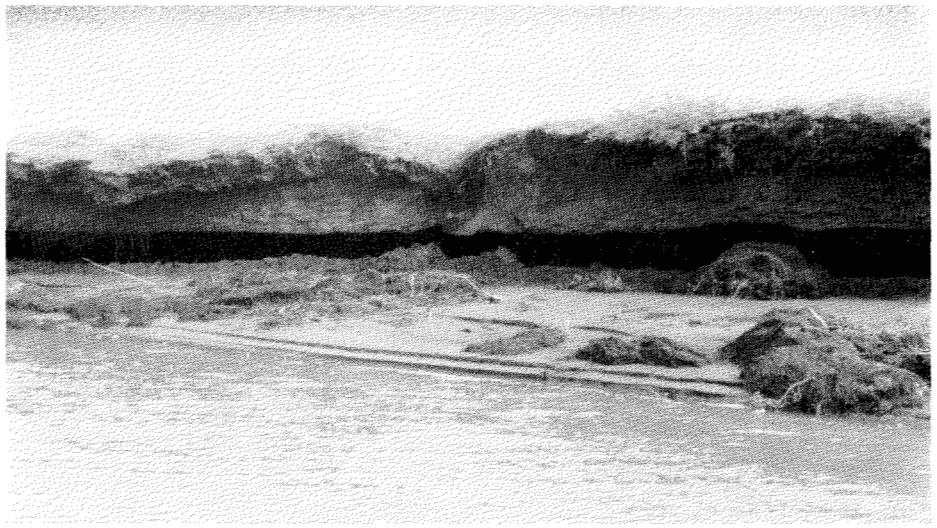

Fig. 3. Exposed undercut along right bank of the Colville River.

the maximum temperature (67°F.) at Barter Island was the highest ever recorded there in June, and, although not a record, the maximum (63°F.) at Barrow was quite high. From June 10 to 20 temperature at Barrow averaged 2.4°F. above normal. When these temperatures are considered together with the fact that the coast experienced more fog than usual during June, 1961, it is probably true that temperatures on the Arctic Slope averaged higher than normal.

**Table 1.** Precipitation records (inches).

| | *Barrow (40)** | | | *Barter Island (13)** | | | *Anaktuvuk Pass (7)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Max.* | *Mean* | *1961* | *Max.* | *Mean* | *1961* | *Max.* | *Mean* | *1961* |
| June | 1.15 | .34 | .08 | 2.09 | .60 | .80 | 4.28 | 1.44 | 1.55 |
| July | 2.24 | .87 | 1.80 | 2.60 | .99 | 2.79 | 1.92 | 1.39 | 3.62 |
| August | 2.13 | .89 | 1.31 | 3.40 | 1.26 | 1.09 | 1.96 | 1.29 | 1.39 |
| September | 1.56 | .57 | .31 | 4.91 | 1.11 | .87 | 2.07 | 1.18 | — |

*years of record used

**Table 2.** Wind records (hourly wind speeds; m.p.h.).

| | *Barrow (31)** | | | *Barter Island (12)** | | |
|---|---|---|---|---|---|---|
| | *Mean* | *1961* | *Fastest* | *Mean* | *1961* | *Fastest* |
| June | 11.4 ENE | 12.0 | 35 SW | 11.0 ENE | 11.0 | 28 E |
| July | 11.7 E | 11.1 | 35 SW | 10.1 ENE | 11.2 | 29 WSW |
| August | 12.6 E | 15.7 | 36 E | 11.6 E | 15.8 | 44 WSW |
| September | 13.0 E | 12.2 | 37 ENE | 12.5 E | 15.2 | 40 E |

*years of record used

## Precipitation

Although snow may fall in any month of the year at the delta, snowfall in the 4 months of June to September is slight (except toward the end of September) and is thus not significant in connection with this paper. However, the amount that has accumulated on the watershed of the Colville River prior to the summer melting season is important for the total runoff. During the 12 months prior to June, 1961, Barrow received slightly more than the normal amount, although Barter Island received rather less than usual. Although no records are available for the Arctic Slope, reports from pilots who flew over the Slope in the spring suggest that snow accumulation was at least normal.

The bulk of the summer precipitation is in the form of rain. During a 66-day period in 1961 rain fell on 29 days. Although most of it was light, some moderate and even heavy falls were experienced.

Table 1 compares conditions in 1961 with the averages and extremes for Barrow, Barter Island, and Anaktuvuk Pass. At all three stations July had exceptionally high precipitation. The total for this month set a record at Barter Island and at Anaktuvuk Pass, where the amount was nearly twice that of the second largest amount recorded. The other summer months had more nearly normal precipitation at all stations.

## Wind

According to the local resident, west wind is a harbinger of bad weather. This was quite evident in the summer of 1961. During periods of winds from the southwest quadrant, heavier than normal rain was frequent. The river

was rougher than usual on account of the higher wind velocity and more bank collapse occurred on the east than on the west banks. In addition, high west winds caused a storm tide in the open water along the arctic coast high enough to flood the foredelta with sea-water. Thus, the direction, duration, and velocity of the wind are very important in the delta.

