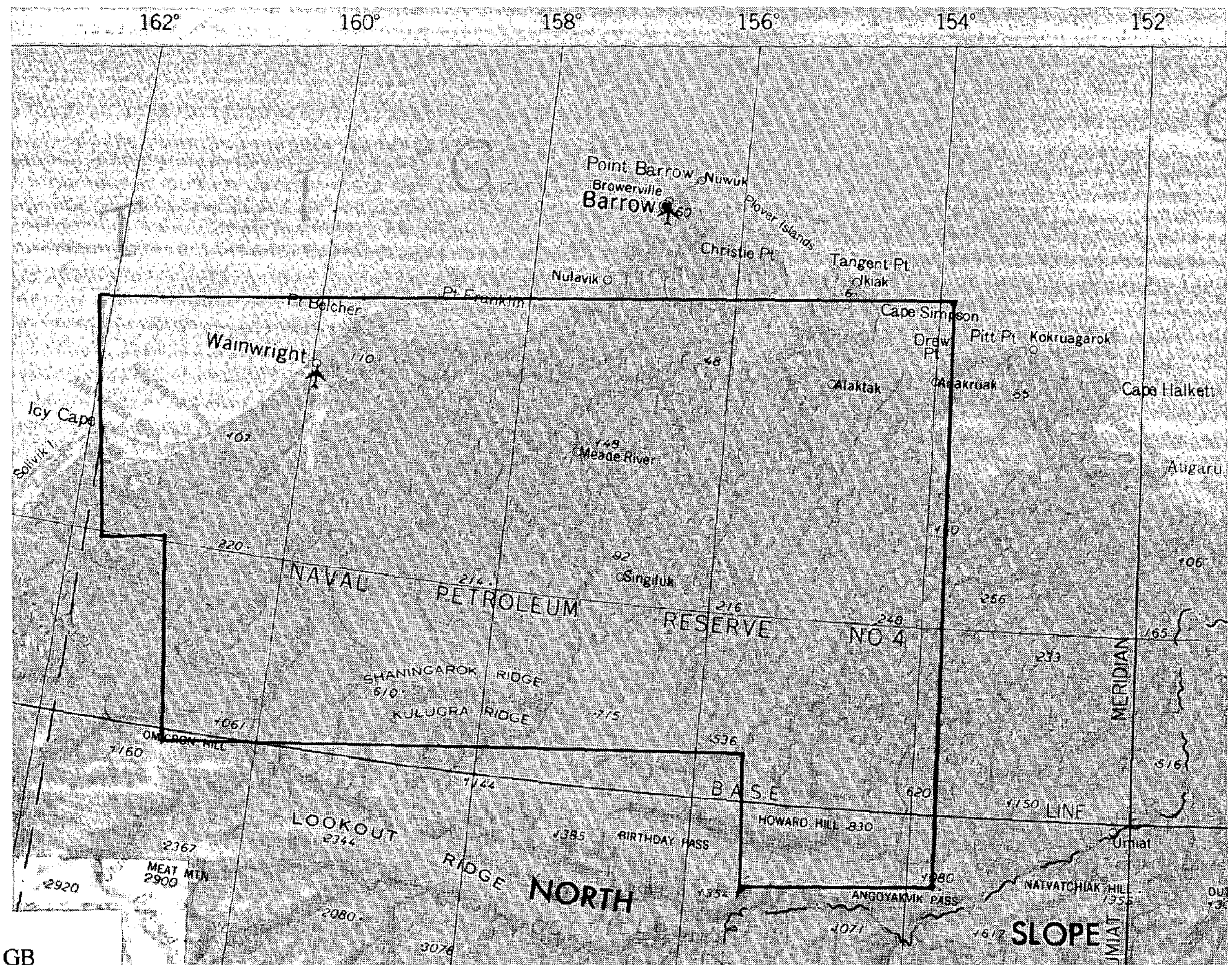
Flood Hazard Potential of 18 Arctic Rivers in the National Petroleum Reserve-Alaska

by

Thomas W. Mortensen



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Volume I

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NORTH SLOPE BOROUGH
PLANNING DEPARTMENT

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Earl L. Finkler, Director

May 30, 1986

Dear Reader:

Because of your interest and involvement in activities on the North Slope I have enclosed for your information a copy of a recent Planning Department Publication entitled "Flood Hazard Potential of 18 Arctic Rivers in the National Petroleum Reserve-Alaska". The objective of the report was to determine the potential flooding hazards of these rivers.

This is the third report in a series on flood hazard potential of rivers within the North Slope Borough. To date 31 rivers have been mapped. If you have questions or comments, or would like additional copies of this report or the previous two reports please contact Linda Okpik in the North Slope Borough Planning Department at the address listed above.

Sincerely yours,

Karla Kolash

Karla Kolash
Deputy Director, Planning Dept.

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Volume I

Maps contained in Volume II have been reduced as much as 60%.
Original mylars may be obtained from the
North Slope Borough, Planning Department for reproduction.

Abstract

The floodplains of 18 Arctic rivers in the National Petroleum Reserve-Alaska were mapped in order to show their potential flooding hazards. The relative flooding frequencies and an estimated frequency interval are tabled and compared for the 18 rivers of this study and the 13 rivers of two previous studies. Although the rivers of Arctic Alaska are considerably different in most aspects from rivers of other climatic regimens, similarities do exist between the Arctic rivers themselves. The flooding units are characterized by distinct geomorphic and physiographic features. These features can be correlated, in part, from one river system to another. The floodplain geomorphology was interpreted by using a combination of Landsat satellite imagery and the stereo viewing of both color infrared and black and white aerial photography. Field verification of the relative flooding frequency and the geomorphic description of each floodplain unit was accomplished in the summer of 1984. The flooding potentials of each river were then mapped after the flooding parameter of each geomorphic unit was determined. The 18 rivers that were mapped in this study are the Ikpikpuk, Chipp, Alaktak, Miguakiak, Piasuk, Oumalik, Topagoruk, Meade, Usuktuk, Ivisaruk, Kuk, Kaolak, Ketik, Avalik, Kugrua, Ongorakvik, Nokotlek and the Tunalik. Potential gravel sources along five rivers were sampled and tested.

The Chipp, Topagoruk and Meade Rivers appear to be responding to tectonic subsidence in the Dease Inlet/Admiralty Bay area. The active subsidence in this area may explain the existence of the large embayment of Dease Inlet/Admiralty Bay into the Arctic Coastal Plain.

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Introduction and Objectives

The major objective of this study was to map at a scale of 1:63,360 the extent of the active and inactive floodplains of 18 Arctic rivers along the Chukchi Sea and Beaufort Sea Coasts within the National Petroleum Reserve-Alaska (formerly Naval Petroleum Reserve No. 4) (Figure 1). Other objectives were to establish relative and estimated flooding frequencies (Table 4) and potential flooding hazards. The 18 rivers are:

Ikpikpuk River	Ivisaruk River
Chipp River	Kuk River
Alaktak River	Kaolak River
Miguakiak River	Ketik River
Piasuk River	Avalik River
Oumalik River	Ongorakvik River
Topagoruk River	Nokotlek River
Meade River	Kugrua River
Usuktuk River	Tunalik River

Fourteen maps were produced by this study. The first map (unnumbered) is an index map showing the location of the rivers and areas mapped as part of this study. Map 1a shows the floodplains and flood hazard potential of the Ikpikpuk, Chipp, Alaktak, Miguakiak, Piasuk and Topagoruk Rivers. Map 1b shows the floodplains and flood hazard potential of the Ikpikpuk, Chipp, Oumalik and Topagoruk Rivers. Map 1c shows the floodplain and flood hazard potential of the Ikpikpuk River. Map 1d shows the floodplain and flood hazard potential of the Ikpikpuk River. Map 2a shows the floodplains and flood hazard potential of the Meade and Usuktuk Rivers. Map 2b shows the floodplains and flood hazard potential of the Meade and Usuktuk Rivers. Map 2c shows the floodplain and flood hazard potential of the Meade River. Map 3 shows the floodplain and flood hazard of the Kugrua River. Map 4a shows the floodplains and flood hazard potential of the Kuk and Ivisaruk Rivers. Map 4b shows the floodplains and flood hazard potential of the Kuk, Ivisaruk and Kaolak Rivers. Map 4c shows the floodplains and flood hazard potential of the Avalik and Ketik Rivers. Map 4d shows the floodplain and flood hazard of the Ketik River. Map 5 shows the floodplains and flood hazard potential of the Tunalik, Ongorakvik and Nokotlek Rivers.

The maps provide information which can be used to delineate the following:

1. active floodplains
2. standard project floodplains
3. abandoned or inactive floodplains
4. active channels
5. the estimated relative flood frequency and flood magnitude for each mapping unit
6. areas of major flooding hazards
7. related non-floodplain geomorphic features and generalized terrain units

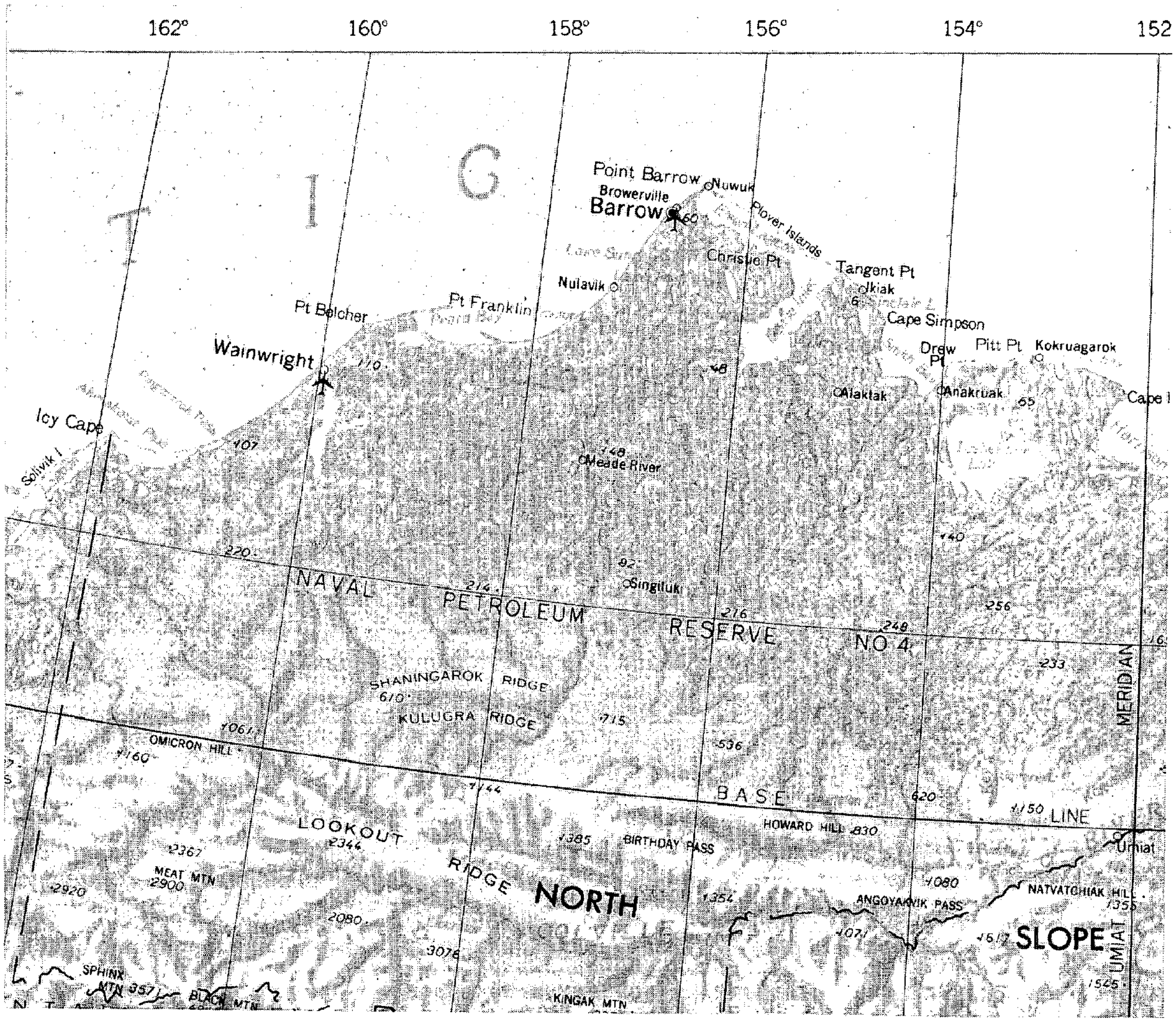

Figure 1.
Location map of the study area. Scale; 1:2,500,000.

Approach and Methods of Mapping

This study is a continuation of two similar studies performed on the Colville, Kuparuk, Sagavanirktok, Shaviovik and Canning Rivers (Mortensen and Cannon, 1982), and the Avak, Utukok, Kokolik, Epizetka, Kukpowruk, Pitmegea, Ipewik and Kukpuk Rivers (Cannon, 1983) (Figure 2). The approach used to map the floodplains of this study and the previous two studies is considered the classic approach to mapping. This approach employs the use of aerial photographs and field work. However, this study was greatly augmented by the use of modern remote sensing data such as false color infrared aerial photographs and Landsat satellite imagery.

The basic geomorphic information about the floodplains was interpreted from Landsat satellite imagery and the stereo viewing of both color infrared and black and white aerial photography (Appendix B). The various geomorphic features which indicate specific floodplain physiographic units and hence topographic levels relative to the active channel were identified and mapped at the scale of the aerial photographs. These features were then field checked and mapped as flood or non-flood units on a preliminary base map at a scale of 1:63,360. The units were rechecked and then transferred to a final map base on mylar at a scale of 1:63,360. The combination of interpretating the floodplain geomorphology and field work is a relatively fast and accurate technique of mapping a river's flood hazard potential (Wolman, 1971). This technique is also applicable to Arctic rivers, provided that the possible changes of the geomorphology/flooding relationships along a particular drainage are considered (Mortensen, 1982).

Low altitude aerial reconnaissance of the rivers was performed in early June to observe and photograph the magnitude of flooding during spring breakup. The main part of the field work was performed during late July and early August. A Bell 206 helicopter was used for acquiring very low altitude aerial photography of the floodplain geomorphic units. The use of a helicopter also made it possible to make ground observations of flooding evidence and measurements at specific locations selected from the preliminary floodplain mapping.

The observed ground evidence of flooding includes:

1. Presence of silts, sands, and gravels that have recently undergone active water transport.
2. Driftwood and debris, especially when found on tundra covered floodplain units (Figures 44 and 45).
3. Fine sand/silt layers on tundra covered floodplain units.
4. Water scour of the tundra covered floodplain units (Figures 44 and 45).

Figure 2.
Location map of the three Floodplain Study areas.

Location and Description of the Study Area

The area of this investigation includes the land along the Chukchi Sea Coast from Icy Cape to Point Franklin, and along the Beaufort Sea Coast from Admiralty Bay to Smith Bay (Figures 1 and 2). This area is the extreme northern part of Alaska, and is entirely above the Arctic Circle. The study area is part of two previously mapped physiographic divisions (Wahrhaftig, 1965). The northern region is part of the Teshekpuk section of the Arctic Coastal Plain province. The southern region of the study area is part of the northern section of the Arctic Foothills province (Figure 3).

The 13 rivers of this study that lie completely or mostly within the limits of the flat and poorly drained Teshekpuk section of the Arctic Coastal Plain province are the Miguakiak, Piasuk, Alaktak, Chipp, Oumalik, Topagoruk, Usuktuk, Kugrua, Kuk, Ivisaruk, Ongorakvik, Nokotlek and the Tunalik. The lower parts of the Ikpikpuk and Meade Rivers lie within the Arctic Coastal Plain province, while large sections of their upper drainages are within the northern section of the Arctic Foothills province. The only rivers of this study that have their watersheds completely within the northern section of the Arctic Foothills province are the Kaolak, Ketik and the Avalik. This northern section rises from an altitude of 600 feet on the north to a maximum elevation of 1541 feet within the Meade River watershed. It has broad east-west trending ridges, that are dominated by mesa-like mountains. The average maximum elevation in this section is approximately 1,000 feet in the Meade, Ikpikpuk and Ketik drainages, 500 feet in the Avalik and 300 feet in the Kaolak watershed.

For a detailed description of the mapping of each river's floodplain, refer to Appendix A.

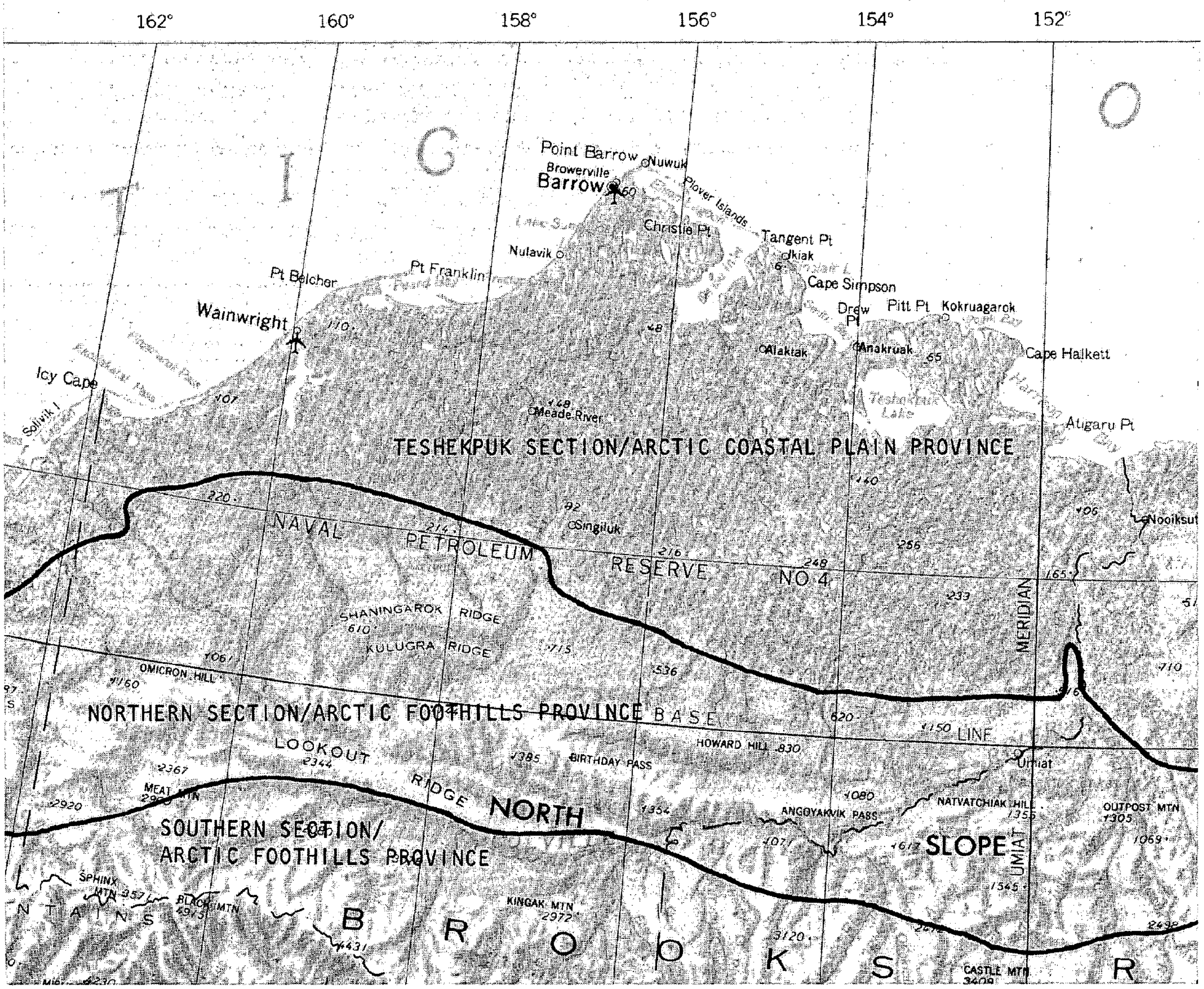

Figure 3.
Physiographic provinces of the study area.

Geologic Setting

The geology of the area of this investigation indicates a tremendous potential for economic resources in the manner of petroleum products. The Teshekpuk section of the Arctic Coastal Plain province is composed of broad folded structures which are ideal petroleum reservoirs. The northern section of the Arctic Foothills province is a transition zone, where the broad folds give way to tighter folds and strong faulting. The southern section of the Arctic Foothills province is predominantly south of this transition zone. This southern section consists of intensely thrust faulted rocks and complex structures.

The bedrock underlying most of the study area is sedimentary sandstone, shale, clay, bentonitic clay, silty shale and coal of the Cretaceous in age Nanushuk Group. It is exposed in the southern part of the northern section of the Arctic Foothills physiographic province, in several places along the bluffs of the Chukchi Sea Coast, and in places along many of the rivers of this study. The Nanushuk Group rocks are covered by a mantle of unconsolidated late Cenozoic marine, lacustrine, alluvial and eolian deposits in the northern part of the northern section of the Arctic Foothills physiographic province, and in the Arctic Coastal Plain physiographic province.

Unconsolidated Late Cenozoic Deposits

The most recent studies of the surficial geology in the area of this investigation have been done by Williams and others (1977), Williams (1983a and 1983b), Carter (1983), and Yeend (1983).

Upland silt: Deposits of silt, silty sand and fine sand with locally scattered pebbles. Stratification is indistinct. Well sorted and calcareous. The deposits are largely wind-blown silt or silt retransported by running water. Contains ice wedges and a very high volume of ice as small interstitial grains, masses and lenses in some areas approaching 80 percent of the volume of the subsurface materials. This deposit occurs along the northern edge of the northern section of the Arctic Foothills physiographic province and ends at an abrupt 50-200 foot high scarp, that may be tectonic in origin, at the Arctic Coastal Plain province boundary (Figure 4 and 5).

Sandy retransported deposits: Deposits of fine to medium, well sorted eolian sand that has been retransported by running water. This deposit overlies older marine and other unconsolidated deposits. Its thickness ranges from 18 to 30 meters. In the mapping area of this study these deposits occur upstream of the junction of the Ikpikpuk and Price Rivers.

Eolian sand: Deposits of fine wind-blown sand containing abundant quartz and minor dark minerals. Well sorted and stratified, with large scale cross-bedding in places. This deposit often contains peat beds and wood in the upper few meters. This eolian sand deposit forms a large sand sea that is Pleistocene in age and extends from the Colville River on the east to just west of the Meade River near Atkasook. The dunes have been modified by younger eolian activity and thermokarst processes. This is the most extensive area of large stabilized dunes yet reported in the North American Arctic (Carter, 1981).

Marine sand: A deposit of predominantly silty sand with scattered pebbles. It ranges from four to six meters thick and overlies marine silt and clay deposits of undetermined thickness. This deposit forms residual surfaces between thaw lake basins on the Arctic Coastal Plain. This deposit forms the northern boundary of the eolian sand sea in the Ikpikpuk and Meade Rivers area.

Elevated marine deposits: These deposits are marine beach, offshore bar and barrier islands related to the Pelukian aged shoreline when sea level was as much as 20 meters higher than at present, and pre-Illionian or Kotzebuan aged shoreline when sea level was 20 to 30 meters higher than at present. The Pelukian deposits occur along the north shore of Teshekpuk Lake, in the Admiralty Bay area to Barrow, in the Peard Bay area near the Kugrua River and along the Chukchi Sea Coast northeast of Icy Cape. The Kotzebuan deposits occur along the Chukchi Sea Coast northeast of Icy Cape, inland from the Pelukian deposits.

Thaw-lake deposits: These are localized and thin deposits that consist of sediment eroded from lake banks and redistributed by currents and wave action. They contain retransported pieces of peat as well as *in situ* peat beds and lenses. These silty and organic rich deposits are exposed when the thaw-lake basin drains.

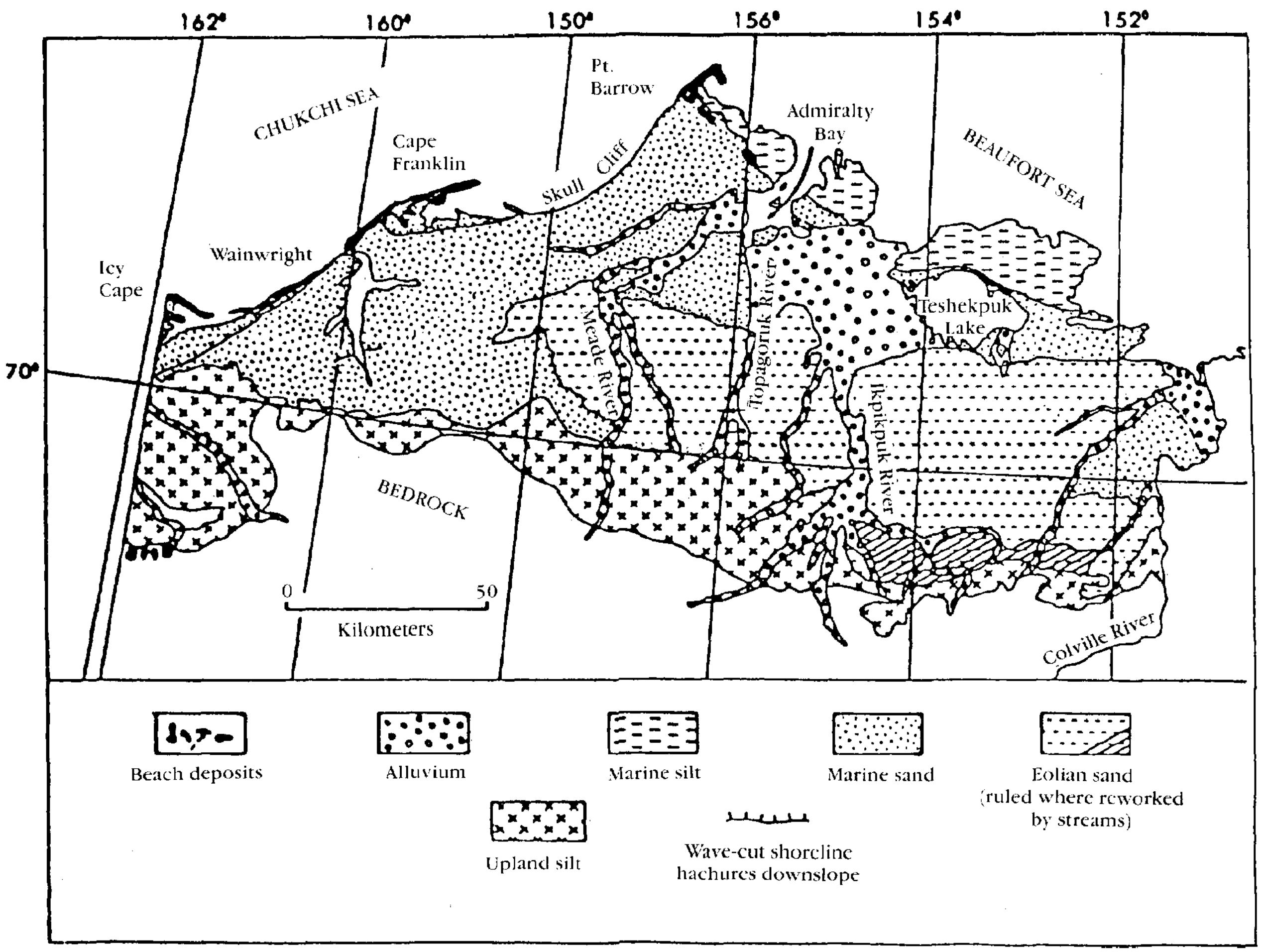

Figure 4.
Generalized surficial deposits map of the National Petroleum Reserve-Alaska. Modified from Williams, 1978.

Alluvial deposits: Stratified to lenticular deposits of sand, silt and some gravel in the upper river drainages, generally becoming finer downstream. Gravel is subrounded to angular, depending on the source in marine deposits, fluvial gravel or

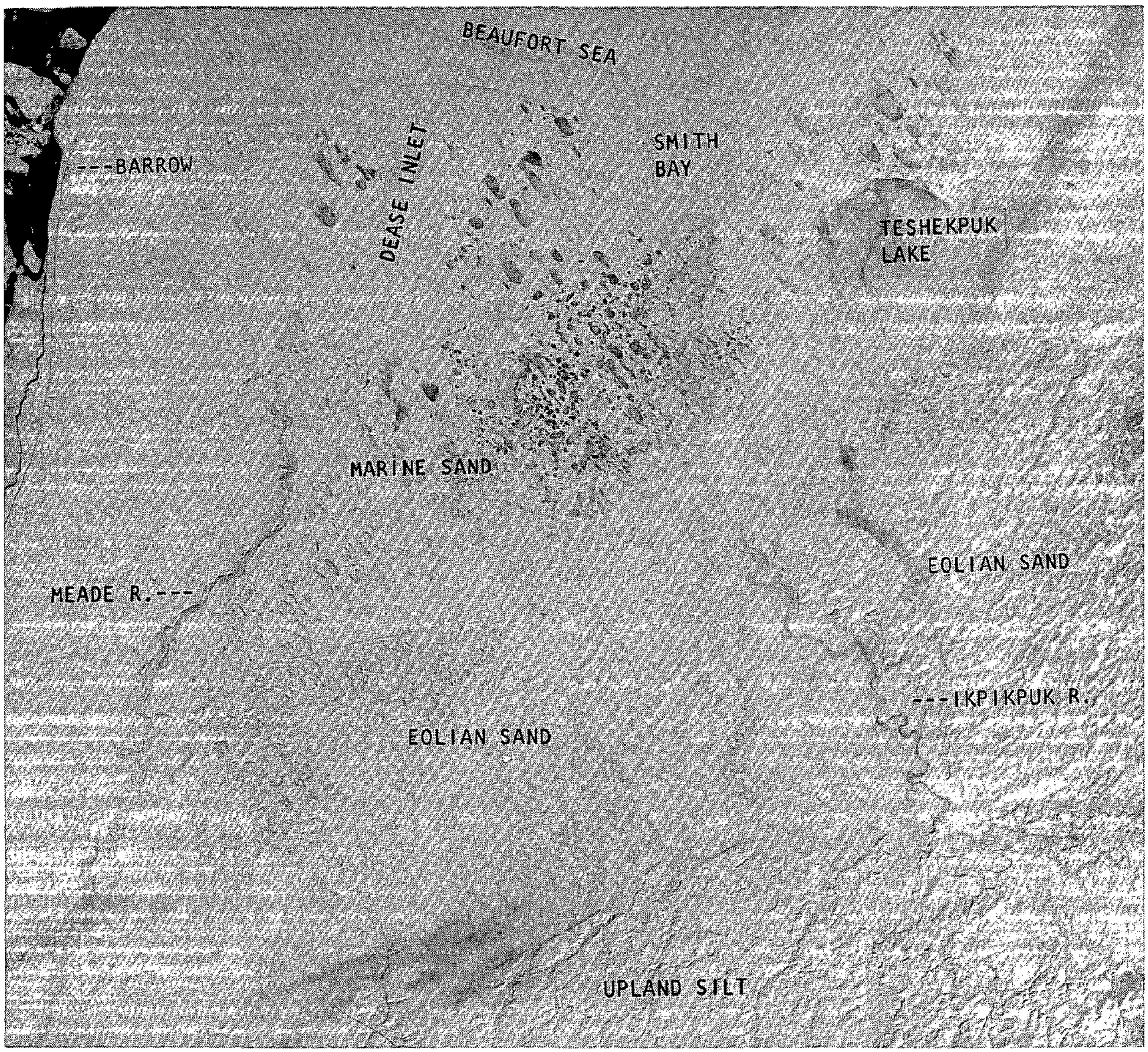

Figure 5.
Landsat image E-30367-21404-7 (7 March 1979)
Generalized surficial deposits of part of the National Petroleum Reserve-Alaska.

in broken and weathered bedrock. Silt and organic beds are common in all types of alluvium, particularly as overbank deposits on active and inactive floodplain surfaces.

Subsidence in the Admiralty Bay Area

The Mapping of the floodplains of the major rivers of the National Petroleum Reserve-Alaska at the detail necessary to produce the flood hazard maps of this investigation, has revealed recent changes in some of the rivers' drainage patterns. These changes may reflect tectonic influences on the rivers. The Meade, Topagoruk and Chipp Rivers flow into Admiralty Bay. All three of these rivers appear to be responding to active subsidence in the Dease Inlet/Admiralty Bay area.

The direction of the channel of the Topagoruk River below the 50 foot topographic contour (Maps 1a and 1b) has shifted from a northeast direction of flow toward the present channel of the Chipp River, to a north northeast direction, and then to its present active channel which flows due north toward, and then west into Admiralty Bay.

The Chipp River below the 50 foot topographic contour (Maps 1a and 1b) appears to be shifting its channel to the west through the process of talik lake breaching. This process is where the active river channel breaches one or a series of talik lakes that are adjacent to the river channel, drains them and forms a new channel through the drained lakes. Aerial photographic evidence shows that the most recent talik lake breaching of the Chipp River has occurred within the last 35 years (see Figures 30 to 34).

The Meade River (Maps 2a and 2b) flows in a northward direction across the Arctic Coastal Plain from its headwaters in the Arctic Foothills until six miles downstream (north) of the village of Atkasook where it makes an abrupt turn to the northeast and flows into Admiralty Bay.

The Arctic Coastal Plain that these rivers flow across is very flat. Thus, the rivers may be expected to respond to even a small local change in the earth's crust. All three of these major Arctic rivers appear to be responding to tectonic subsidence in the Dease Inlet/Admiralty Bay area. The active subsidence in this area may explain the existence of the large embayment of Dease Inlet/Admiralty Bay into the Arctic Coastal Plain (Figure 16).

This theory of subsidence is further supported by a 30-year period of aerial photographic data. A comparison of aerial photographs taken of the Meade River Delta in 1949 and 1979 shows that the delta front is neither prograding or stable, but is in fact receding slowly (Figure 6). This is unexpected for a large river like the Meade, which should be supplying its delta with enough material to keep it growing, or at least stable, in a relatively protected area like Admiralty Bay.

In comparison to the Meade, the Chipp River has virtually no delta, and the Topagoruk River has an anomalously small delta in comparison to its drainage basin (see Figures 35 and 38).

An alternative explanation to tectonic subsidence is the local subsidence in Admiralty Bay due to the loss of ground ice. This process would adequately explain the receding delta of the Meade River and the anomalously small deltas of the Chipp and Topagoruk Rivers. However the localized subsidence due to the loss of ground ice does not seem adequate to explain the observed behaviour of the channels of the three rivers.

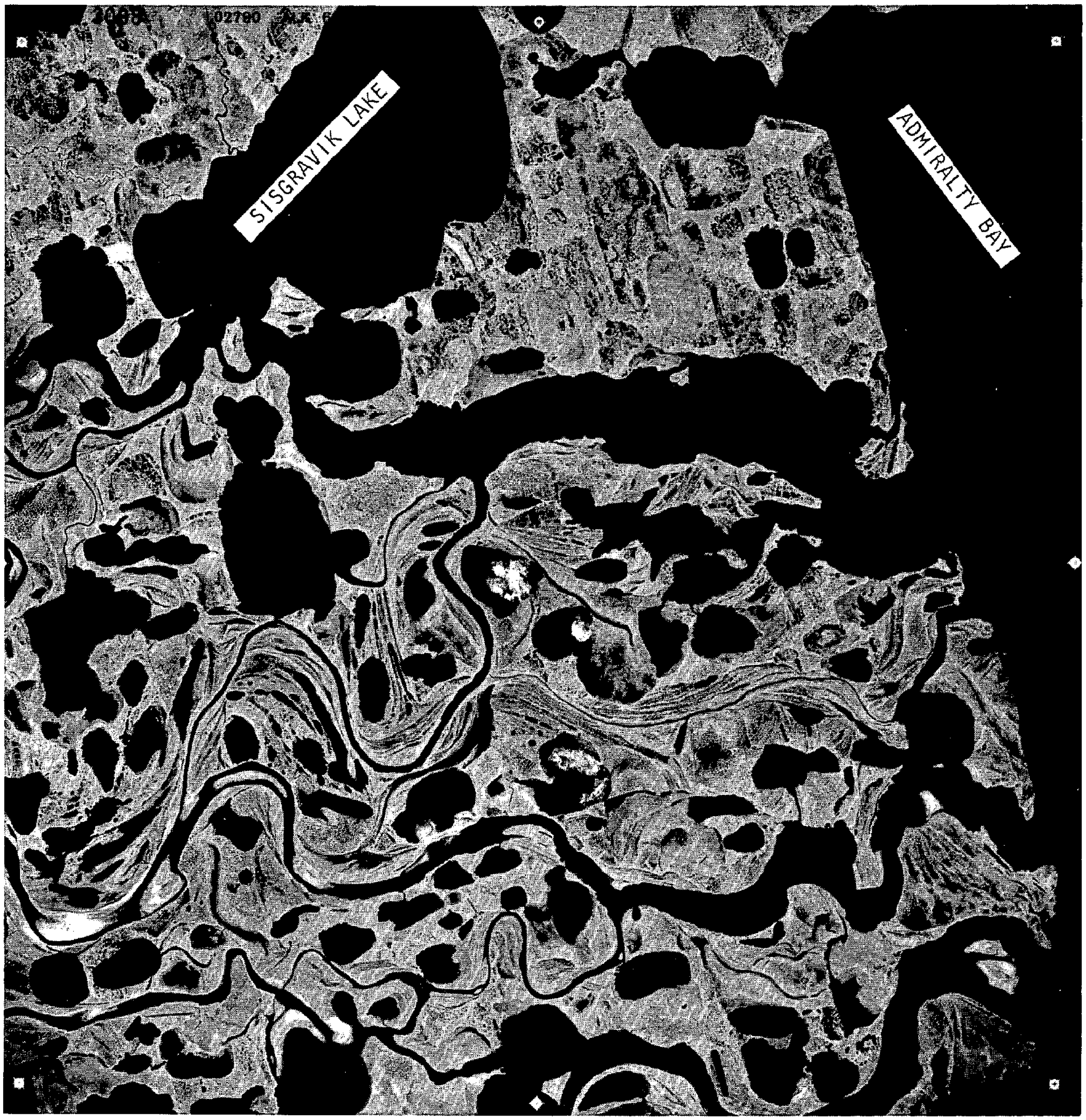

Figure 6.
A NASA high altitude aerial photograph of part of the Meade River Delta (the black areas are water). The delta front is neither prograding (growing) nor stable, but is receding slowly. Notice that the delta (left) lacks deposits of sand and silt at the channel mouths. Compare this photograph to Figure 26 of the Ikpikpuk River Delta which is an actively prograding delta. The scene is 15 km. (9 mi.) across. Roll 2790, frame number 3098, July 1979.

Flood Frequency and Flooding Potential

The magnitude and frequency of flooding may be predicted where sufficient discharge data for a river exists. For a particular river, the flood of the greatest recorded discharge is designated as number one, the flood of the second greatest discharge as number two, etc. Since there may be more than one flood of a given discharge, a flood recurrence interval (RI) is calculated:

$$RI = \frac{N - 1}{M}$$

where N is the number of years that a flood of a given discharge recurs, and M is the number assigned in listing flood discharge.

The recurrence interval is the number of years, on the average, until a given flood will be equaled or exceeded one time. It is inversely related to the probability that a given flood will be equaled or exceeded in any one year. (A 25-year flood would have one chance in 25, or a 50-year flood one chance in 50 of being equaled or exceeded in any one year.)

The data may be extrapolated to predict a flood magnitude with a recurrence interval that is greater than the length of continuous records.

Predicting flood frequency and discharge magnitudes by this method is not applicable to the Arctic rivers of this study, because of the lack of recorded flooding data.

Maximum Flooding Potential

The intermediate regional flood is defined as a flood at any given location having an average frequency or recurrence interval of once in 100 years. It is less severe than the standard project flood (Figure 7) (Leopold, 1978). This flood stage will probably cover the lower areas of flood unit 4 (Table 4) that are closest to the active channel.

The standard project flood is defined as the largest flood that can be experienced from the most severe combinations of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved. Estimates indicate that the standard project flood discharges are generally equal to 40 to 60 percent of the maximum probable floods for the same basins (Ven Te Chow, 1964). The standard project flood will probably cover all of flood unit 4.

The maximum probable (or maximum possible) flood is defined as the flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region (Ven Te Chow, 1964). If a maximum probable flood were to occur on the rivers of this investigation it will cover all of flood unit 4 and may even inundate some of flood unit 5 (which is designated a non-flooding unit). This is because the maps of this study were done under the assumption that the standard project flood was the maximum reasonable discharge that the study rivers could produce.

Flooding Potential of Arctic Rivers

The discharge of a river is equal to the total amount of effective precipitation that falls on the watershed minus the amounts of infiltration, evaporation and transporation. In warmer climates the discharge will be 15 to 46 percent of the total effective precipitation. However in the Arctic this is much different. Because the ground is frozen, there is almost no infiltration into it. The cooler climate decreases

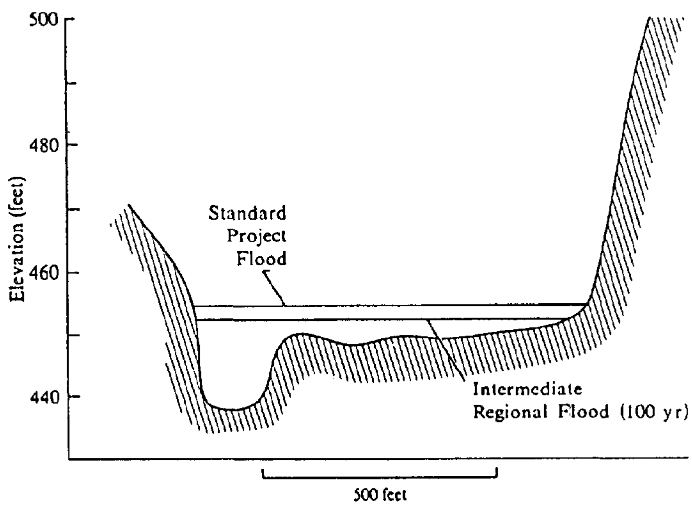

Figure 7.
General comparison of the intermediate regional flood to the standard project flood.

the amount of water evaporated back into the atmosphere, and the type of vegetation that is in the Arctic would transpire only small amounts of water. From two studies done on the hydrologic effects of frozen ground in the tundra zone of the Northern U.S.S.R., the amount of runoff ranged from 70 to 76 percent of the total effective precipitation (Dingman, 1975).

Since an Arctic river would only have a time window for flowing of four or five months, the mean rate of discharge would be greater for the Arctic river than for a more temperate river. The rivers of this investigation have the majority of their discharge occurring within the first two weeks after the spring breakup. It seems possible, therefore, that certain flooding events would have a greater frequency of occurrence on the Arctic rivers than on rivers of warmer climates. An estimated range of flooding frequency in years is presented in Table 4 for the various flooding units of the 18 Arctic rivers of this investigation. These are tentative estimates based on limited data and observations. They will undoubtedly be revised with future observations and study.

Table 1. Stream Gradient Characteristics of the 29 Arctic Rivers

Rivers	Channel Length Measured (miles)	Gradient (feet per mile)	Elevation of Channel (feet)
(This Investigation)			
Usuktuk	97.0	0.3	50
Oumalik	40.0	0.5	75
Alaktak	43.5	0.6	25
Chipp	62.0	0.9	57
Kuk/Avalik	104.9	0.9	98
Topagoruk	101.5	1.0	100
Ikpikpuk	181.3	1.2	213
Meade	150.4	1.3	200
Ketik	60.8	1.6	98
Ivisaruk	56.0	1.8	100
Kugrua	39.0	1.9	75
Kaolak	43.7	2.3	98
Nokotlek	18.0	2.8	50
Tunalik	27.5	3.6	100
Ongorakvik	16.5	6.1	100
(Cannon, 1983)			
Kokolik	110.5	2.7	300
Utukok	95.4	3.1	300
Epizetka	46.7	3.2	150
Avak	59.2	3.4	200
Kukpuk	103.0	3.9	400
Kukpowruk	62.2	5.6	350
Ipewik	45.2	5.9	250
Pitmegea	40.7	8.6	350
(Mortensen and Cannon, 1981)			
Colville	134.0	2.3	300
Kuparuk	82.0	3.1	250
Sagavanirktok	56.0	6.3	350
Shaviovik	40.0	6.9	275
Canning	34.5	10.1	350

Table 2. The 29 Arctic Rivers Arranged in Order of Increasing Gradient

Rivers	Gradient in Feet Per Mile	
Usuktuk	0.3	Lowest Gradient
Oumalik	0.5	
Alaktak	0.6	
Chipp	0.9	
Kuk/Avalik	0.9	
Topagoruk	1.0	
Ikpikpuk	1.2	
Meade	1.3	
Ketik	1.6	
Ivisaruk	1.8	
Kugrua	1.9	
Kaolak	2.3	
Colville	2.3	
Kokolik	2.7	
Nokotlek	2.8	
Kuparuk	3.1	
Utukok	3.1	
Epizetka	3.2	
Avak	3.4	
Tunalik	3.6	
Kukpuk	3.9	
Kukpowruk	5.6	
Ipewik	5.9	
Ongorakvik	6.1	
Sagavanirktok	6.3	
Shaviovik	6.9	
Pitmegea	8.6	
Canning	10.1	Highest Gradient

Table 3. The 29 Arctic Rivers Arranged in Order of Decreasing Area Watershed

Rivers	Area of Watershed (square miles)
Colville (1)	17,344.0
Ikpikpuk (2)	4,488.0
Kuk (3)	4,275.0
Meade (3)	3,885.0
Sagavanirktok (1)	3,566.0
Kuparuk	2,673.0
Utukok	2,278.0
Kokolik	1,746.0
Kukpuk (4)	1,690.0
Canning (1)	1,485.0
Chipp/Oumalik	1,475.0
Kukpowruk	1,360.0
Shaviovik	1,254.0
Avalik	1,197.0
Ipewik	870.0
Topagoruk	783.0
Kaolak	736.0
Ketik	721.0
Usuktuk	622.0
Ivisaruk	522.0
Pitmegea	433.0
Epizetka	366.0
Kugrua	318.0
Avak	282.0
Tunalik	145.0
Nokotlet	105.0
Ongorakvik	73.0
Alaktak (5)	N/A

1 Does not include large area of delta.
2 Does not include distributary channels or delta.
3 Includes the Avalik, Kaolak, Ketik and Ivisaruk Rivers.
4 Includes the Ipewik River.
5 Distributary channel of the Ikpikpuk River.

Table 4. A Tentative Flood Frequency Interval and Comparison of Flooding Units for the 18 Arctic Rivers of This Investigation.

River	Flooding Units = 1	2	3	4
	Estimated Flood Frequency in Years			
Ikpikpuk	1	3-10	10-50	100-200
Chipp	1	3-10	10-50	100-200
Alaktak	1	3-10	10-50	100-200
Miguakiak	1	3-10	10-50	100-200
Piasuk	1	N/A	10-50	100-200
Oumalik	1	3-10	10-50	100-200
Topagoruk	1	3-10	10-50	100-200
Meade	1	3-7	7-25	50-100
Usuktuk	1	3-10	10-50	50-100
Ivisaruk	1	3-10	25-50	50-100
Kuk	1	3-10	10-25	50-100
Kaolak	1	3-10	10-25	50-100
Ketik	1	3-10	10-25	50-100
Avalik	1	3-10	10-25	50-100
Ongorakvik	1	3-7	5-50	N/A
Nokotlek	1	3-7	5-50	N/A
Kugrua	1	3-7	5-50	N/A
Tunalik	1	3-7	5-50	N/A

Table 5. A Tentative Flood Frequency Interval and Comparison of Flooding Units for the 8 Arctic Rivers of Cannon, 1983.

River	Flooding Units = 1	2	3	4	5
	Estimated Flood Frequency in Years				
Avak	1	3-7	5-50	N/A	N/A
Utukok	1	3-7	5-50	25-100	N/A
Kokolik	1	3-7	5-50	25-100	N/A
Epizetka	1	3-7	5-50	25-100	N/A
Kukpowruk	1	3-7	5-50	25-100	75-500
Pitmegea	1	3-7	5-50	N/A	N/A
Ipewik	1	3-7	5-50	25-100	N/A
Kukpuk	1	3-7	5-50	25-100	N/A

Table 6. A Tentative Flood Frequency Interval and Comparison of Flooding Units for the 5 Arctic Rivers of Mortensen and Cannon, 1982 (from Cannon, 1983)

River	Flooding Units = F1	F2	F3	F4
	Estimated Flood Frequency in Years			
Colville	1	3-7	5-50	25-100
Kuparuk	1	3-7	5-50	25-100
Sagavanirktok	1	3-7	5-50	25-100
Shaviovik	1	3-7	5-50	25-100
Canning	1	3-7	5-50	25-100

Spring Breakup Characteristics of the Arctic Rivers

Observations of Landsat imagery at the breakup period for the 18 rivers of this study indicate that breakup occurs during late May to early June. This is a week or more later than the breakup on all but one of the rivers (the Avak River, Floodplain Study No. 2) of the previous two North Slope Borough Floodplain Studies (Mortensen and Cannon, 1982 and Cannon, 1983). This observed difference of river breakup timing can be explained by the fact that all of the river drainages of this study, and the Avak River, have watersheds that are restricted to the Arctic Coastal Plain and the northern section of the Arctic Foothills physiographic provinces (Figure 3). The rivers of the previous two studies have their headwaters in the Brooks Range, where the winter snowpack usually begins to melt and supply the river channels with water before the snowpack begins to melt on the Arctic Coastal Plain (Figures 8, 9 and 10). Thus, the Arctic rivers of this investigation have a generally later breakup than the rivers of the previous two studies. This area where the river watersheds are restricted to the Arctic Coastal Plain and the northern section of the Arctic Foothills physiographic province is here designated the Barrow River Basin (Figure 11).