Table 2 compares the average wind speeds in 1961 with the long-term averages for Barrow and Barter Island. They were higher than normal in August at Barrow, and in August and September at Barter Island. Fig. 4 shows in August at Barrow for more than half the time the wind was between 13 and 24 m.p.h. and for 10 per cent of the time over 24 m.p.h. At Barter Island in August the frequency of winds over 24 m.p.h. was about 3 times that normally expected, occurring during some 15 per cent of the total hours of the month.

In addition to the increased speed of these winds, the frequency and intensity from certain directions was quite different from normal. For the subject of this paper it is important that winds with a westerly component were more frequent or stronger than usual. In July, although only slightly stronger than normal, they were much more common. In August, winds with a westerly component were twice as strong as normal, averaging 24.5 m.p.h. from west-northwest. At Barter Island, on the other hand, the frequency of westerly winds was not as great in any of the 4 summer months of 1961 as the average but, although only slightly stronger than normal in July, they were, as at Barrow, nearly twice as strong in August.

**Wind and precipitation**

There is also a correlation between wind direction and rainfall frequency and intensity (Table 3). At Barrow in July and August a large percentage of the precipitation falls when the winds are from a westerly direction. Not only is total precipitation more frequent with winds from the southwest quadrant, but it is even more striking and important that nearly always in July and August heavy rain is accompanied by winds from the southwest quadrant (Table 4). Table 5 indicates that during the summer months the 24-hour period with the maximum precipitation is likely to record between a fourth and a half of the month's total (see ref. 2).

**Table 3.** Wind direction and precipitation, 1961 (percentage of total hours).

| | *Barrow* | | | | *Barter Island* | | | |
|---|---|---|---|---|---|---|---|---|
| 1. Monthly wind | | | | | | | | |
| | June | July | Aug. | Sept. | June | July | Aug. | Sept. |
| NE-SE | 71 | 32 | 71 | 72 | 69 | 56 | 65 | 73 |
| SW-NW | 14 | 44 | 14 | 7 | 17 | 27 | 25 | 20 |
| Other | 15 | 21 | 15 | 21 | 14 | 17 | 10 | 7 |
| 2. Rainy days | | | | | | | | |
| NE-SE | 74 | 29 | 84 | 68 | 68 | 39 | 50 | 75 |
| SW-NW | 18 | 42 | 11 | 7 | 15 | 37 | 36 | 16 |
| Other | 7 | 29 | 6 | 25 | 17 | 24 | 14 | 9 |
| 3. Total precipitation | | | | | | | | |
| NE-SE | 12 | 16 | 37 | 65 | 91 | 67 | 57 | 48 |
| SW-NW | 75 | 67 | 61 | 0 | 9 | 15 | 43 | 52 |
| Other | 13 | 17 | 2 | 35 | 0 | 18 | 0 | 0 |