During the river breakup in June 1984, because of warm and relatively cloud free weather, almost the entire snowpack in the Barrow River Basin melted within two days (9 and 10 June). As a result, the rivers of this study went from zero discharge rates to almost bankfull channels in a matter of hours. Had the winter snowpack been heavier than it was, the discharge rates would have been much higher than those observed. It is apparent that the Arctic rivers of this investigation have the potential of very high peak discharge rates during the spring breakup if the winter snowpack is sufficiently heavy and melts rapidly.

After the winter snowpack has melted on the Arctic Coastal Plain the discharge of the rivers in the Barrow River Basin quickly falls to a low level (Figure 12), and remains low throughout the summer unless additional precipitation is received in the form of summer rain.

The five Arctic rivers of the first North Slope Borough Floodplain Study (Mortensen and Cannon, 1982) began spring breakup with water flowing over the river channel ice and creating a large pond of pre-polynya water on the Arctic Ocean ice at the mouth of the rivers. This water then drained off the ocean ice through cracks and strudle holes, leaving a deposit of fine sand and silt behind. Of the eight Arctic rivers of the second North Slope Borough Floodplain Study (Cannon, 1983) only one river, the Pitmegea, exhibited this overice flow during the breakup of 1982. The other seven rivers of Floodplain Study Number 2 began breakup by melting in the mid-regions of their drainages, with water flowing under the ice in the lower regions. The polynyas opened up by melting from the bottom of the ice up.

A significant difference between the rivers of this study and Floodplain Study Number 2 with the rivers of Study Number 1 is the lack of aufeis. Aufeis causes the temporary damming of a river, producing localized flooding. Though ice-block damming was observed along the Meade River, no aufeis occurred along the rivers of this investigation.

The spring breakup characteristics of each individual river of this investigation will be discussed later in the text, also see Figures 8 through 25.

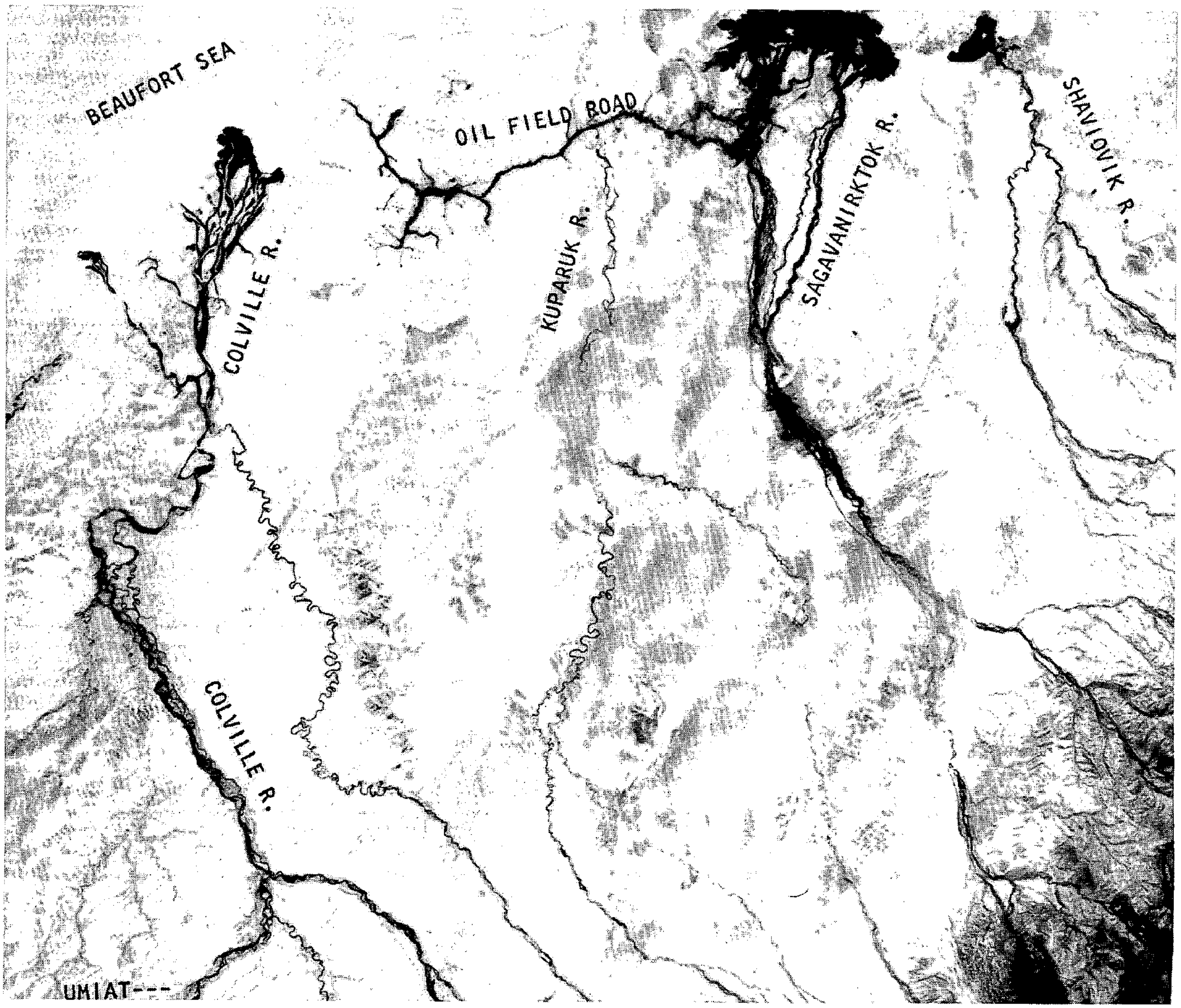

Figure 8.
Landsat image 4068221080-7 (28 April 1984) showing the spring breakup flood waters (black) of the Colville, Sagavanirktok and Shaviovik Rivers (of N.S.B. Floodplain Study No. 1) ponding on the near shore Arctic Ocean ice as pre-polynya water. Notice that the Arctic Coastal Plain in this image is still snow covered. The source of the water in the rivers is coming from the melting snowpack of the Brooks Range to the south. The scene is 185 km. across (115 mi.). Compare to Figures 9, 10 and 13.

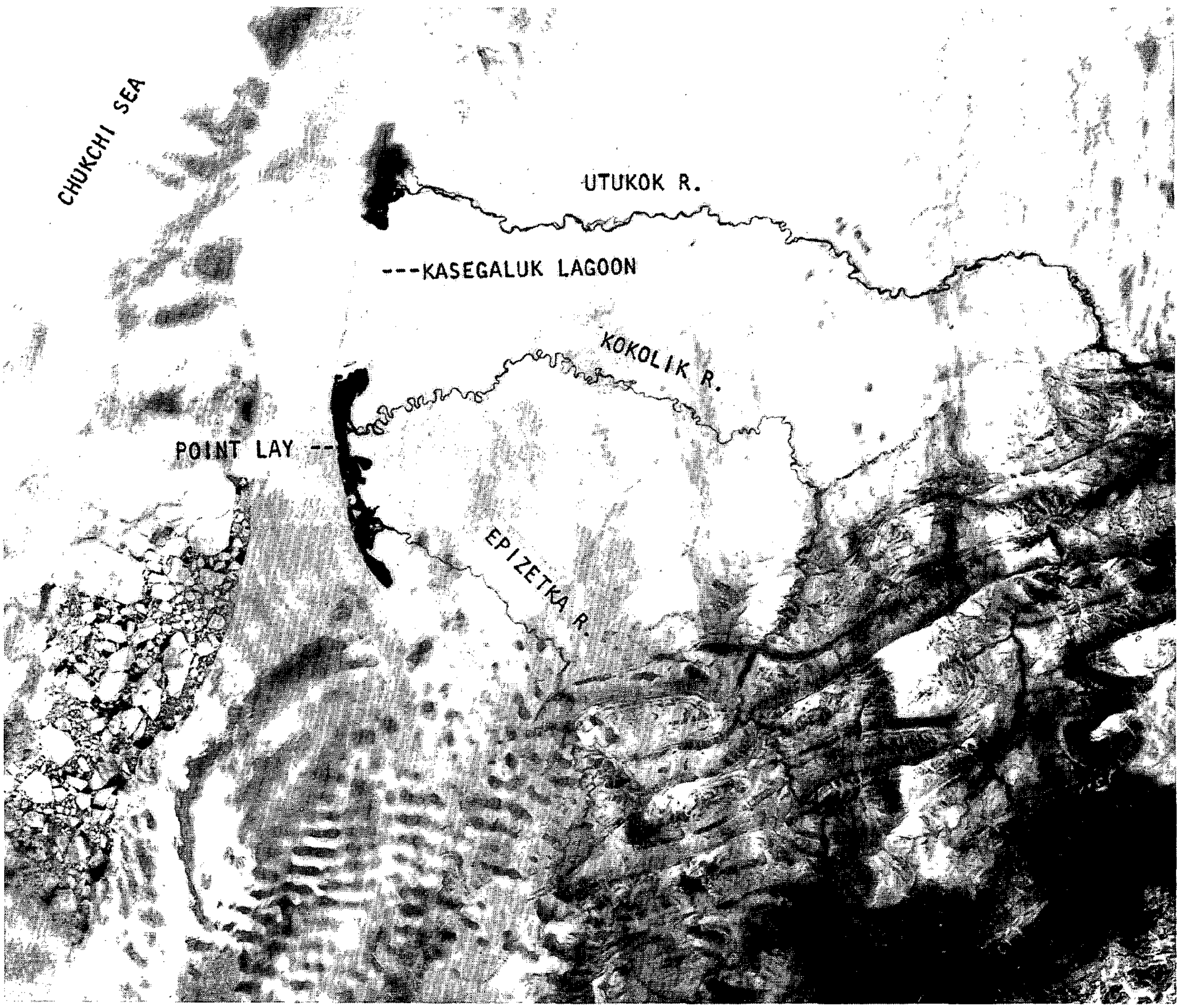

Figure 9.
Landsat image 5008821594-7 (28 April 1984) showing the breakup flood waters (black) of the Utukok, Kokolik and Epizetka Rivers (of N.S.B. Floodplain Study No. 2) ponding on the ice of Kasegaluk Lagoon as pre-polynya water. Notice that the Arctic Coastal Plain in this image is still snow covered. The source of the water in the rivers is coming from the melting snowpack of the Brooks Range to the southeast. The scene is 185 km. across (115 mi.). Compare to Figures 8, 10 and 13.

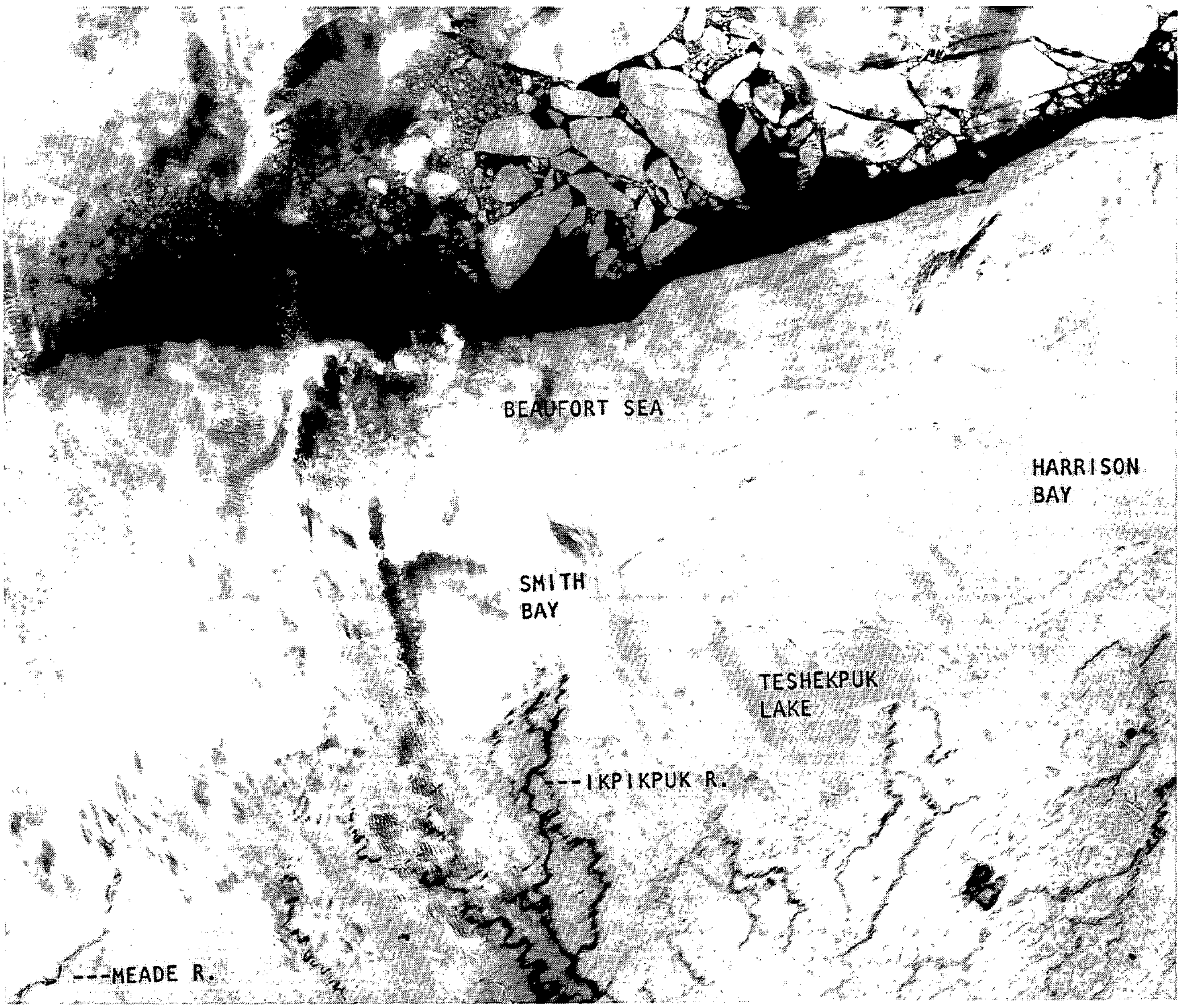

Figure 10.
Landsat image 5009221344-7 (01 June 1984) showing the Ikpikpuk and Meade River channels (black) (of this investigation) nine days before breakup occurred on these rivers. The silt and sand of the active river channels is moist, and there is some standing water in the channels from local snowmelt. Notice that the prevailing winds have blown some of the silt and sand onto the still snow covered Arctic Coastal Plain. There is no flowing water in the river channels (four days after the images of Figures 8 and 9 were taken) because these river drainages do not have their headwaters in the Brooks Range. The scene is 185 km. (115 mi.) across. Compare to Figures 8, 9 and 13.

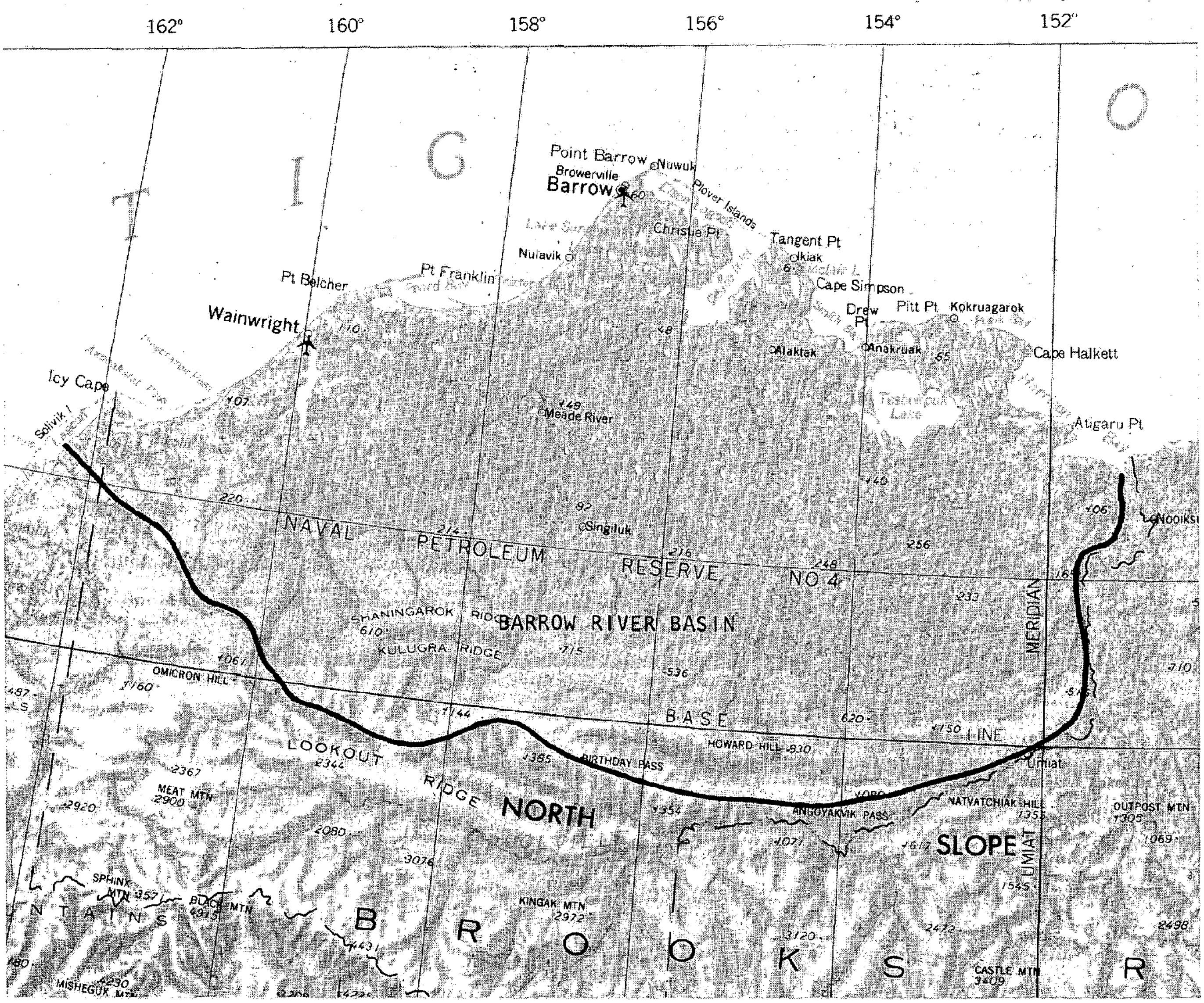

Figure 11.
Map of the Barrow River Basin.

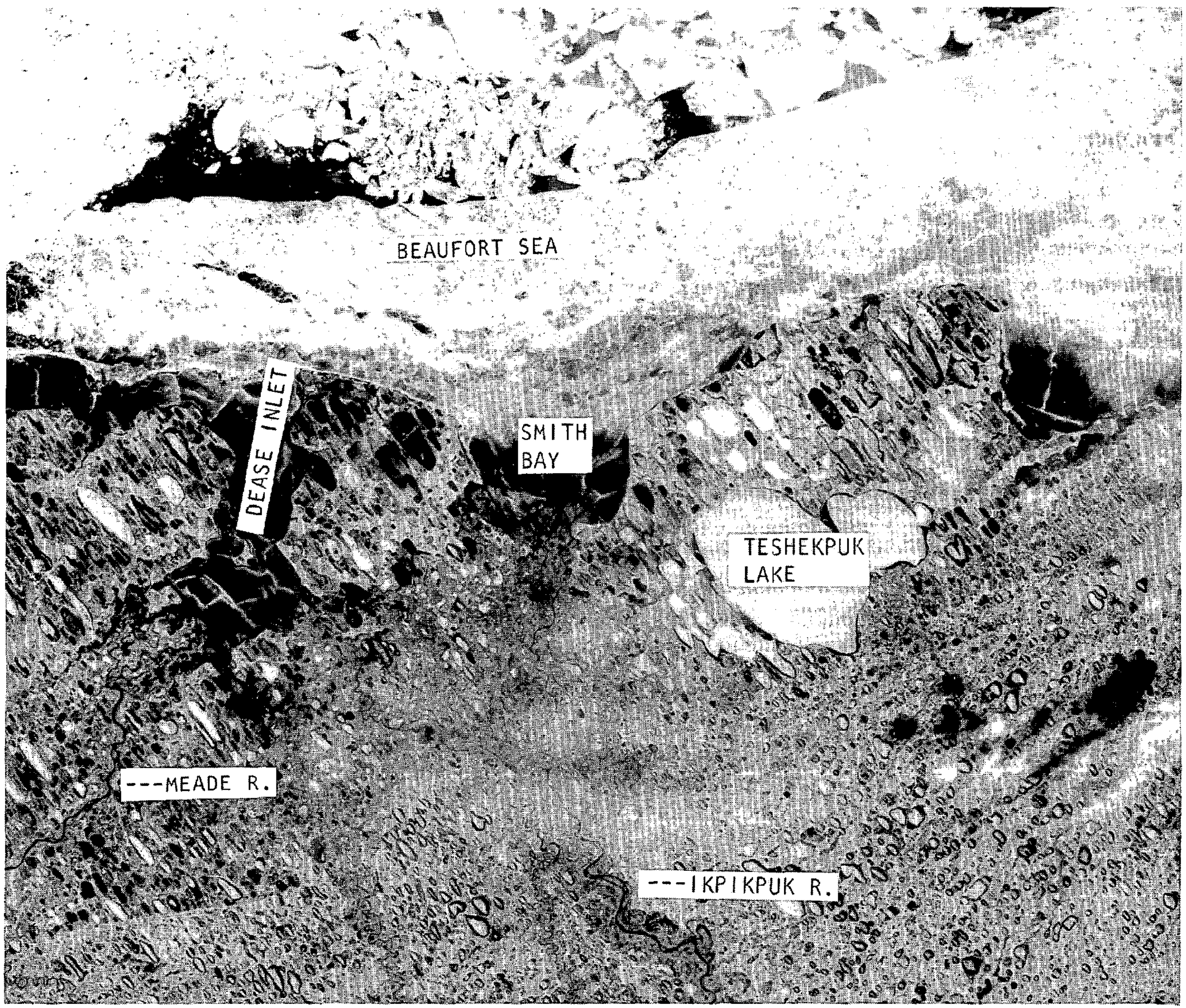

Figure 12.
Landsat image 5010821350-7 (17 June 1984) showing the Ikpikpuk and Meade Rivers seven days after the start of breakup on 10 June. The river channels still have flowing water, but the discharge is much less than one week earlier. Notice that most of the talik lakes are still frozen, but that the Arctic Coastal Plain is clear of snow. The scene is 185 km. across (115 mi.).

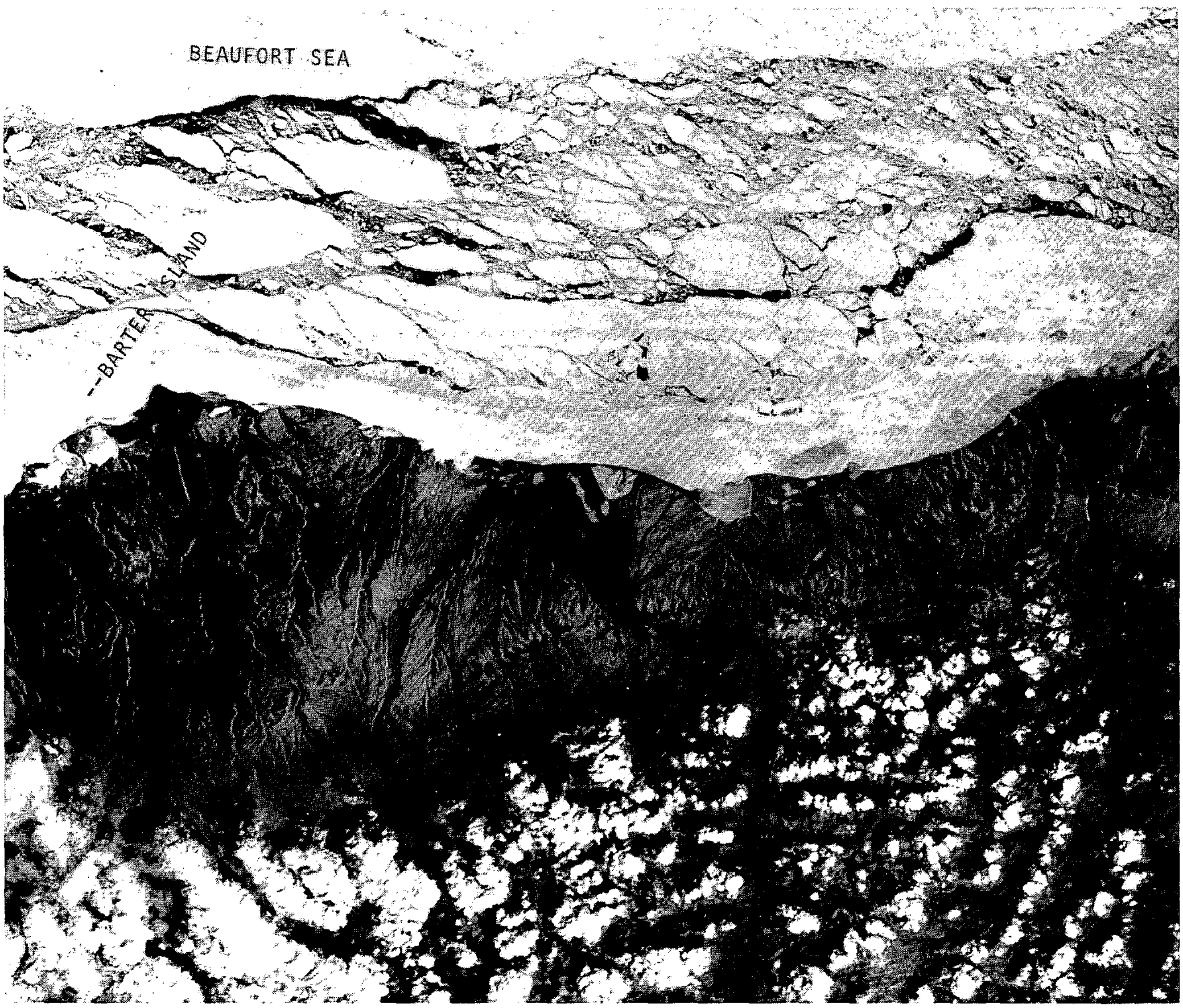

Figure 13.
Landsat image 5009320392-7 (02 June 1984) showing the rivers of the Arctic National Wildlife Refuge and the Yukon Territory. This image was taken five days after the scenes of Figures 8 and 9, and one day after the scene of Figure 10. The Arctic Coastal Plain is clear of snow, the rivers have already undergone breakup, and the polynyas have started to open. This scene is 185 km. across (115 mi.).

Figure 14.
Very low altitude oblique aerial photograph taken from a Cessna 182 on 4 June 1984. This view is looking upstream (south) along the main channel of the Ikpikpuk River six days before breakup occurred. Notice that the channel contains very little ice. The water in the channel has come from local snowmelt. Compare to Figure 10.

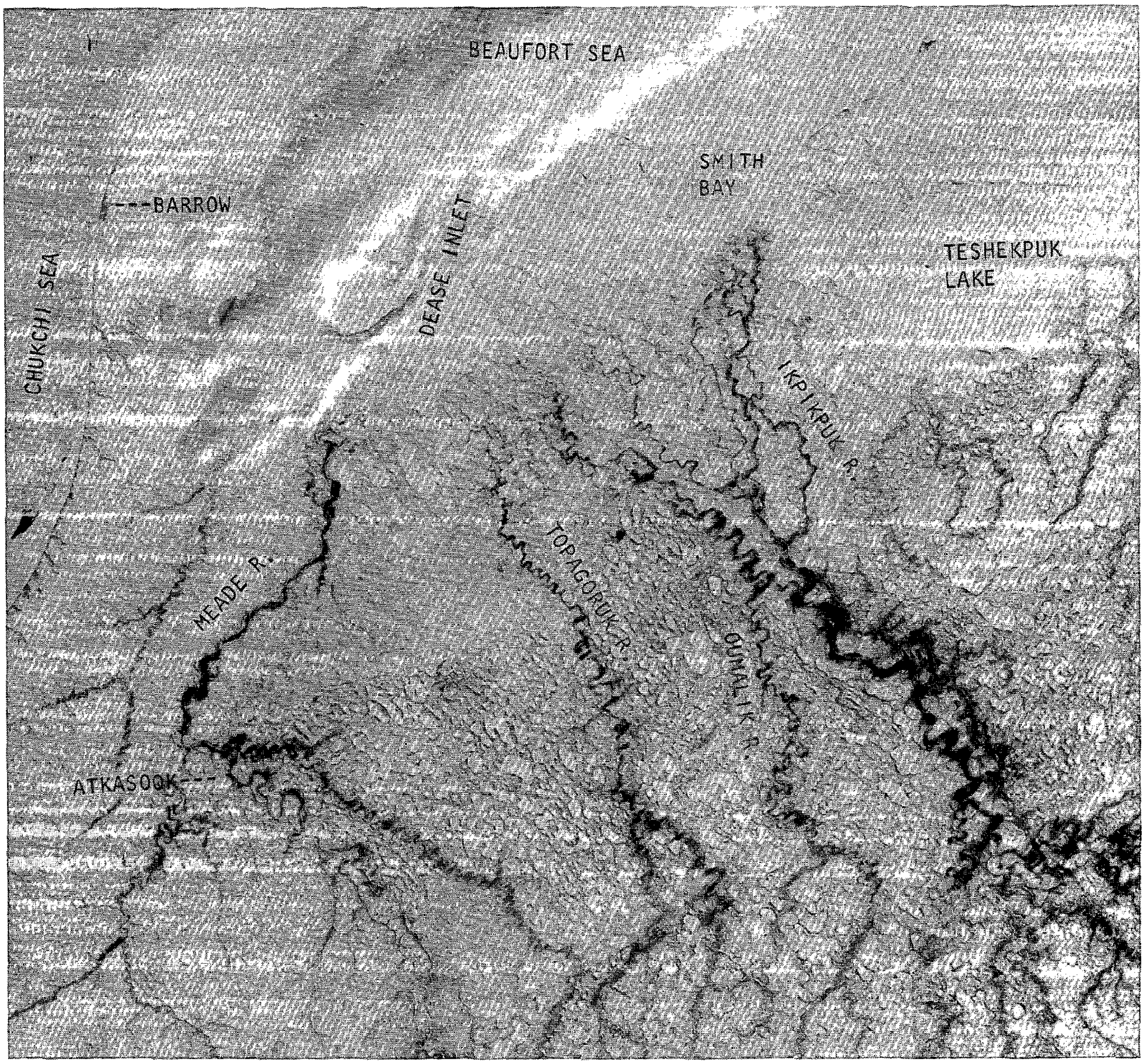

Figure 15.
Landsat image E-22306-21372-7 (16 May 1981) showing the dry sand (black) of the river channels and the wind blown silt and sand (black) adjacent to the river channels. The only river in this image that has abundant channel ice is the Meade upstream (south) of the village of Atkasook. The scene is 185 km. (115 mi.) across.

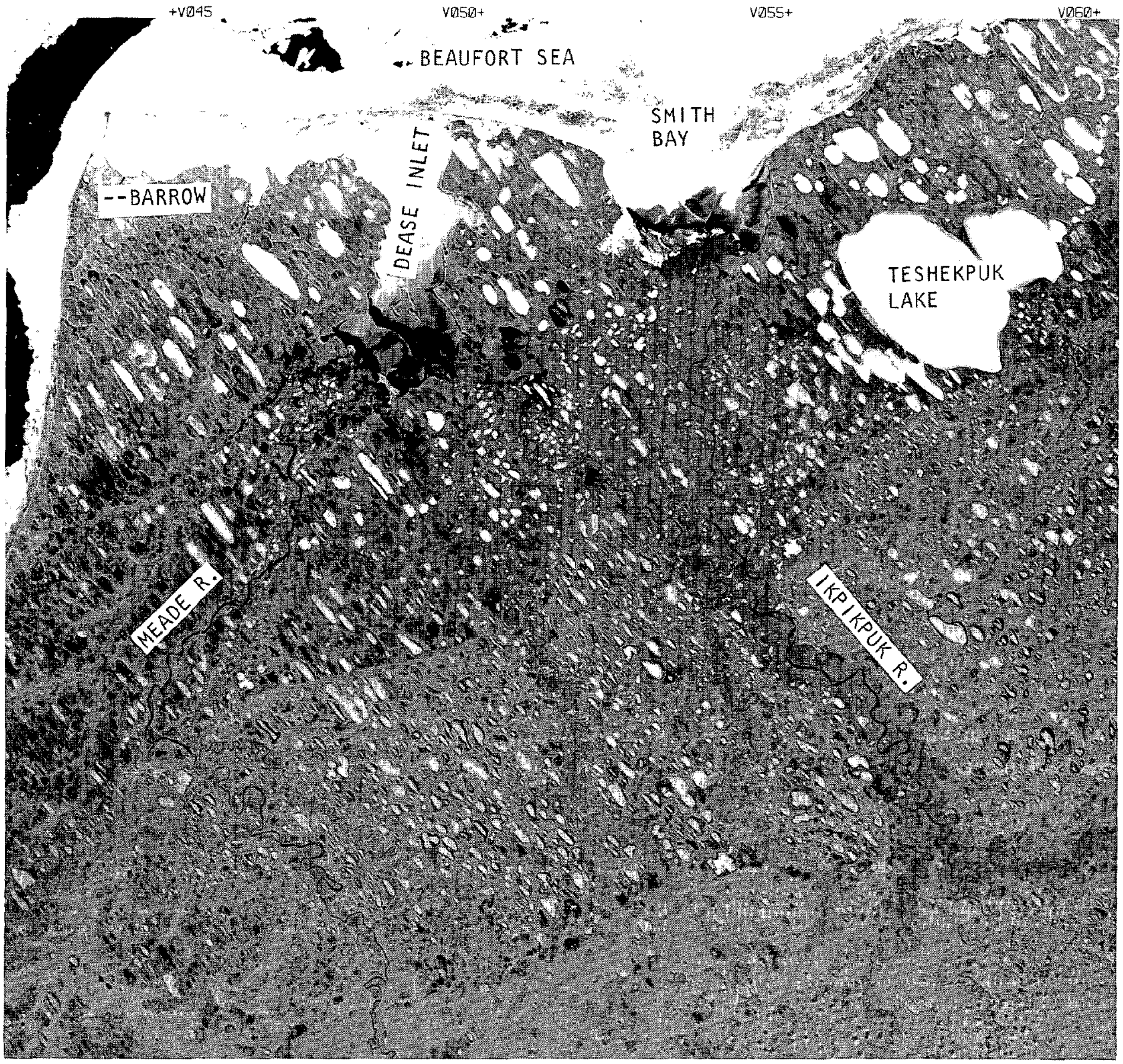

Figure 16.
Landsat image E-30457-21401-7 (5 June 1979) showing the rivers at breakup. The water in the channels is black in this image as is the pre-polynya water that is ponding on the ocean ice of Dease Inlet and Smith Bay. Although the snow is gone from the Arctic Coastal Plain, the talik lakes are still frozen. The scene is 185 km. (115 mi.) across.

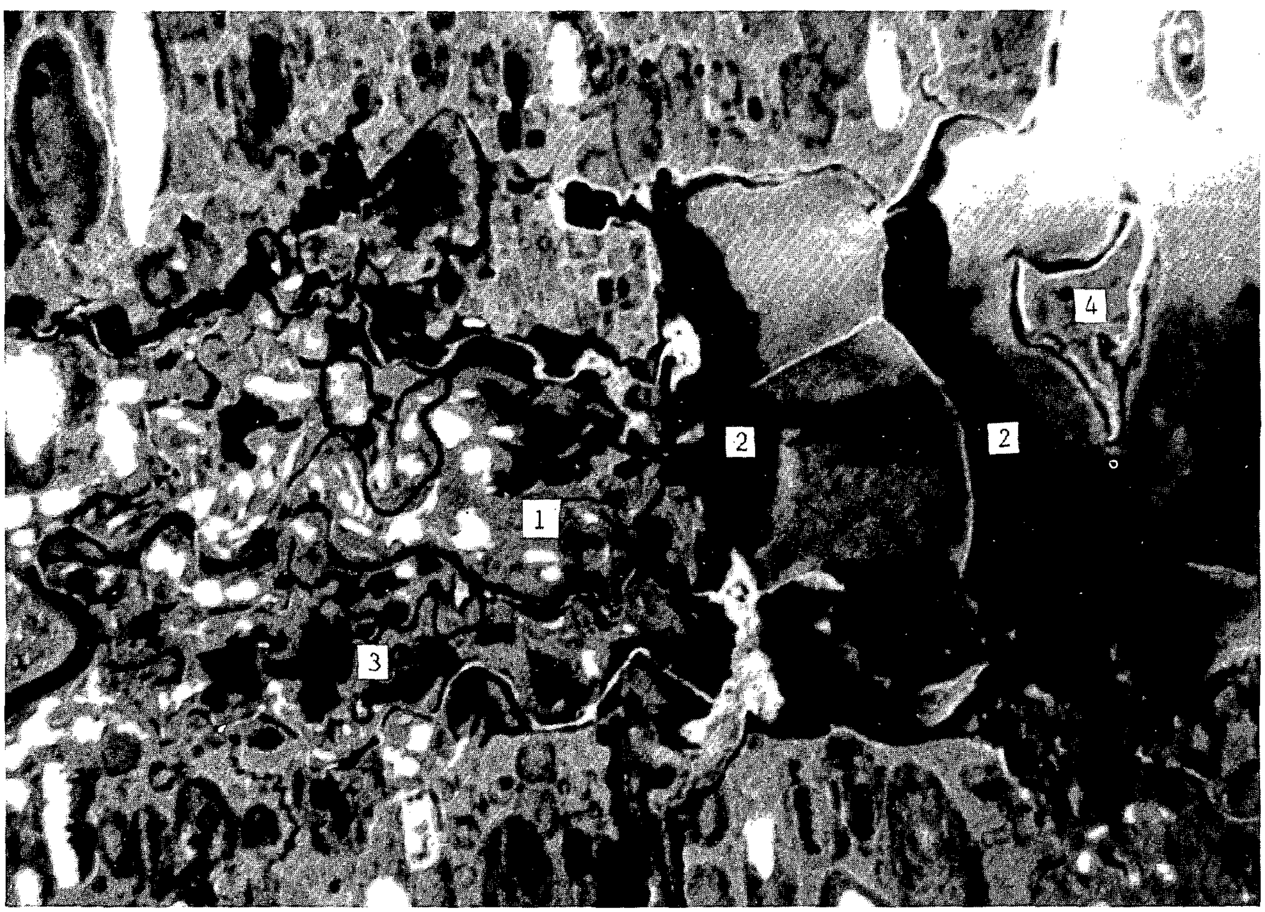

Figure 17.
An enlargement of Landsat image E-30457-21401-7 (5 June 1979) (of Figure 16) showing the spring breakup flood waters (black) of the Meade River Delta (1) ponded on top of the ocean ice of Admiralty Bay (2). Notice how the flood waters cover the interconnecting, and still frozen, lakes on the delta. Oarlock Island is at 4. The scene is 35 km. (22 mi.) across.

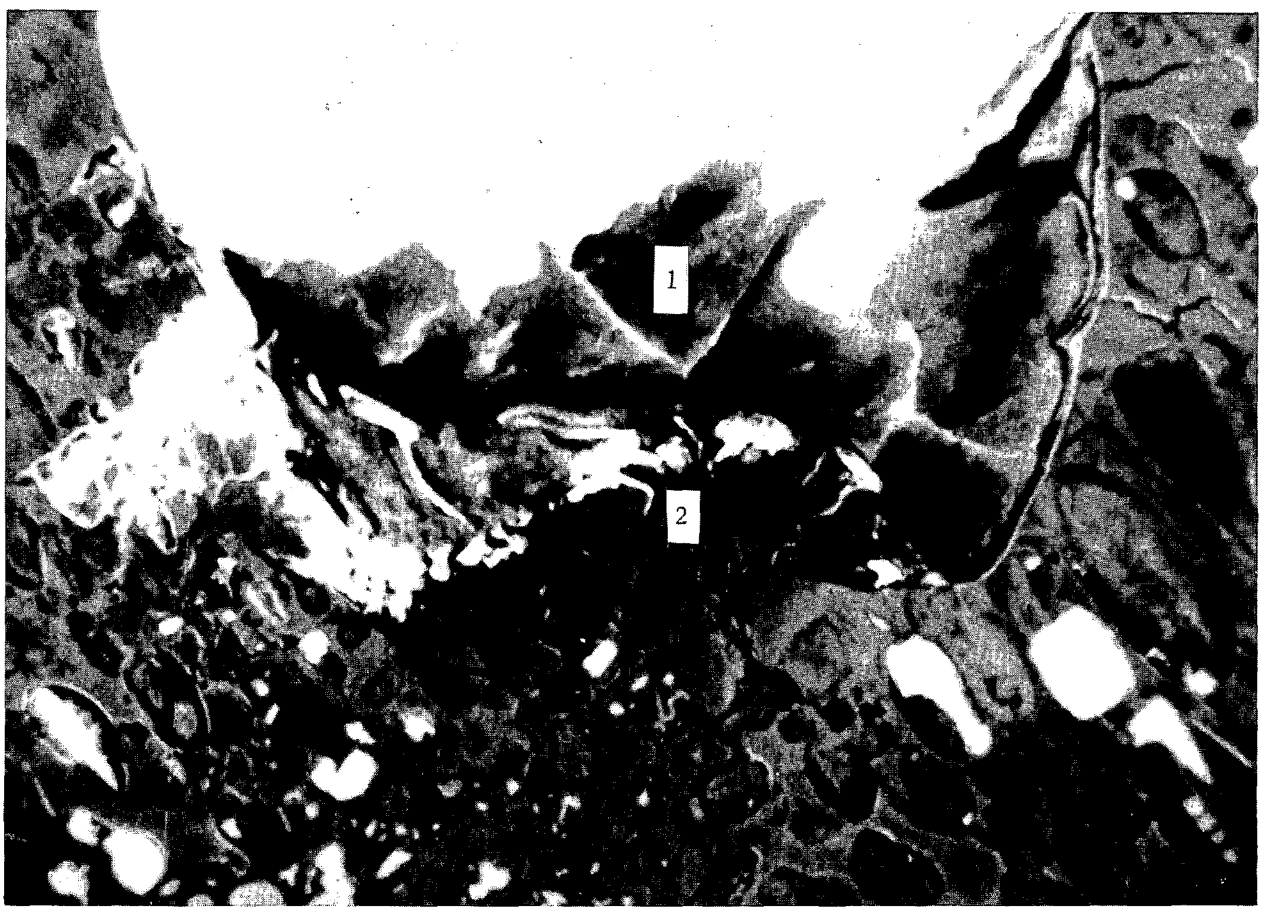

Figure 18.
An enlargement of Landsat image E-30457-21401-7 (5 June 1979) (of Figure 16) showing the spring breakup flood waters (black) of the Ikpikpuk River ponded (1) on top of the ocean ice of Smith Bay. The polynya has started to open at the boundary between the ocean ice and the Ikpikpuk River Delta (2). The scene is 31 km. (20 mi.) across.

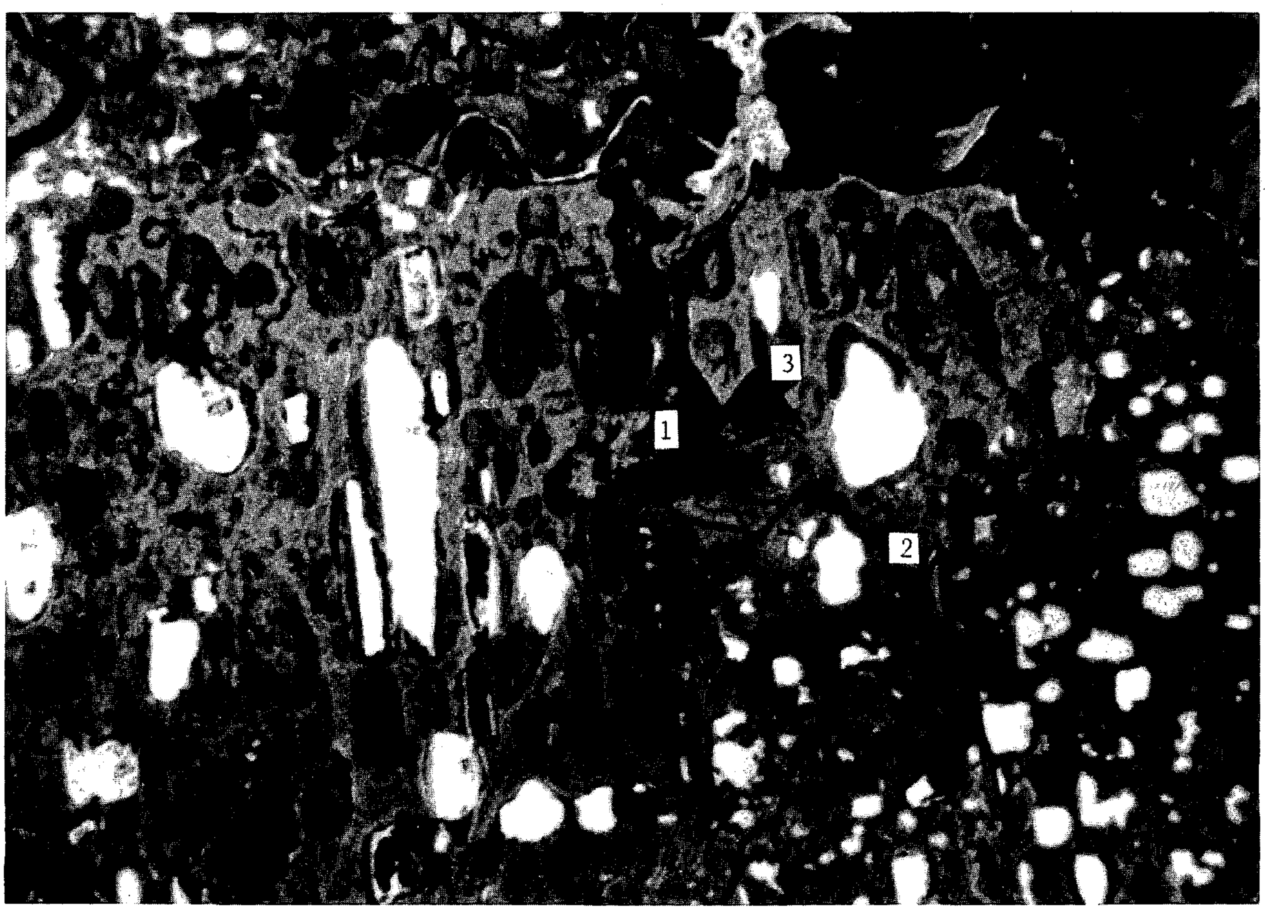

Figure 19.
An enlargement of Landsat image E-30457-21401-7 (5 June 1979) (of Figure 16) showing the spring breakup flood waters (black) (1) of the Topagoruk River (2) ponded on top of the ocean ice of Admiralty Bay. As the depth of the ponded water increases it may flood adjacent low lying areas of the coastal plain (3). The scene is 29 km. (18 mi.) across.

Figure 20.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984 looking northeast across the southern end of Admiralty Bay and the delta of the Topagoruk River. The breakup waters of the Topagoruk River are just reaching the delta. The pre-polynya water will begin to pond on the ocean ice in the next few days, flooding low lying areas adjacent to the shore. Compare to Figure 19.