**Discussion**

The figures given above indicate that the summer of 1961 was climatically

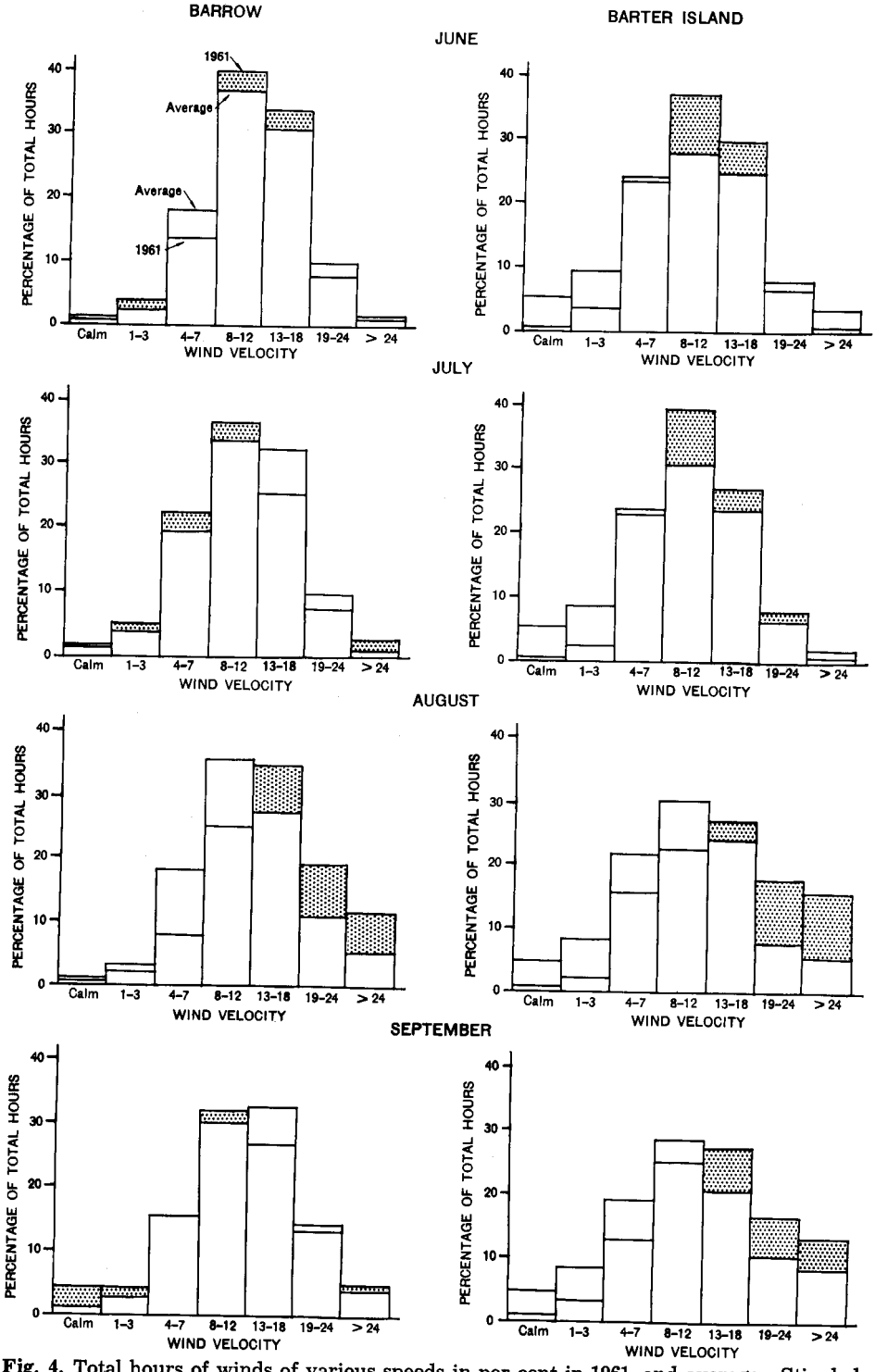


**Fig. 4.** Total hours of winds of various speeds in per cent in 1961, and averages. Stippled areas represent excess of total hours in 1961 over the average in per cent.

**Table 4.** Percentage of time during which the greatest 24-hour rainfall of the month is accompanied by winds from the southwest quadrant.

| | June | July | Aug. | Sept. |
|---|---|---|---|---|
| Barrow (7 years) | 85 | 72 | 72 | 57 |
| Barter Island (5 years) | 40 | 80 | 100 | 60 |

**Table 5.** Amount of total monthly precipitation occurring in one 24-hour period

| | June | July | Aug. | Sept. |
|---|---|---|---|---|
| Barrow (7 years) | 48 | 32 | 38 | 27 |
| Barter Island (5 years) | 51 | 41 | 38 | 28 |

unusual, not only at the delta of the Colville River but also along much of the arctic coast of Alaska. When these findings are considered in relation to the Colville River, it appears that the greater-than-normal flooding frequency was the result of a series of weather phenomena. The floods in mid-June following those that accompany break-up were the result mainly of melting more rapid than usual. The floods of July and August were primarily the result of four more or less evenly spaced rain storms in July and two rather intense storms in August, which contributed more than normal amounts of rain to the Arctic Slope.

These storms were accompanied by stronger-than-normal westerly winds, which caused high waves on the river. However, only one storm, that of July 30 to August 2, brought about great amounts of undercutting and extreme collapsing of the river banks.

Observations showed that the combination of high water and strong westerly winds is especially important in exposing the undercut parts of the banks and causing bank collapse. An analysis of past climatic records indicates that such a combination is more frequent than at first believed. Most of the exposures of undercut banks, especially those with a low peat content, are hidden from view within a few days because of the rapid sloughing of sediments on account of melting in the frozen banks once they are exposed to the sun (Fig. 3). As the banks in question face southwest, they are exposed to the sun when its energy is most effective.

Thus, it is probable that at least once during most summers flooding of the river in combination with wind-generated waves will be sufficient to expose and even deepen the notch which, although normally hidden from view, is present in the banks of the river. It is also probable that some collapse of the banks occurs every summer. However, because the duration and intensity of the high-energy waves was much longer and greater in the summer of 1961 than is common, it is unlikely that the great amount of collapse observed during that season is of very common occurrence.

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[1] Williams, J. R. 1952. Effect of wind-generated waves on migration of the Yukon River in the Yukon Flats, Alaska. Science 115:519-20.

[2] Conover, J. H. 1960. Macro- and microclimatology of the Arctic Slope of Alaska, Quarterm. Res. and Eng. Com., U.S. Army, Tech. Rept. EP-139.

[3] Dickey, W. W. 1961. A study of a topographic effect on wind in the Arctic. J. Meteor. 18:790-803.

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