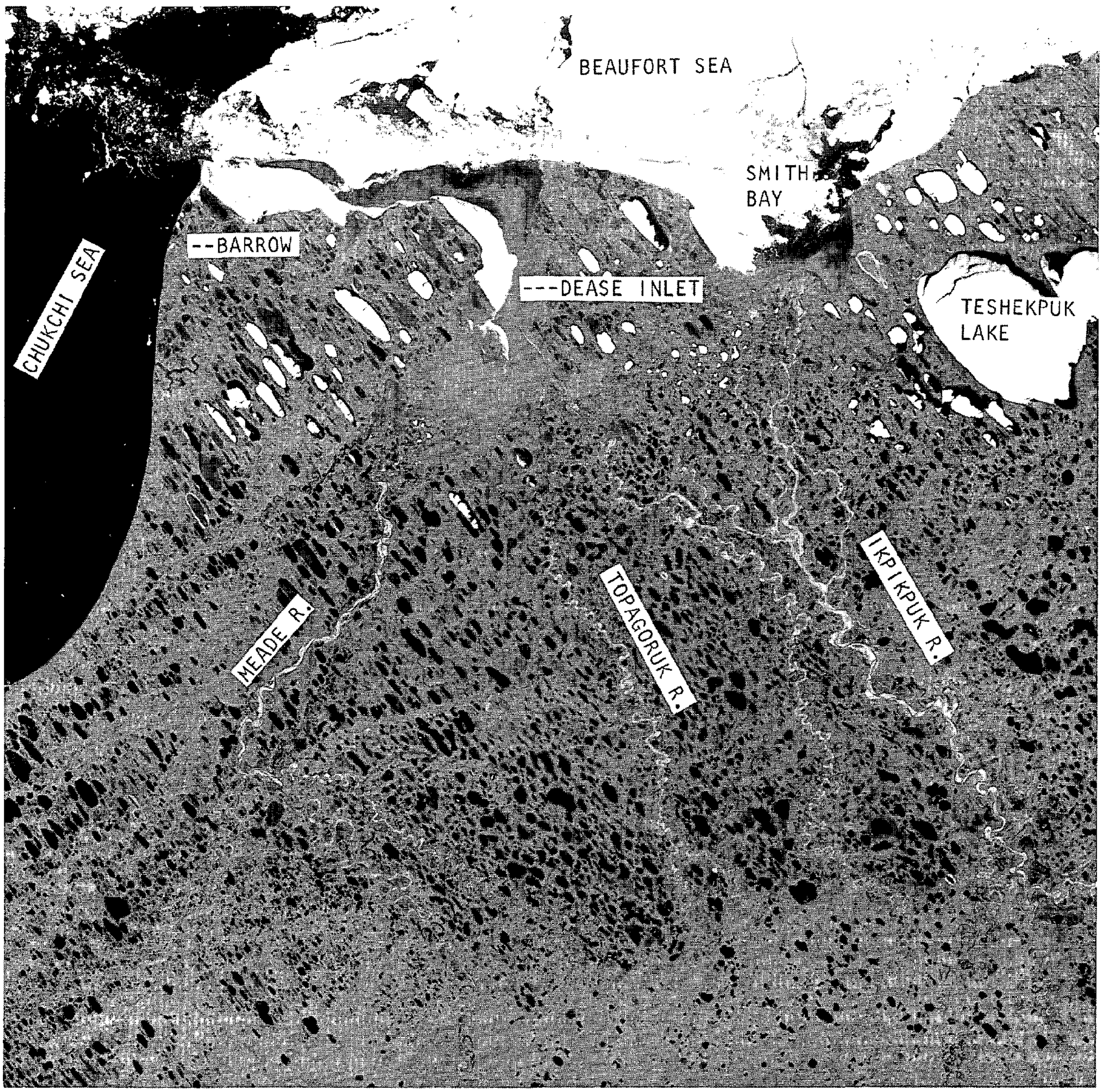

Figure 21.
Landsat image E-2902-21175-5 (12 July 1977) showing the rivers after breakup. Notice the plumes of sediment (lighter areas in the dark ocean water) in Dease Inlet and Smith Bay. The rivers now have a very low discharge and the river channels are almost dry (white areas along the rivers). The scene is 185 km. (115 mi.) across. Compare to Figures 22 and 23.

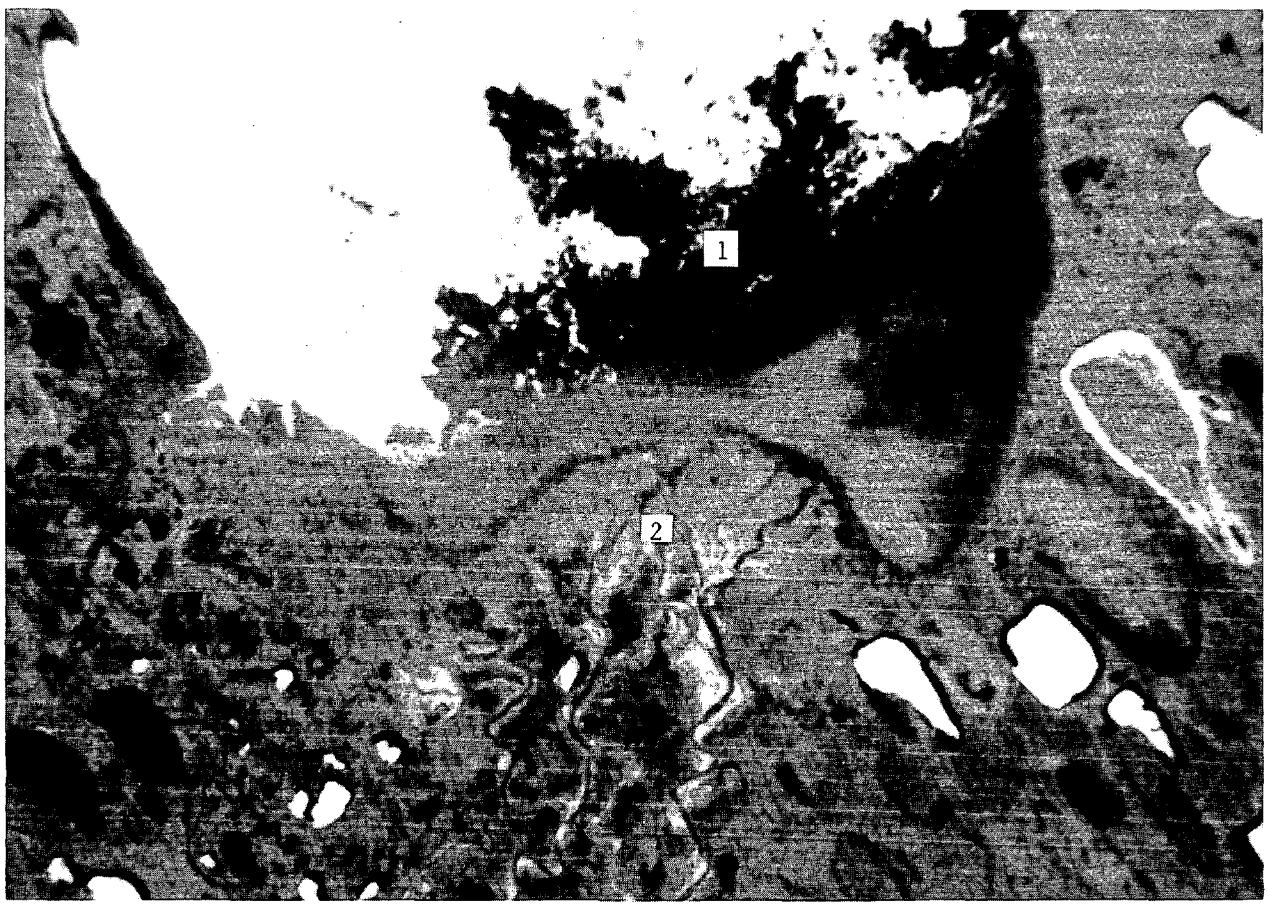

Figure 22.
An enlargement of Landsat image E-2902-21175-5 (12 July 1977) (of Figure 21) showing the sediment plumes in the ocean water of the open polynya at the mouth of the Ikpikpuk River. The scene is 34 km. (21 mi.) across. Compare to Figure 21.

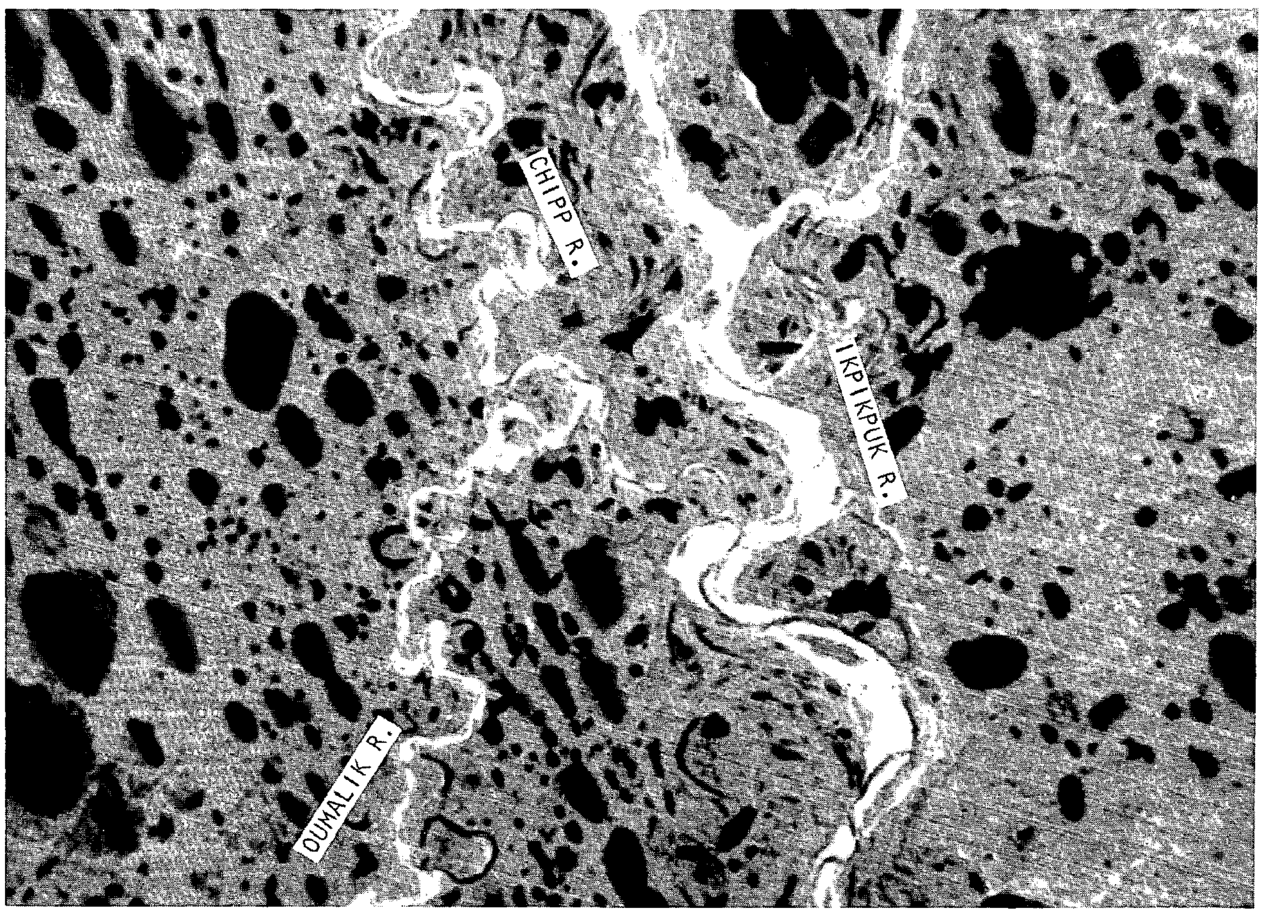

Figure 23.
An enlargement of Landsat image E-2902-21175-5 (12 July 1977) (of Figure 21) showing the Ikpikpuk, Chipp and Oumalik Rivers at very low discharge. The white areas in this scene are the dry active channels of the rivers. This scene is 34 km. (21 mi.) across. Compare to Figure 21.

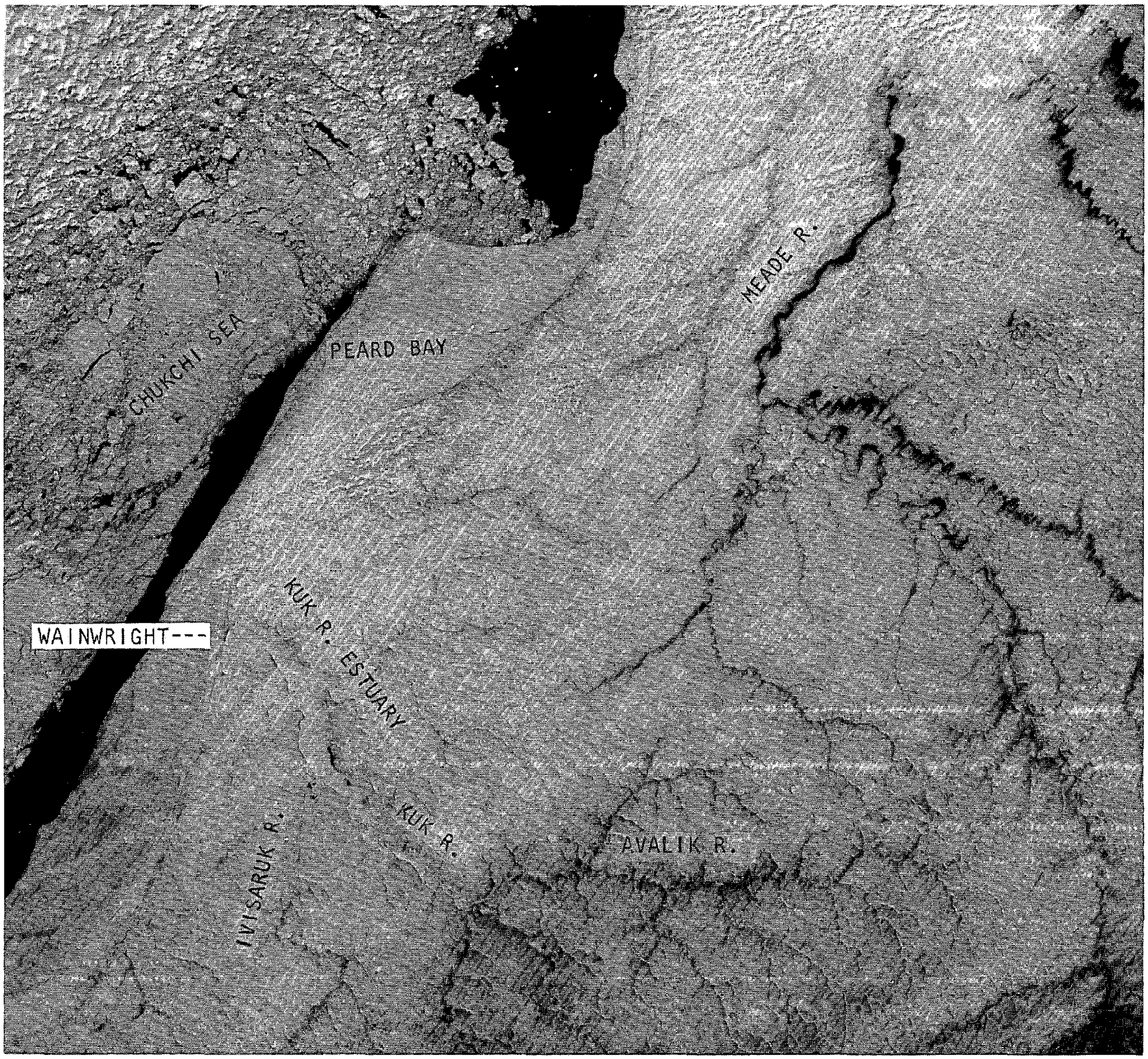

Figure 24.
Landsat image E-30423-21520-7 (2 May 1979) showing the Kuk River and its tributaries before breakup. Notice that the lower regions of the Kuk and Ivisaruk Rivers are covered by channel ice. At breakup the waters of the Kuk and Ivisaruk Rivers will pond on top of the ice of the Kuk River Estuary similar to pre-polynya water on ocean ice (compare to Figure 25). The scene is 185 km. (115 mi.) across.

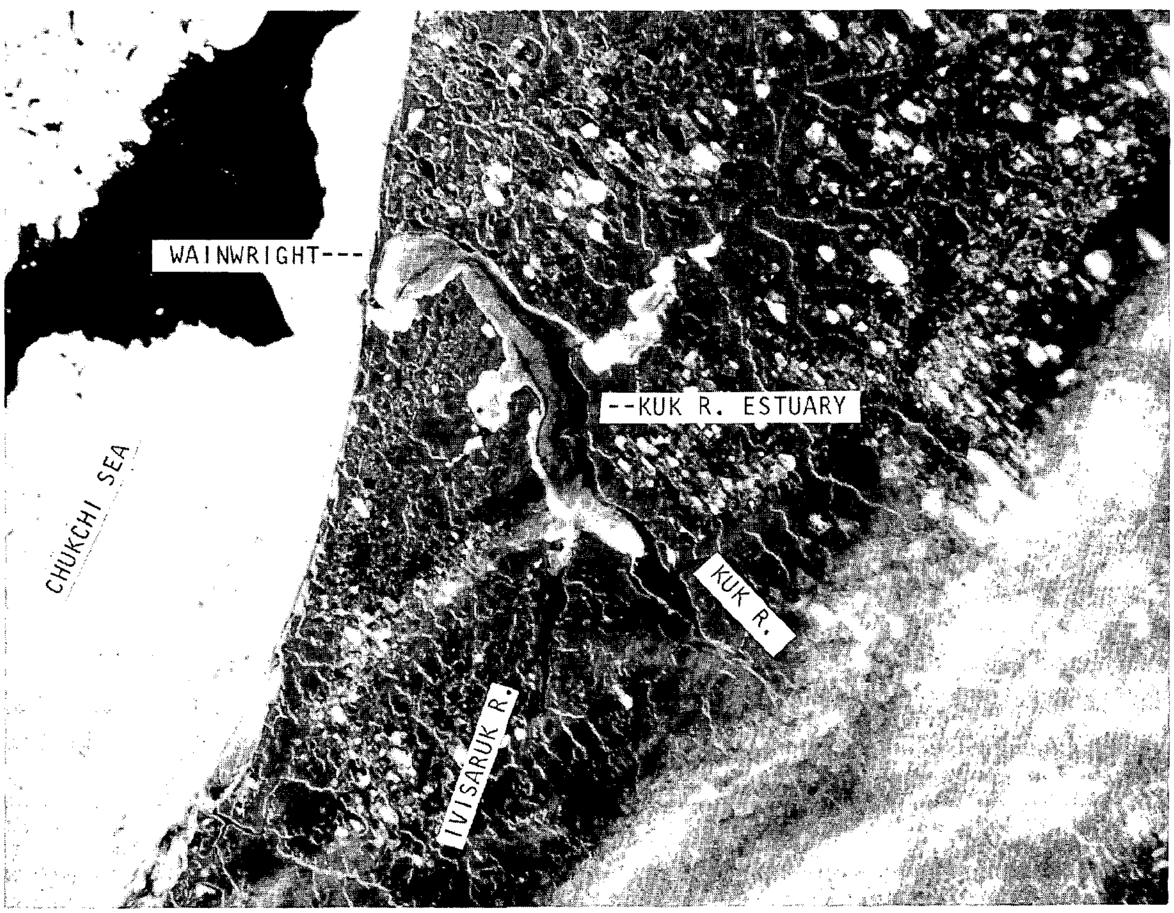

Figure 25.
An enlargement of Landsat image E-2508-21450-5 (13 June 1976) showing the breakup flood waters (black) of the Kuk and Ivisaruk Rivers flowing across and ponding on top of the ice of the Kuk River Estuary. The scene is 102 km. (63 mi.) across.

Floodplain Geomorphology and Flooding Potential of the Study Rivers

Ikpikpuk River

The Ikpikpuk River is located on the Teshekpuk and Ikpikpuk River 1:250,000 USGS quadrangle maps. The flooding units of the Ikpikpuk River are shown on Maps 1a, 1b, 1c and 1d. A total of 268.3 miles of the Ikpikpuk River active channel was mapped from Smith Bay to the Maybe Creek/Kigalik River junction, including the distributary channels (Appendix A). The Ikpikpuk River has the largest watershed area (Table 3) of the rivers studied in this investigation. It is a meandering stream that is slightly incised to slightly entrenched in the upper part of its drainage. It has a gradient of 1.2 feet per mile (Table 2, Appendix C, Figures 49 and 50).

Spring breakup starts with water flowing over an essentially dry channel that has only small amounts of ice in it. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Ikpikpuk River.

Childers (1979) has estimated that the Ikpikpuk River has a bankfull channel discharge of 1,274 m^3/sec. (45,000 $ft.^3$/sec.) and a 50 year flood discharge of 2,095 m^3/sec. (74,000 $ft.^3$/sec.) The mean annual precipitation of the river basin is 23 cm. (9 in.).

Map Flood Units, Ikpikpuk River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably

at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding: This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

7 = very high floodplain terrace, no flooding: This unit is physiographically higher than non-flood unit 6 and there is a definite physiographic break between units 6 and 7.

Table 7. General Geomorphic River Channel Characteristics

River	
(This Investigation)	
Ikpikpuk	Meandering, Slightly Incised, Slight Entrenchment
Chipp	Meandering
Alaktak	Meandering
Miguakiak	Meandering, Yazoo Stream
Piasuk	Meandering, Underfit Stream
Oumalik	Meandering, Slightly Incised
Topagoruk	Meandering, Slightly Incised
Meade	Incised Meandering, Slight Entrenchment to Entrenched
Usuktuk	Meandering, Slightly Incised
Ivisaruk	Incised Meandering, Slight Entrenchment
Kuk	Estuarine, Slightly Meandering, Slight Entrenchment
Kaolak	Incised Meandering, Slight Entrenchment
Ketik	Incised Meandering, Slight Entrenchment
Avalik	Incised Meandering, Slight Entrenchment
Ongorakvik	Straight to Slightly Meandering, Incised
Nokotlek	Straight to Slightly Meandering, Incised
Kugrua	Meandering
Tunalik	Straight to Slightly Meandering, Incised, Slight Entrenchment
(Cannon, 1983)	
Avak	Incised Meandering
Utukok	Incised Meandering, Slightly Braided
Kokolik	Incised Meandering
Epizetka	Incised Meandering, Slight Entrenchment
Kukpowruk	Incised Meandering, Slight Entrenchment
Pitmegea	Braided
Ipewik	Entrenched Meandering
Kukpuk	Entrenched Meandering
(Mortensen and Cannon, 1982)	
Colville	Braided-Meandering, Slight Entrenchment
Kuparuk	Meandering, Slightly Braided
Sagavanirktok	Braided-Meandering, Underfit Stream
Shaviovik	Braided-Meandering
Canning	Braided

Note: An entrenched stream is one in which the stream is cut down into bedrock. An incised stream differs from this by not being related to tectonic uplift, and refers to the floodplains being set into the surrounding alluvial materials.

Figure 26.
A NASA high altitude infrared aerial photograph of the Ikpikpuk River Delta (the black areas are water) which is an actively prograding (growing) delta. Compare this photograph to Figure 6 of the Meade River Delta. The scene is 15 km. (9 mi.) across. Roll number 2790, frame number 3138, July 1979.

Figure 27.
A very low altitude aerial photograph taken from a Bell 206 helicopter on 3 August 1984. This view is looking north across a part of the Ikpikpuk River Delta. The log in the foreground is approximately 50 feet long and was deposited on this tundra covered part of the delta by an ocean storm surge. An ocean storm surge may cause widespread flooding across the Ikpikpuk River Delta area.

Figure 28.
A photograph taken from the ground on 3 August 1984 showing an "abandoned" channel of the Ikpikpuk River. This channel is a flood unit 3, while the high ground on the left of the channel is a non-flood unit 5.

Chipp River

The Chipp River is located on the Teshekpuk 1:250,000 USGS quadrangle map. The flooding units of the Chipp River are shown on Maps 1a and 1b. A total of 62.0 miles of the Chipp River active channel was mapped from Admiralty Bay to the junction with the Ikpikpuk River (Appendix A). The Chipp River is both a distributary channel of the Ikpikpuk River and an extension of the Oumalik River. Because of this the exact area of its watershed cannot be calculated. The Chipp/Oumalik watershed is 1,485 square miles (Table 3). The Chipp River is a meandering stream. It has a gradient of 0.9 feet per mile (Table 2, Appendix C, Figures 49 and 50).

Spring breakup starts with water flowing over an essentially dry channel that has only small amounts of ice in it (Figure 29). Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Chipp River. However, talik lake breaching is a major flooding hazard on the Chipp River (see Figures 30 to 34).

Map Flood Units, Chipp River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

Figure 29.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. The view is looking north (downstream) along the Chipp River during the rising stage of the spring breakup flood waters. Notice the small amount of block ice floating in the channel. The localized flooding produced by ice jams in the channel is probably only a minor to moderate flooding hazard on the Ikpikpuk, Alaktak, Chipp and Topagoruk Rivers.

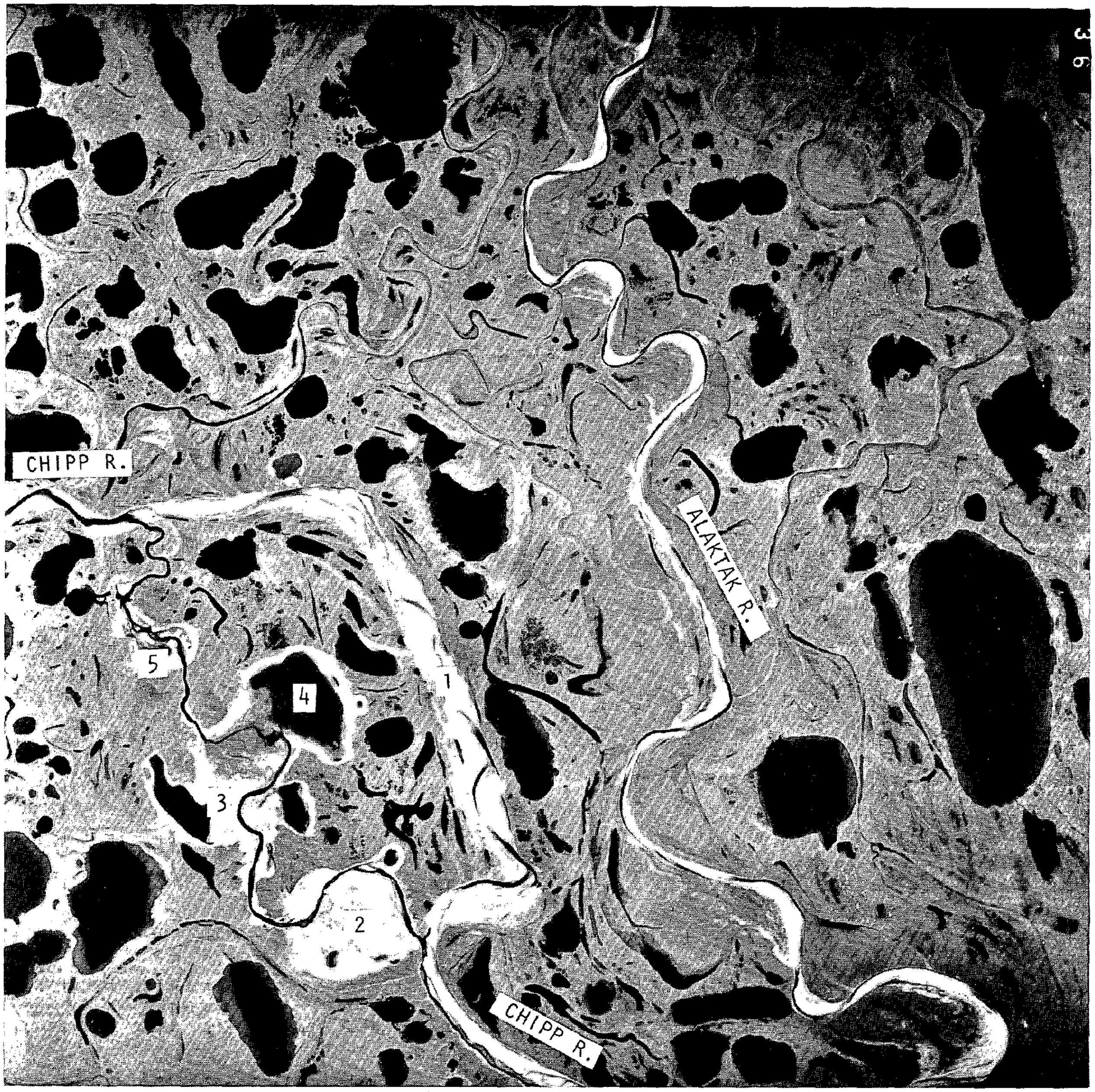

Figure 30.
A NASA high altitude infrared aerial photograph of the Chipp and Alaktak Rivers. The black areas are water, the white areas are dry sand of the active river channels (north is at the top). This scene shows where the Chipp River has breached a series of four talik lakes (2, 3, 4 and 5) adjacent to the former main channel (1) of the Chipp River. The river has breached the lakes, drained them and then formed a new channel through the drained lakes within the last 35 years (the river is flowing to the upper left). This process of lake breaching along the Chipp River would be a major hazard to permanent facilities built adjacent to the river. The Chipp River may be changing its course in this manner because of 1) localized subsidence due to the loss of ground ice, or 2) as a response to regional tectonic subsidence. Also see Figures 31 to 34. The scene is 15 km. (9 mi.) across. Roll number 23, frame number 35, July 1977.

Figure 31.
A black and white aerial photograph of the Chipp and Alaktak Rivers taken in August 1955 showing the series of talik lakes that will later be breached by the Chipp River to form a new channel. The lake numbers correspond to the numbers of Figures 30 and 32. Notice how lake number 2 has already been breached by the Chipp River. Also see Figures 33 and 34. The scene is 9 km. (5.6 mi.) across. USGS aerial photography, Mission 57, Roll 106, frame number 13734, 13 August 1955.

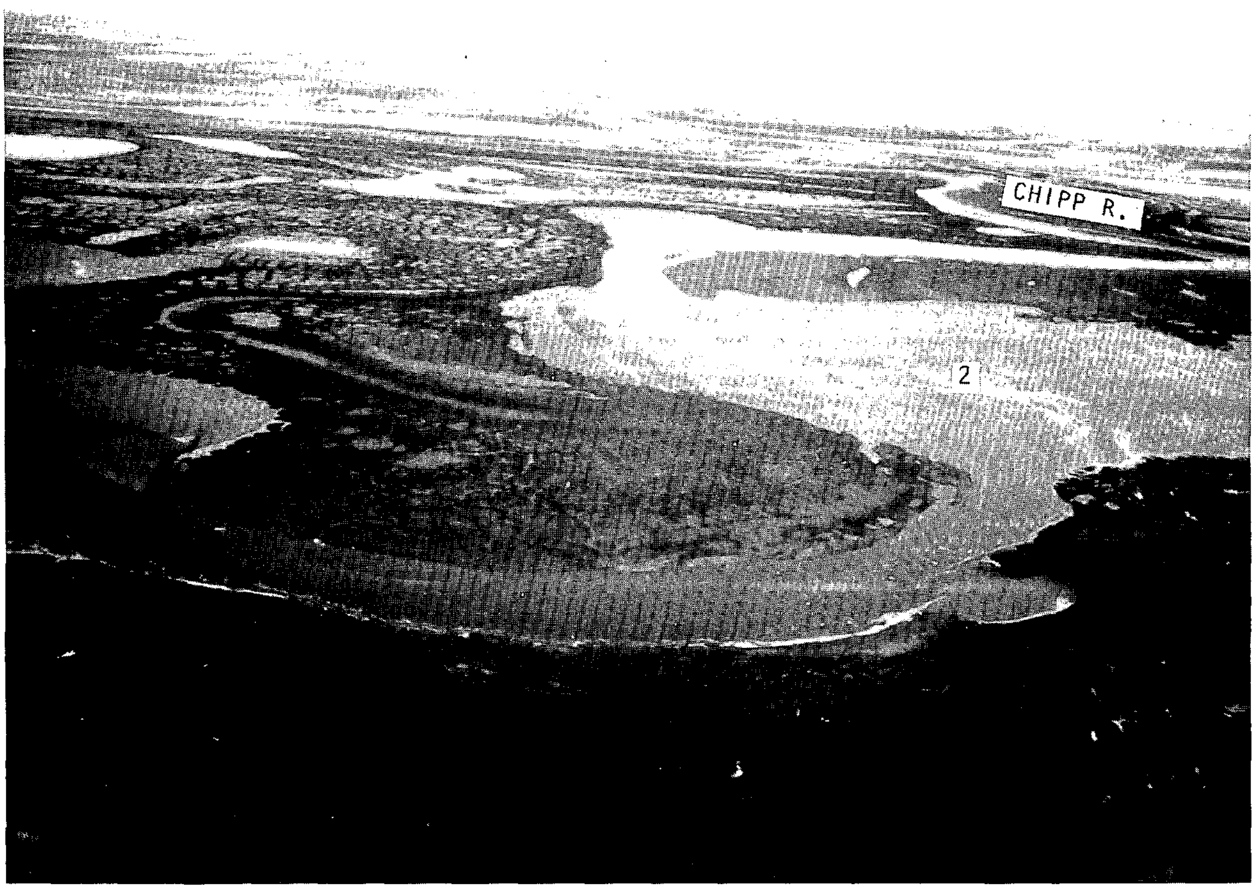

Figure 32.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. The view is looking east across breached talik lake No. 2 (see Figures 30 and 31). During spring breakup the majority of the Chipp River's discharge is flowing through this new channel.

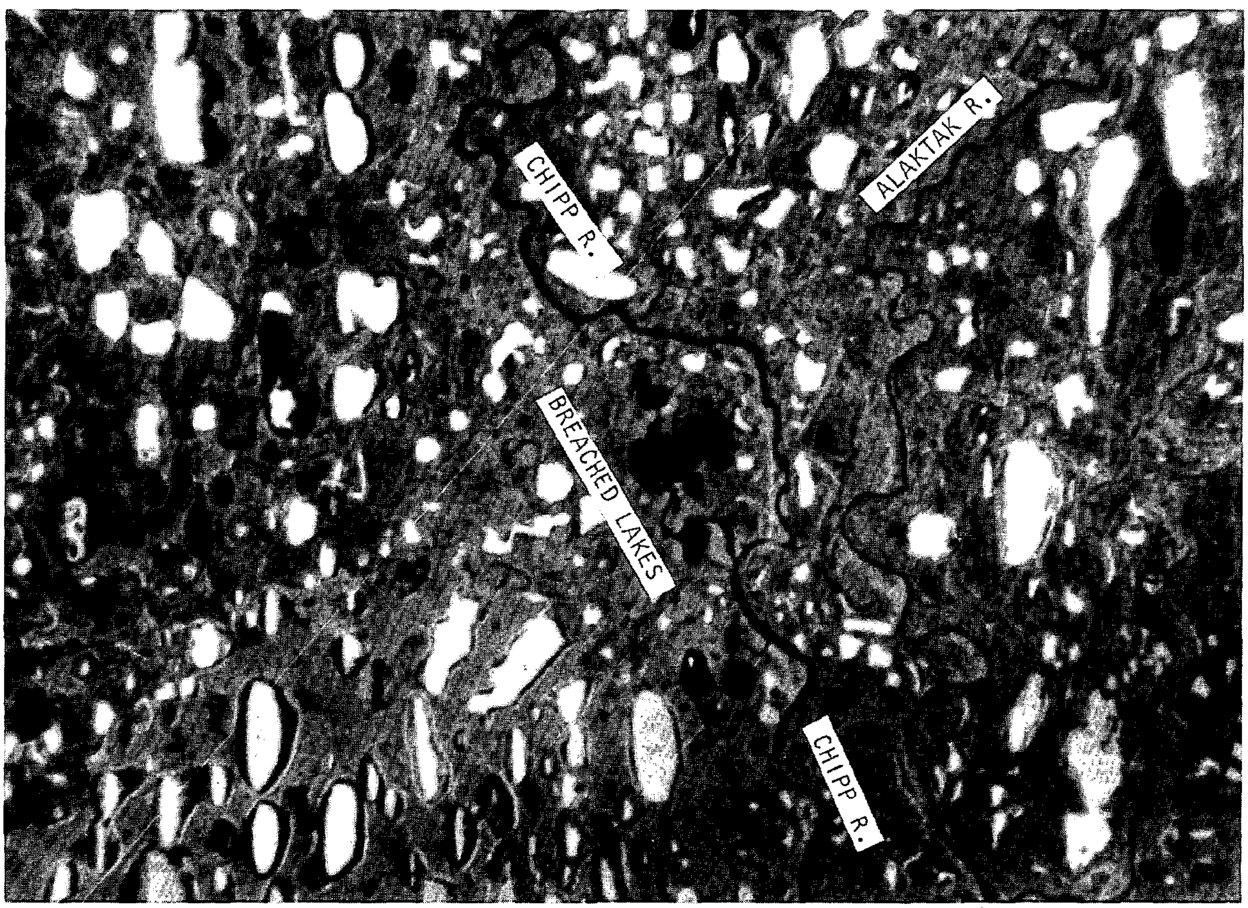

Figure 33.
An enlargement of Landsat image E-30457-21401-7 (5 June 1979) (of Figure 16) showing the spring breakup flood water (black) of the Chipp River filling up and flowing through the breached talik lakes of Figures 30, 31, and 32. Compare this image to Figure 34 which was taken after the spring breakup water had receded. The scene is 56 km. (35 mi.) across.

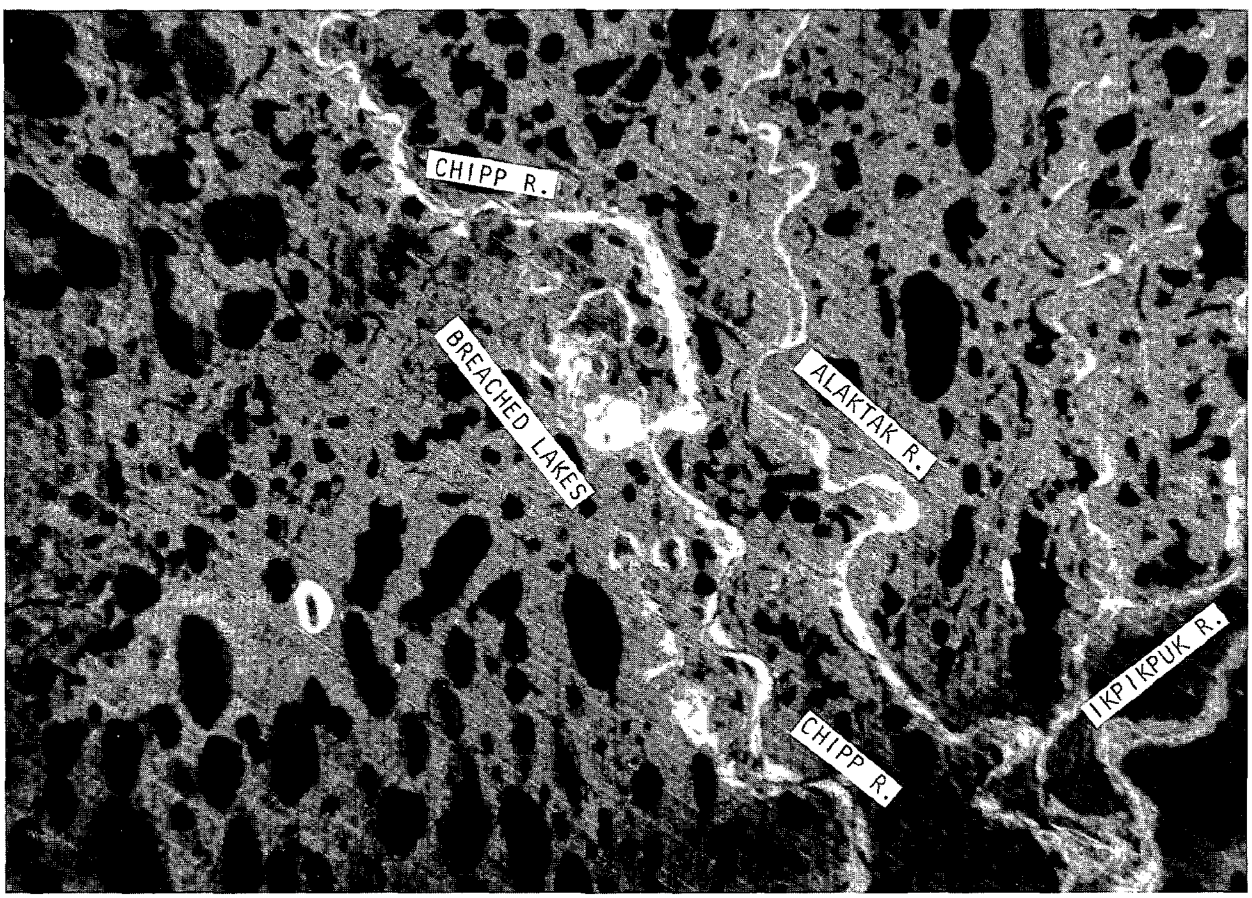

Figure 34.
An enlargement of Landsat image E-2902-21175-5 (12 July 1977) (of Figure 21) showing the active channels (white areas) of the Chipp and Alaktak Rivers after the spring breakup flood waters have receded. Notice the breached lakes and compare to Figure 33. The scene is 58 km. (36 mi.) across.

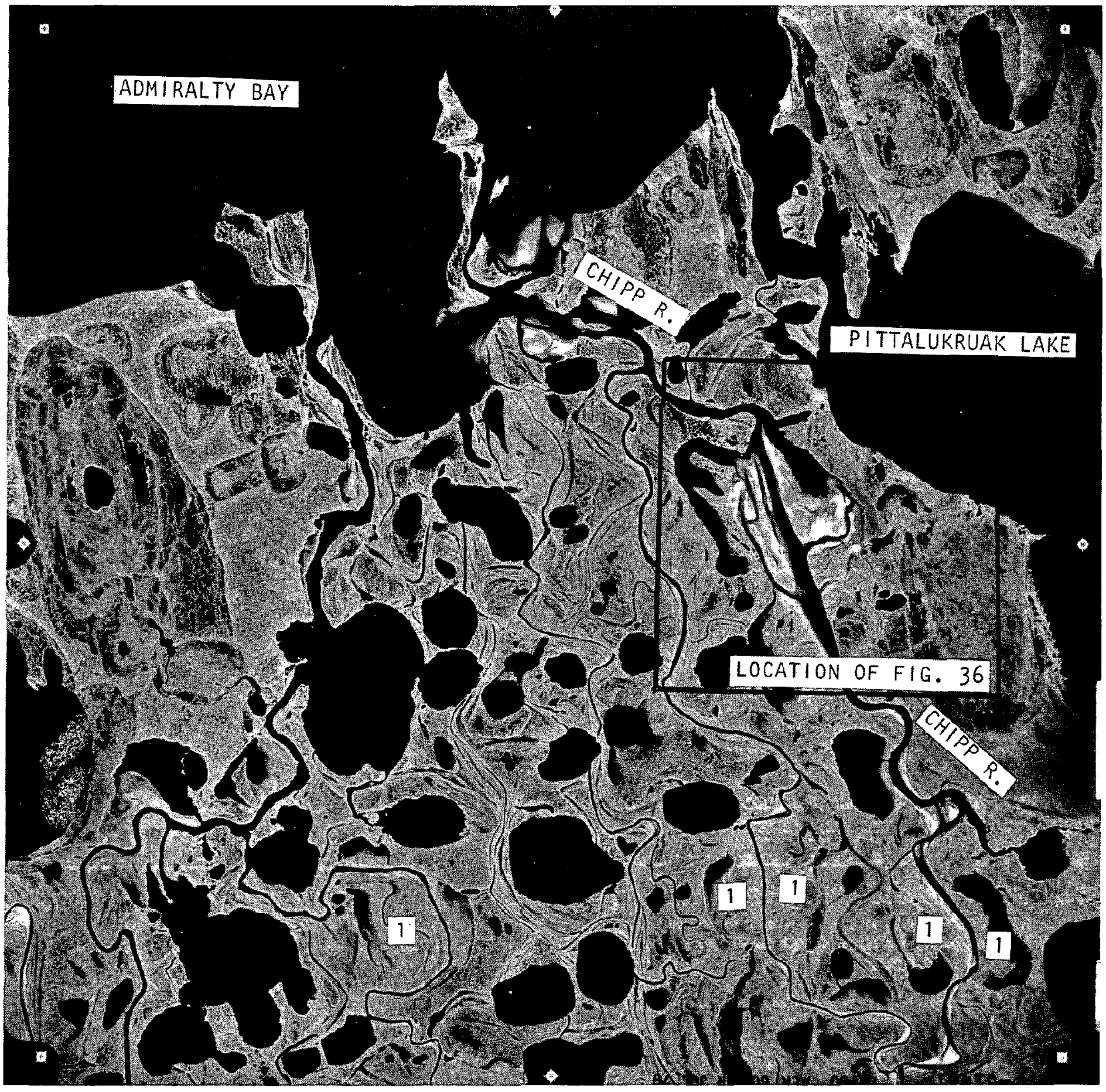

Figure 35.
A NASA high altitude infrared aerial photograph of the Chipp River Delta area (the black areas are water). Notice that where the Chipp River empties into Admiralty Bay that there is no true delta. Talik lake breaching (Figures 30 to 34) appears to be a common process along the Chipp River floodplain. The features at "1" are all breached talik lakes that have now been partly filled with river transported sediments. The feature in the box is a breached talik lake along the main channel of the Chipp River that is presently being filled by river sediments (see Figure 36). The scene is 15 km. (9 mi.) across. Roll number 2790, frame number 3145, July 1979.

Figure 36.
A low altitude black and white aerial photograph taken by the U.S. Navy in 1949. This photograph is a close-up of the breached talik lake of Figure 35. Compare these two figures to see changes from the two photographs taken 30 years apart. The scene is 4.3 km. (2.7 mi.) across. U.S. Navy (BAR), Roll number 23, frame number 32. 1949.

Alaktak River

The Alaktak River is located on the Teshekpuk 1:250,000 USGS quadrangle map. The flooding units of the Alaktak River are shown on Map 1a. A total of 43.5 miles of the Alaktak River active channel was mapped from Pittalukruak Lake to the junction with the Ikpikpuk River (Appendix A). The Alaktak River is a distributary channel of the Ikpikpuk River; because of this its watershed cannot be calculated. It is a meandering stream. It has a gradient of 0.6 feet per mile (Table 2, Appendix C, Figures 49 and 50).

Spring breakup starts with water flowing over an essentially dry channel that has only small amounts of ice in it. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Alaktak River.

Map Flood Units, Alaktak River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

Miguakiak River

The Miguakiak River is located on the Teshekpuk 1:250,000 USGS quadrangle map. The flooding units of the Miguakiak River are shown on Map 1a. A total of 20.3 miles of the Miguakiak River active channel was mapped from Teshekpuk Lake to the junction with the Ikpikpuk River (Appendix A). It is a meandering, Yazoo type stream (Figure 37).

The Miguakiak River flows from Teshekpuk Lake to the Ikpikpuk River. Spring breakup starts with the flood waters of the Ikpikpuk River flowing backward up the still frozen and ice covered channel of the Miguakiak River. Because of this, the Miguakiak is a Yazoo type stream, and has the same flooding potential as the Ikpikpuk River.

Map Flood Units, Miguakiak River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

Figure 37.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. This view is looking east (upstream) along the Miguakiak River at spring breakup showing the dark sediment laden water from the Ikpikpuk River flowing backward up the still frozen channel of the Miguakiak River. The Miguakiak River normally drains water from Teshekpuk Lake (see Map 1a) to the Ikpikpuk River. However, during the spring breakup, the flood waters from the Ikpikpuk River flow backward up the Miguakiak River. The Miguakiak River is a Yazoo type stream.

Piasuk River

The Piasuk River is located on the Teshekpuk 1:250,000 USGS quadrangle map. The flooding units of the Piasuk River are shown on Map 1a. A total of 13.0 miles of flood unit 1 was mapped from Smith Bay (Appendix A). The Piasuk River has no true watershed area as it is an "abandoned" distributary channel of the Ikpikpuk River. It is an underfit meandering stream (Table 7). Its gradient is too low and channel too short to calculate the gradient from USGS topographic maps.

The Piasuk River is connected to the Ikpikpuk River distributary system by "abandoned" channels that are designated as flood unit 3. Thus, it receives water from the Ikpikpuk River only when a stage 3 flood occurs on that river. (See Figure 28 for an example of a flood unit 3 channel.)

Map Flood Units, Piasuk River

1 = the former active channel:
It is at present no more than a long lake that receives water from local snowmelt during the spring breakup.

2 = there is no flood unit 2 on the Piasuk River.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 1. The areas of this flood unit are vegetated "abandoned" channels of the Ikpikpuk River distributary system. The estimated flood frequency is the same as the Ikpikpuk River — 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 1. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and very poor drainage characterize this unit. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

Fd = fluvial delta deposits of the now mostly inactive Piasuk River Delta:
This area is subject to ocean storm surge flooding.

Oumalik River

The Oumalik River is located on the Teshekpuk, Ikpikpuk River and Lookout Ridge 1:250,000 USGS quadrangle maps. The flooding units of the Oumalik River are shown on Map 1b. A total of 40.0 miles of the Oumalik River active channel was mapped from the junction with the Chipp River to the 75 foot topographic contour (Appendix A). The Oumalik River has a watershed area of 1,475 square miles (Table 3). It is a meandering to slightly incised stream (Table 7). It has a gradient of 0.5 feet per mile (Table 2, Appendix C, Figure 49).

Spring breakup starts with water flowing over an essentially dry channel that has only small amounts of ice in it. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Oumalik River.

Map Flood Units, Oumalik River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

Topagoruk River

The Topagoruk River is located on the Teshekpuk, Meade River and Lookout Ridge 1:250,000 USGS quadrangle maps. The flooding units of the Topagoruk River are shown on Maps 1a and 1b. A total of 115.5 miles of the Topagoruk River active channel was mapped from Admiralty Bay to the 100 foot topographic contour (Appendix A). The Topagoruk River has a watershed area of 783.0 square miles (Table 3). It is a meandering stream that is slightly incised in the upper part of its drainage (Table 7). It has a gradient of 1.0 foot per mile (Table 2, Appendix C, Figure 49).

Spring breakup starts with water flowing over an essentially dry channel that has only small amounts of ice in it. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Topagoruk River.

Map Flood Units, Topagoruk River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with sparse groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. Areas of flood unit 4 on Map 1a may not flood. The estimated flooding frequency is 100 to 200 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

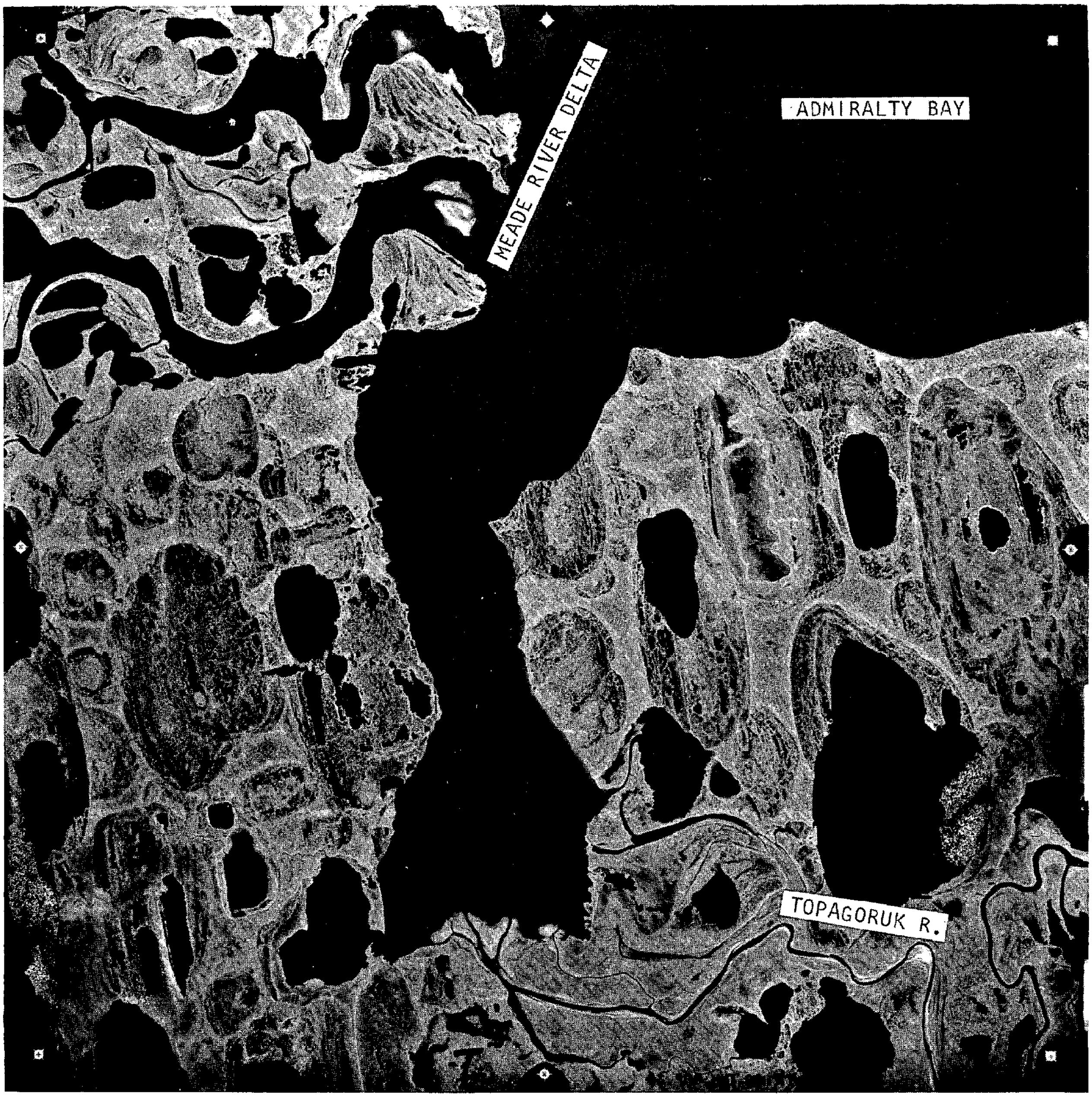

Figure 38.
A NASA high altitude infrared aerial photograph of part of the Meade River Delta and the Topagoruk River Delta (the black areas are water). The Topagoruk River has a small delta in comparison to the size of its drainage basin. Compare to Figures 19 and 20. The scene is 15 km. (9 mi.) across. Roll number 2790, frame number 3147, July 1979.

Meade River

The Meade River is located on the Meade River and Lookout Ridge 1:250,000 USGS quadrangle maps. The flooding units of the Meade River are shown on Maps 2a, 2b and 2c. A total of 212.4 miles of the Meade River active channel was mapped from Admiralty Bay to the 200 foot topographic contour, including the distributary channels (Appendix A). The Meade River has the third largest watershed area, 3,885.0 square miles (Table 3), of the rivers studied in this investigation. It is a meandering river that is incised to slightly entrenched and entrenched in the upper part of its drainage (Table 7). It has a gradient of 1.3 feet per mile (Table 2, Appendix C, Figure 49).

Spring breakup starts with water flowing over the channel ice. Localized flooding caused by ice jams is a major flooding hazard on the Meade River (Figures 39, 40 and 41).

Childers (1979) has estimated that the Meade River has a bankfull channel discharge, adjacent to the village of Atkasook, of 246 m^3/sec. (8,700 $ft.^3$/sec.) and a 50 year flood discharge of 1,076 m^3/sec. (38,000 $ft.^3$/sec.). The mean annual precipitation of the river basin is 20 cm (8 in.).

Map Flood Units, Meade River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of low willows. This unit shows the effects of recent erosion and deposition by running water. Eolian sand dunes may be common in places. The estimated flooding frequency is 3 to 7 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 7 to 25 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 50 to 100 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

Figure 39.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. This view is looking downstream (north) along the Meade River at spring breakup. The village of Atkasook is at the upper left. In this photograph the channel ice is being floated up from the river channel bottom by the rising spring breakup flood waters. The source of the channel ice is the deeper pools of water that are in the river at freezeup in the fall, when the river commonly has a very low or zero discharge. The channel ice, 1) decreases the water flow capacity of the river channel during spring breakup, 2) is the source of the ice blocks that form ice jams on the river, 3) large pans of channel ice can block the river channel causing the smaller floating ice blocks to form an ice jam. Ice jams are a major flooding hazard along the Meade River during spring breakup.

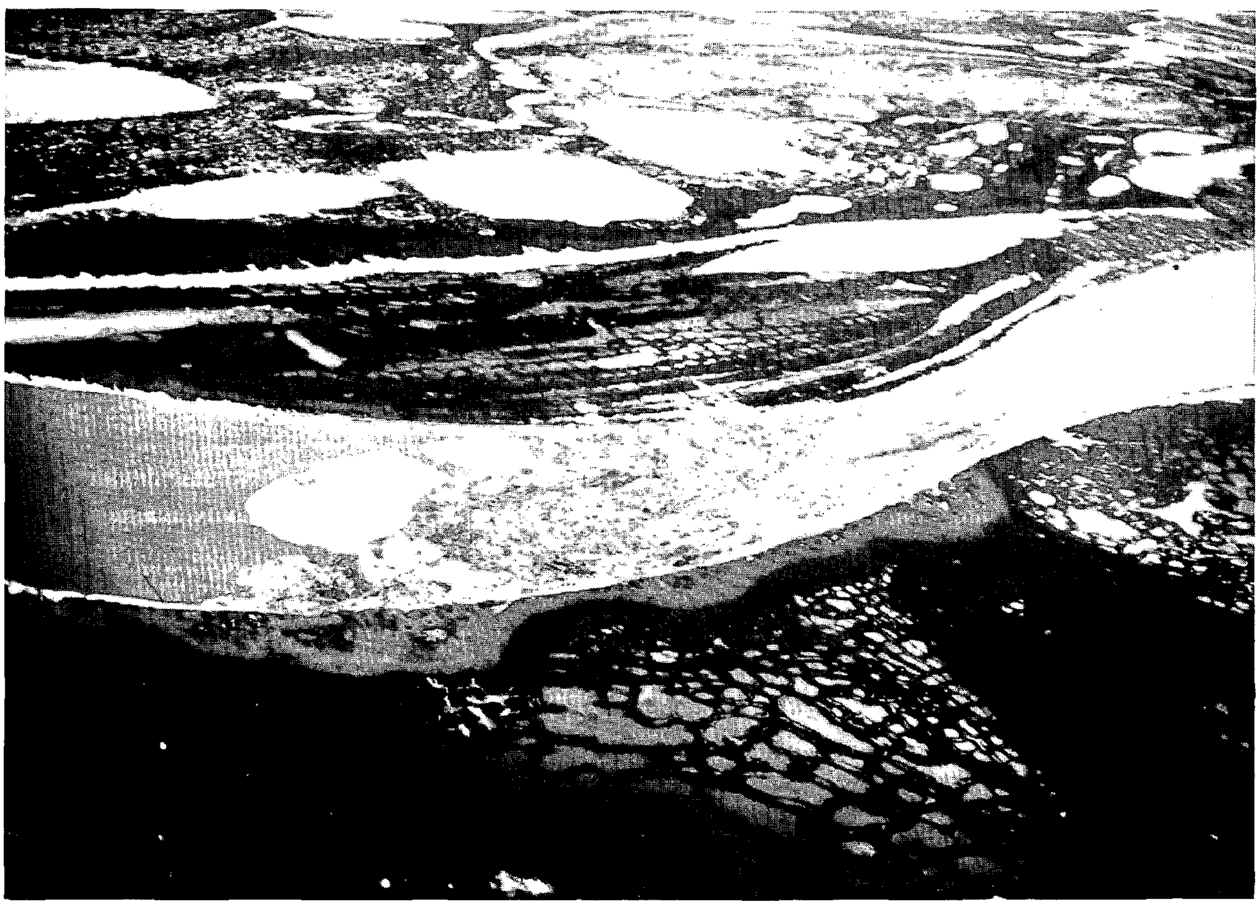

Figure 40.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. This photograph shows an ice jam on the Meade River. The water in the river is flowing from left to right. Notice how the large pan of channel ice on the downstream side has caused the smaller floating ice blocks to form an ice jam at this location.

Figure 41.
A low altitude oblique aerial photograph taken from a Cessna 182 on 10 June 1984. This view is looking upstream (south) along the Meade River. The photograph shows a large ice jam on the river that has backed up water onto flood unit 2 areas that are in the immediate upstream area of the ice jam. No flood unit 2 areas are flooded downstream of this ice jam. Notice how the ice in the river has been blocked by the channel ice on the left side of the front of the ice jam.

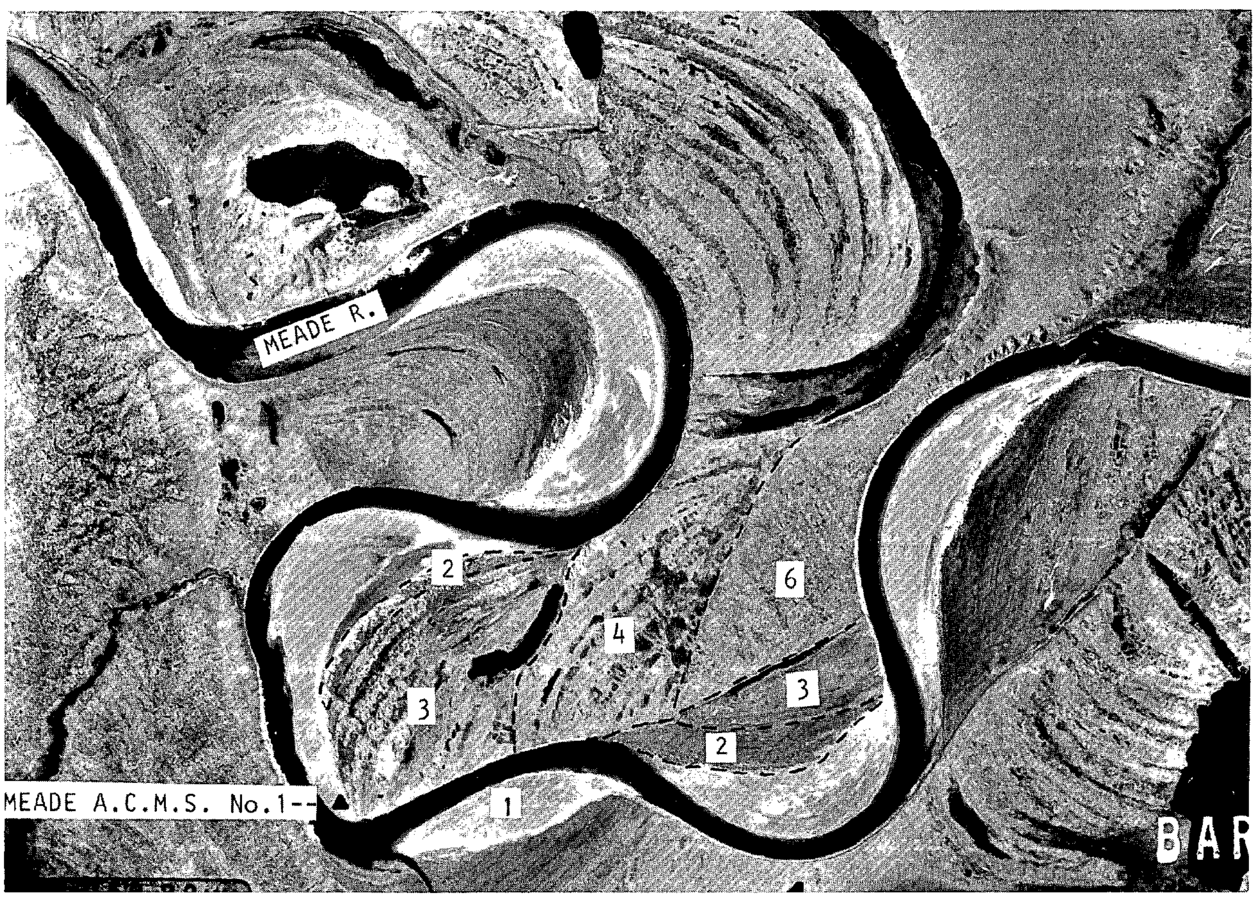

Figure 42.
A low altitude black and white aerial photograph taken by the U.S. Navy in 1948. This photograph is showing the geomorphic (physiographic) floodplain units and the corresponding flood potential units along a part of the Meade River. 1 is flood unit 1 (the active channel), 2 is flood unit 2, 3 is flood unit 3, 4 is flood unit 4 and 6 is non-flood unit 6 (also see Figures 43 and 44). Meade A.C.M.S. No. 1 is an Active Channel Material Sample site, see Map 2b and Appendix D. The scene is 3.5 km. (2.2 mi.) across. U.S. Navy (BAR), Roll number 269, frame number 55, 1948.

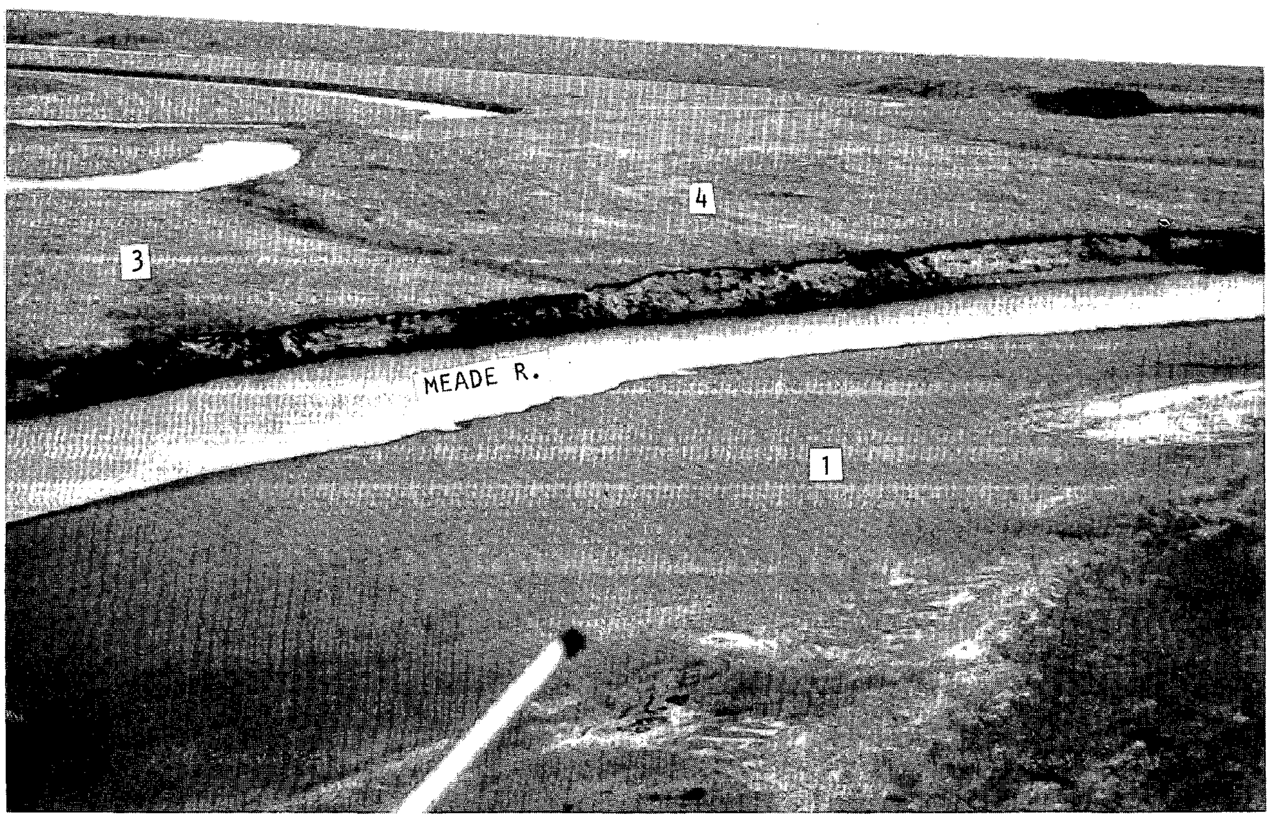

Figure 43.
A very low altitude oblique aerial photograph taken from a Bell 206 helicopter on 2 August 1984. This photograph shows three potential flood units along the Meade River of Figure 42. The river is flowing from right to left. 1 is flood unit 1 (the active channel), 3 is flood unit 3 and 4 is flood unit 4. Notice the definite physiographic break between flood units 3 and 4.

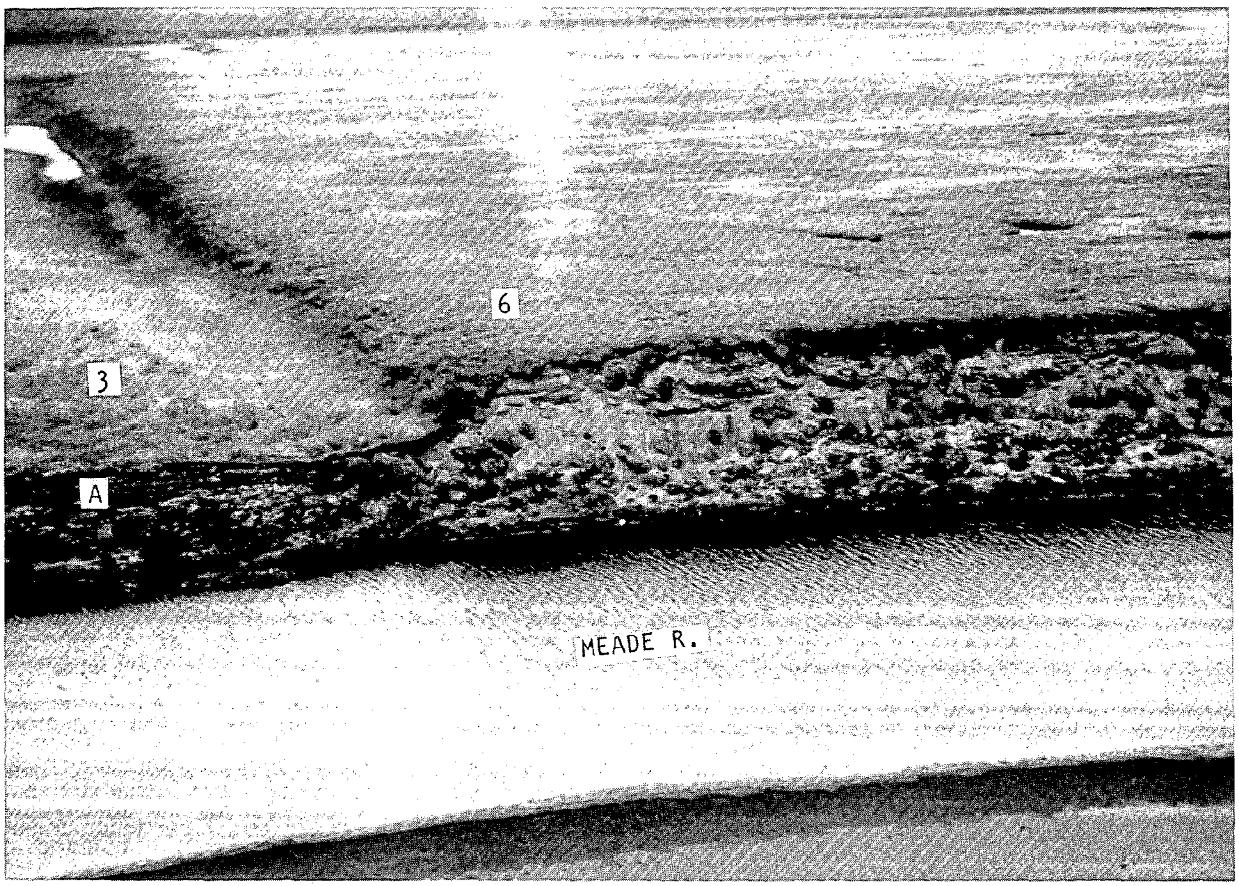

Figure 44.
A very low altitude oblique aerial photograph taken from a Bell 206 helicopter on 2 August 1984. This photograph shows the relationship of flood unit 3 and non-flood unit 6 along the Meade River of Figure 42. The river is flowing from right to left. Flood unit 3 is 4.9 meters (16 ft.) above the present low discharge level of the river. Non-flood unit 6 is 8.2 meters (27 ft.) above the present low discharge level of the river. Notice the definite physiographic break between flood unit 3 and non-flood unit 6. Location "A" in this photograph (see Figure 45) has water scoured peat beds (that underly the tundra mat) and driftwood that indicates a former high flood water level of the Meade River.

Figure 45.
A photograph taken from the ground on 2 August 1984 of location "A" of Figure 44. This photograph shows water scoured peat beds and driftwood 4.9 meters (16 ft.) above the present water level of the Meade River. Also see Figures 42 and 44.

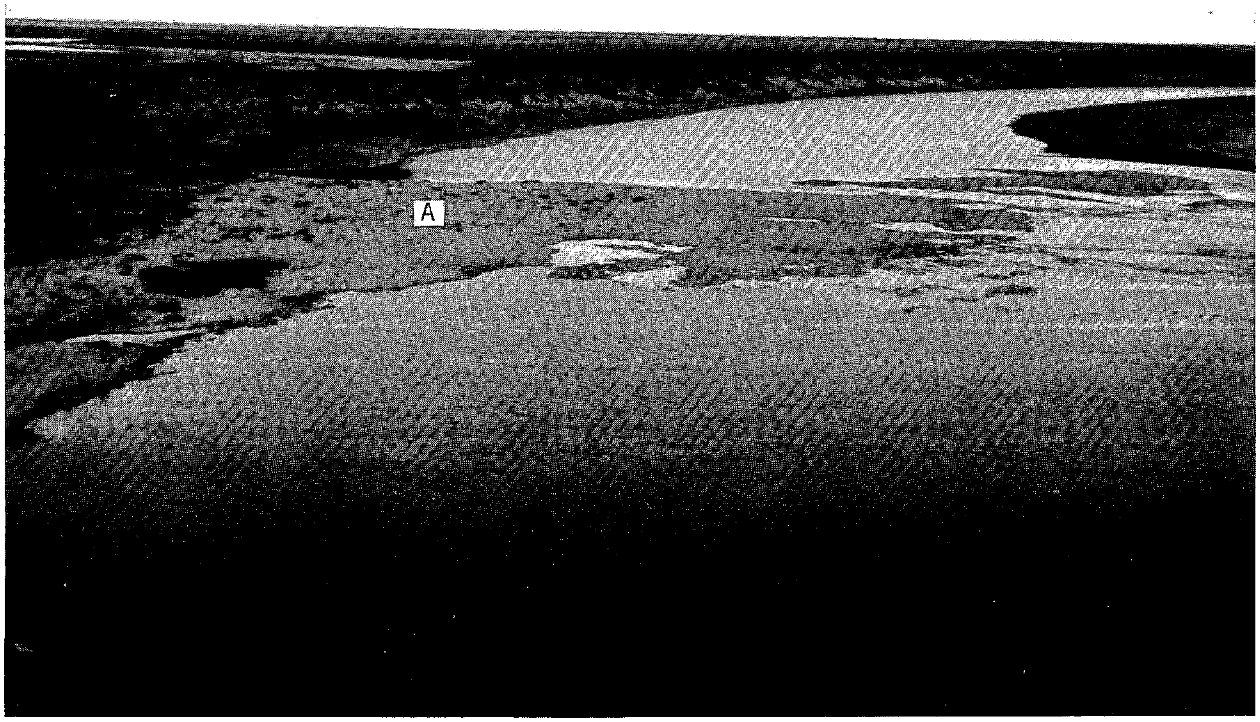

Figure 46.
A very low altitude oblique aerial photograph taken from a Bell 206 helicopter on 2 August 1984. This photograph shows a bar ("A") of gravel, cobbles and boulders in the Meade River channel. These bars are localized features that occur only where the river has cut into the underlying Cretaceous in age bedrock. Also see Figure 47.

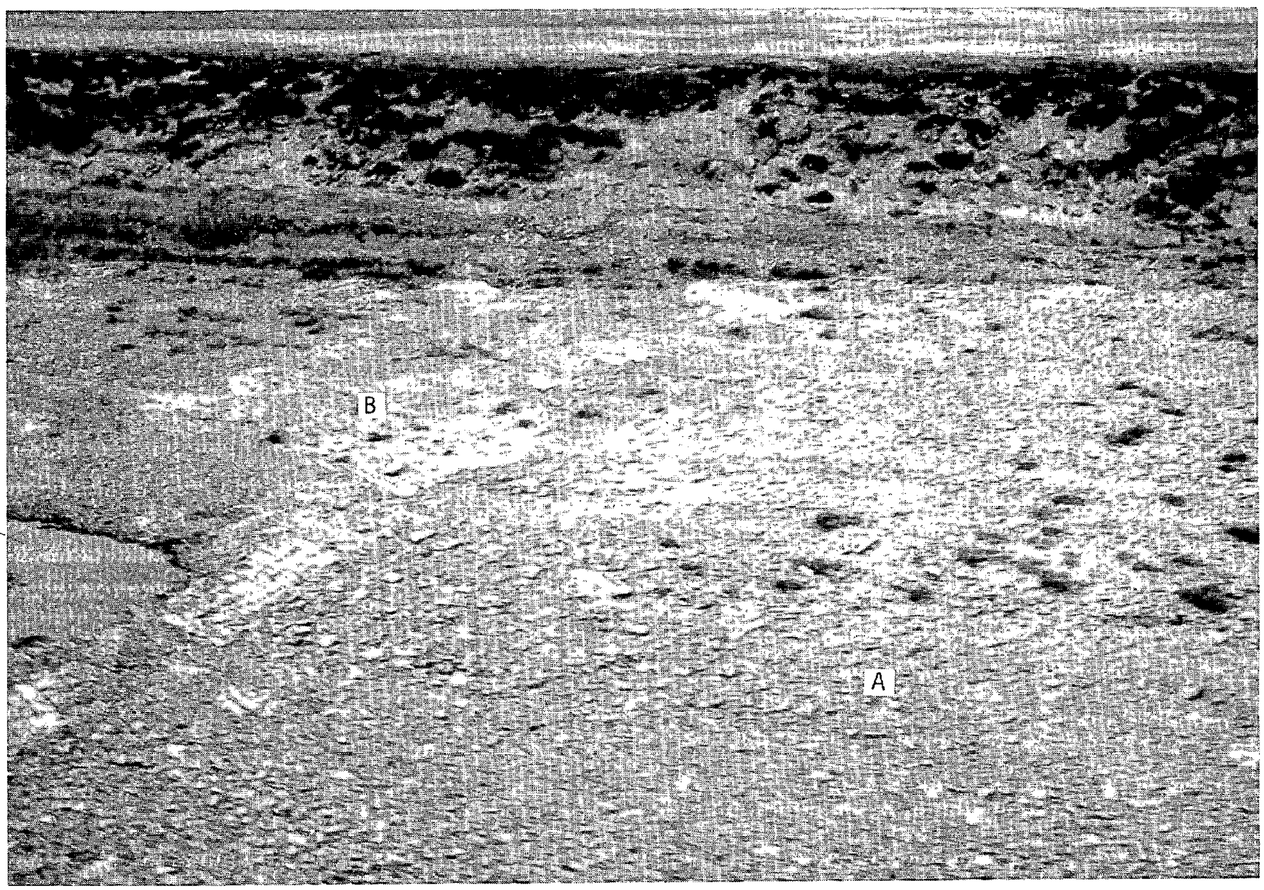

Figure 47.
A very low altitude oblique aerial photograph taken from Bell 206 helicopter on 2 August 1984. This photograph shows a closeup of the bar of Figure 46. "B" is inplace Cretaceous in age bedrock, "A" is gravel, cobbles and boulders derived from the bedrock.

Usuktuk River

The Usuktuk River is located on the Meade River and Lookout Ridge 1:250,000 USGS quadrangle maps. The flooding units of the Usuktuk River are shown on Maps 2a and 2b. A total of 46.0 miles of the Usuktuk River active channel was mapped from the junction with the Meade River (Appendix A). The Usuktuk River has a watershed area of 622.0 square miles (Table 3). It is a meandering, slightly incised stream (Table 7).

Spring breakup starts with water flowing over a channel with only small amounts of ice in it. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Usuktuk River.

Map Flood Units, Usuktuk River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of low willows. This unit shows the effects of recent erosion and deposition by running water. Eolian sand dunes may be common in places. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a gradational to definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. Vegetated eolian sand dunes may be common in places. It has minor permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Flood unit 4 shows the old scars of running water. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground, high and low centered polygons, and poor drainage characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 50 to 100 years.

5 = no flooding:
There is no physiographic break between flood units 5 and 4. Flood unit 5 is probably at the limit of the Project Flood. It has the same geomorphology as unit 4.

6 = high floodplain terrace or eolian dune on the floodplain, no flooding:
This unit is physiographically higher than flooding units 4 and 5 and there is a definite physiographic break between non-flood unit 6 and units 4 and 5.

Ivisaruk River

The Ivisaruk River is located on the Wainwright and Utukok River 1:250,000 USGS quadrangle maps. The flooding units of the Ivisaruk River are shown on Maps 4a and 4b. A total of 56.0 miles of the Ivisaruk River active channel was mapped from Neakok Island (Kuk River) to the 100 foot topographic contour (Appendix A). The Ivisaruk River has a watershed area of 522.0 square miles (Table 3). It is an incised meandering stream that is slightly entrenched (Table 7). It has a gradient of 1.8 feet per mile (Table 2, Appendix C, Figure 49). The Ivisaruk River has a narrow, confined delta where it empties into the Kuk River estuary.

Spring breakup starts with water flowing over the channel ice. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Ivisaruk River (see Figures 24 and 25).

Map Flood Units, Ivisaruk River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. It has permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 25 to 50 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a gradational to definite physiographic break between this flood unit and unit 3. This unit has a well established cover of tundra. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons. The estimated flooding frequency is 50 to 100 years. Flood unit 4 areas may flood in the delta area during a Chukchi Sea storm surge, especially if the surge coincides with a period of high river discharge.

5 = high floodplain terrace, no flooding:
This unit is physiographically higher than flooding unit 4 and there is a definite physiographic break between non-flood unit 5 and unit 4.

Kuk River

The Kuk River is located on the Wainwright 1:250,000 USGS quadrangle map. The flooding units of the Kuk River are shown on maps 4a and 4b. A total of 43.5 miles of the Kuk River estuary and active channel was mapped from the Chukchi Sea to the Avalik River (Appendix A). The Kuk River has the second largest watershed area, 4,275.0 square miles (Table 3), of the rivers studied in this investigation. It is an estuarine stream for 25 miles from the Chukchi Sea to its confined delta, and is slightly meandering and slightly entrenched upstream of its confined delta (Table 7). The Kuk/Avalik River system has a gradient of 0.9 feet per mile upstream of the Kuk River estuary (Table 2, Appendix C, Figures 49 and 51).

Spring breakup starts with water flowing over the channel ice. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Kuk River (see Figures 24 and 25).

Childers (1979) has estimated that the Kuk River has a bankfull channel discharge as it enters the estuary of 1,603 m^3/sec. (56,600 ft.^{3}/sec.) and a 50 year flood discharge of 2,860 m^3/sec. (101,000 ft.^{3}/sec.). The mean annual precipitation of the river basin is 25 cm. (10 in.).

Map Flood Units, Kuk River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of willows. This unit shows the effects of recent erosion and deposition by running water. Eolian sand dunes may be common in places. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 10 to 25 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a gradational physiographic break between this flood unit and unit 3. This unit has a well established cover of tundra. Such features as patterned ground and high and low centered polygons characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 50 to 100 years.

5 = high floodplain terrace, no flooding:
This unit is physiographically higher than flooding unit 4 and there is a definite physiographic break between non-flood unit 5 and unit 4.

Figure 48.
A very low altitude oblique aerial photograph taken from a Bell 206 helicopter on 2 August 1984. This photograph shows a strandline of driftwood deposited by an ocean storm surge on the coast of the Chukchi Sea 18 km. (11 mi.) northeast of Peard Bay. Ocean storm surges may flood areas along the coast that are three meters (10 ft.) or less above normal sea level.

Kaolak River

The Kaolak River is located on the Wainwright and Utukok River 1:250,000 USGS quadrangle maps. The flooding units of the Kaolak River are shown on Map 4b. A total of 45.2 miles of the Kaolak River active channel was mapped from the junction with the Avalik River to the 100 foot topographic contour (Appendix A). The Kaolak River has a watershed area of 736.0 square miles (Table 3). It is an incised meandering stream that is slightly entrenched (Table 7). It has a gradient of 2.3 feet per mile (Table 2, Appendix C, Figures 49 and 51).

Spring breakup starts with water flowing over the channel ice. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Kaolak River. Recent flood levels along the Kaolak River as high as six meters (20 ft.) were observed during the spring breakup in June 1948 (Hopkins and others, 1978).

Map Flood Units, Kaolak River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. It has permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 25 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a gradational to definite physiographic break between this flood unit and unit 3. This unit has a well established cover of tundra. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons. The estimated flooding frequency is 50 to 100 years.

5 = high floodplain terrace, no flooding:
This unit is physiographically higher than flooding unit 4 and there is a definite physiographic break between non-flood unit 5 and unit 4.

Ketik River

The Ketik River is located on the Wainwright and Utukok River 1:250,000 USGS quadrangle maps. The flooding units of the Ketik River are shown on Maps 4c and 4d. A total of 61.5 miles of the Ketik River active channel was mapped from the junction with the Avalik River to the 100 foot topographic contour (Appendix A). The Ketik River has a watershed area of 721.0 square miles (Table 3). It is an incised meandering stream that is slightly entrenched (Table 7). It has a gradient of 1.6 feet per mile (Table 2, Appendix C, Figures 49 and 51).

Spring breakup starts with water flowing over the channel ice. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Ketik River. Recent flood levels along the Ketik River as high as six meters (20 ft.) were observed during the spring breakup in June 1948 (Hopkins and others, 1978).

Map Flood Units, Ketik River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a definite physiographic break between units 2 and 3. Unit 3 shows the scars of running water but has a good cover of tundra and some grasses. It has permanent ice features such as polygons and patterned ground. The estimated flooding frequency is 10 to 25 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a gradational to definite physiographic break between this flood unit and unit 3. This unit has a well established cover of tundra. This unit strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons. The estimated flooding frequency is 50 to 100 years.

5 = high floodplain terrace, no flooding:
This unit is physiographically higher than flooding unit 4 and there is a definite physiographic break between non-flood unit 5 and unit 4.

Avalik River

The Avalik River is located on the Wainwright, Meade River and Lookout Ridge 1:250,000 quadrangle maps. The flooding units of the Avalik River are shown on Maps 4b and 4c. A total of 64.3 miles of the Avalik River active channel was mapped from the Kuk River to the 100 foot topographic contour (Appendix A). The Avalik River has a watershed area of 1,197.0 square miles (Table 3). It is an incised meandering stream that is slightly entrenched (Table 7). It has a gradient of 0.9 feet per mile (Table 2, Appendix C, Figures 49 and 51).

Spring breakup starts with water flowing over the ice. Localized flooding caused by ice jams is a minor to moderate flooding hazard on the Avalik River.

Map Flood Units, Avalik River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some groves of willows. This unit shows the effects of recent erosion and deposition by running water. Eolian sand dunes may be common in places. The estimated flooding frequency is 3 to 10 years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 10 to 25 years.

4 = rarely floods, very high magnitude - very low frequency flooding:
This flooding unit is physiographically the highest active floodplain. There is a gradational physiographic break between this flood unit and flood unit 3. This unit has a well established cover of tundra. Such features as patterned ground and high and low centered polygons characterize this unit. Contains vegetated eolian sand dunes. The estimated flooding frequency is 50 to 100 years.

5 = high floodplain terrace, no flooding:
This unit is physiographically higher than flooding unit 4 and there is a definite physiographic break between non-flood unit 5 and unit 4.

Kugrua River

The Kugrua River is one of four rivers of this investigation that has its watershed completely within the Teshekpuk section of the Arctic Coastal Plain province (Figure 3). The other three rivers are the Ongorakvik, Nokotlek and the Tunalik Rivers. All four of these rivers have a simple three stage flooding frequency (Table 4). The Kugrua River is located on the Wainwright and Meade River 1:250,000 USGS quadrangle maps. The flooding units of the Kugrua River are shown on Map 3. A total of 39.0 miles of the Kugrua River active channel was mapped from Kugrua Bay to the 75 foot topographic contour (Appendix A). The Kugrua River has a watershed area of 318.0 square miles (Table 3). It is a meandering incised stream with no delta (Table 7). It has a gradient of 1.9 feet per mile (Table 2, Appendix C, Figure 49). The localized flooding caused by ice jams is a minor flooding hazard on the Kugrua River.

Map Flood Units, Kugrua River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is three to seven years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2 and it is the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. The estimated flooding frequency is five to 50 years.

Ongorakvik River

The Ongorakvik River is the smallest river that was mapped in this investigation. It is located on the Wainwright 1:250,000 USGS quadrangle map. The flooding units of the Ongorakvik River are shown on Map 5. A total of 16.5 miles of the Ongorakvik River active channel was mapped from Kasegaluk Lagoon to the 50 foot topographic contour (Appendix A). The Onogorakvik River has a watershed area of 73.0 square miles (Table 3). It is a straight to slightly meandering stream (Table 7). It has the highest gradient of all the rivers mapped in this investigation of 6.1 feet per mile (Table 2, Appendix C, Figure 49).

Map Flood Units, Ongorakvik River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is three to seven years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2 and it is the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. The estimated flooding frequency is five to 50 years.

Nokotlek River

The Nokotlek River is located on the Wainwright 1:250,000 USGS quadrangle map. The flooding units of the Nokotlek River are shown on Map 5. A total of 18.0 miles of the Nokotlek River active channel was mapped from Kasegaluk Lagoon to the 50 foot topographic contour (Appendix A). The Nokotlek River has a watershed area of 105.0 square miles (Table 3). It is a straight to slightly meandering incised stream (Table 7). It has a gradient of 2.8 feet per mile (Table 2, Appendix C, Figure 49).

Map Flood Units, Nokotlek River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is three to seven years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2 and it is the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. The estimated flooding frequency is five to 50 years.

Tunalik River

The Tunalik River is located on the Wainwright 1:250,000 USGS quadrangle map. The flooding units of the Tunalik River are shown on Map 5. A total of 27.5 miles of the Tunalik River active channel was mapped from Avak Inlet to the 100 foot topographic contour (Appendix A). The Tunalik River has a watershed area of 145.0 square miles (Table 3). It is a straight to slightly meandering incised stream that is slightly entrenched (Table 7). It has a gradient of 3.6 feet per mile (Table 2, Appendix C, Figure 49).

Map Flood Units, Tunalik River

1 = low magnitude - high frequency flooding:
Physiographically the lowest active floodplain unit which is covered by water every year. This unit is the active channel which exhibits annual change and is bare of vegetation.

2 = intermediate magnitude - intermediate frequency flooding:
There is not a sharp physiographic break between flood units 1 and 2. Flood unit 2 is mainly covered with grasses with some low willows. This unit shows the effects of recent erosion and deposition by running water. The estimated flooding frequency is three to seven years.

3 = high magnitude - low frequency flooding:
This unit is physiographically higher than flood unit 2 and it is the highest active floodplain. There is a definite physiographic break between this flood unit and flood unit 2. This unit has a well established cover of tundra. It strongly exhibits the features of an ice-rich, permanently frozen material. Such features as patterned ground and high and low centered polygons characterize this unit. The estimated flooding frequency is five to 50 years.

Summary of Conclusions

This study supports the supposition that the rivers of Arctic Alaska are unique, and their features and behavior cannot be expected to reflect data from river studies in subarctic and temperate areas.

The flooding units mapped in this investigation are defined by physiographic features. These units represent the field evidence for certain flooding events. However it must be kept in mind that flooding which occurs at breakup may be the largest flooding event. But, flooding at breakup may have the least physical effect because the ground is mostly still frozen at that time.

The Arctic Coastal Plain that these rivers flow across is very flat. Thus, the rivers may be expected to respond to even a small local change in the earth's crust. The Chipp, Topagoruk and Meade Rivers appear to be responding to tectonic subsidence in the Dease Inlet/Admiralty Bay area. The active subsidence in this area may explain the existence of the large embayment of Dease Inlet/Admiralty Bay into the Arctic Coastal Plain.

The Arctic rivers of this investigation have a generally later spring breakup than the rivers of the previous two studies. This area where the river watersheds are restricted to the Arctic Coastal Plain and the northern section of the Arctic Foothills physiographic province is designated the Barrow River Basin.

A significant difference between the rivers of this study and the rivers of Floodplain Study number 1 is the lack of aufeis. Aufeis causes the temporary damming of a river, producing localized flooding. Though ice-block damming is a major flooding hazard along the Meade River, no aufeis occurred along the rivers of this investigation.

The process of talik lake breaching on the Chipp River is a major flooding hazard to permanent facilities built adjacent to the river.

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Williams, J.R., 1983b, Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle, U.S.G.S. Open-File Report 83-457.

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Appendix A. List of the Channel Miles of the 18 Rivers Mapped.

Ikpikpuk River; 268.3 miles of active channel from Smith Bay to Maybe Creek/Kigalik River junction, including distributary channels.

Meade River; 212.4 miles of active channel from Admiralty Bay to the 200 foot contour, including distributary channels.

Topagoruk River; 115.5 miles of active channel from Admiralty Bay to the 100 foot contour, including distributary channels.

Avalik River; 63.4 miles of active channel from the Kuk River to the 100 foot contour.

Chipp River; 62.0 miles of active channel from Admiralty Bay to the junction with the Ikpikpuk River.

Ketik River; 61.5 miles of active channel from the junction with the Avalik River to the 100 foot contour.

Ivisaruk River; 56.0 miles of active channel from Neakok Island (Kuk River) to the 100 foot contour.

Usuktuk River; 46.0 miles of active channel from the junction with the Meade River.

Kaolak River; 45.2 miles of active channel from the junction with the Avalik River to the 100 foot contour.

Alaktak River; 43.5 miles of active channel from Pittalukruak Lake to the junction with the Ikpikpuk River.

Kuk River; 42.5 miles of estuary and active channel from the Chukchi Sea to the Avalik River.

Oumalik River; 40.0 miles of active channel from the junction with the Chipp River to the 75 foot contour.

Kugrua River; 39.0 miles of active channel from Kugrua Bay to the 75 foot contour.

Tunalik River; 27.5 miles of active channel from Avak Inlet to the 100 foot contour.

Miguakiak River; 20.3 miles of active channel from Teshekpuk Lake to the junction with the Ikpikpuk River.

Nokotlek River; 18.0 miles of active channel from Kasegaluk Lagoon to the 50 foot contour.

Ongorakvik River; 16.5 miles of active channel from Kasegaluk Lagoon to the 100 foot contour.

Piasuk River; 13.0 miles of flood unit 1 from Smith Bay.

Grand total = 1,190.6 miles of active and active distributary channels mapped.

Appendix B: Sources of Mapping Data

Map 1a: Flood Hazard Potential of the Ikpikpuk, Chipp, Alaktak, Miguakiak, Piasuk and Topagoruk Rivers.

Maps

USGS 1:250,000 Topographic Map: Teshekpuk Quadrangle
USGS 1:63,360 Topographic Maps: Teshekpuk: C-2, C-3, C-4, C-5, D-2, D-3, D-4, D-5

Carter, L. David (1983) Engineering-Geologic Maps of Northern Alaska, Teshekpuk Quadrangle. USGS Open File Report 83-634.

Williams, John R. and Others (1977) Preliminary Surficial Deposits Map of NPR-A. USGS Open File Report 77-868.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Ikpikpuk, Chipp, Alaktak, Miguakiak and Piasuk Rivers

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 30, 31, 32, 33, 34, 35, 36, 37, 38.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3101, 3102, 3106, 3107, 3137, 3138, 3139, 3140, 3141, 3142, 3143, 3144, 3145, 3146, 3200, 3201, 3202, 3203, 3204, 3205, 3206, 3207, 3273, 3274, 3275, 3276, 3277, 3278.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 15, Frame Numbers: 74, 75, 76.
Roll 16, Frame Numbers: 126, 127, 128.
Roll 22, Frame Numbers: 30, 31, 32, 99, 100.
Roll 23, Frame Numbers: 8, 9, 10, 11, 12, 12, 32, 33, 153, 154, 155, 156, 163, 164, 165.
Roll 26, Frame Numbers: 28, 29, 30.

USGS Black & White Aerial Photography, August 1955
Mission 57, Roll 106, Frame Numbers: 13733, 13734.

2) Topagoruk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 38, 39, 40.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3145, 3146, 3147, 3198, 3199, 3200, 3280, 3281, 3282.

Appendix B: Sources of Mapping Data

Landsat Satellite Imagery Used for Map 1a

Date	Image Number	MSS Band
07/12/77	2902-21175	5
02/25/79	21495-21231	7
03/07/79	30367-21404	7
05/02/79	30423-21520	7
06/05/79	30457-21401	7
05/16/81	22306-21372	7
05/29/83	40317-21422	4
05/16/84	50076-21342	7
06/01/84	50092-21344	7
06/08/84	50099-21410	7
06/08/84	50099-21410	5
06/10/84	50101-21284	5
06/17/84	50108-21350	7
06/17/84	50108-21350	5
07/01/84	50122-21473	7
07/01/84	50122-21473	5

Map 1b: Flood Hazard Potential of the Ikpikpuk, Chipp, Oumalik and Topagoruk Rivers.

Maps

USGS 1:250,000 Topographic Map: Teshekpuk Quadrangle
USGS 1:250,000 Topographic Map: Meade River Quadrangle
USGS 1:63,360 Topographic Maps: Teshekpuk: A-2, A-3, A-4, A-5, B-2, B-3, B-4, B-5; Meade River: A-1, B-1

Carter, L. David (1983) Engineering-Geologic Maps of Northern Alaska, Teshekpuk Quadrangle. USGS Open File Report 83-634.

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Meade River Quadrangle. USGS Open File Report 83-294.

Williams, John R. and Others (1977) Preliminary Surficial Deposits Map of NPR-A. USGS Open File Report 77-868.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Ikpikpuk and Chipp Rivers

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 305, 306, 307, 308, 309.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3273, 3274, 3275, 3276, 3277, 3278.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9605, 9606, 9607, 9686, 9687, 9688, 9689, 9728, 9729, 9730, 9731, 9843, 9844, 9845.

Map 1b: continued

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 8, Frame Numbers: 175, 176, 177, 178, 179, 180, 181.
Roll 9, Frame Numbers: 7, 8, 9, 39, 40, 41, 42, 43, 52, 53, 54, 55, 56, 57.
Roll 17, Frame Numbers: 10, 11, 12, 13, 14, 15, 43, 44, 45.
Roll 26, Frame Numbers: 130, 131, 132, 133, 134, 135, 136, 137, 138.
Roll 29, Frame Numbers: 123, 124, 125, 144, 145, 146, 147, 198, 199, 200, 201.
Roll 31, Frame Numbers: 14, 15.
Roll 120, Frame Numbers: 67, 68, 69, 70, 82, 83, 84, 85, 86, 145, 146, 147, 148, 190, 191, 192, 193, 211, 212, 213.

2) Oumalik River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 305, 306

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9610, 9611, 9726, 9727, 9845, 9846.

3) Topagoruk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 300, 301.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3280, 3281, 3282, 3339, 3340.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, August 1982
Roll 3101, Frame Numbers: 9614, 9615, 9695, 9696, 9697, 9721, 9722, 9723.

Landsat Satellite Imagery Used for Map 1b

Date	**Image Number**	**MSS Band**
07/12/77	2902-21175	5
02/25/79	21495-21231	7
03/07/79	30367-21404	7
06/05/79	30457-21401	7
05/16/79	22306-21372	7
05/29/83	40317-21422	4
05/16/84	50076-21342	7
06/08/84	50099-21410	7
06/08/84	50099-21410	5
06/17/84	50108-21350	7
06/17/84	50108-21350	5
07/01/84	50122-21473	7
07/01/84	50122-21473	5

Map 1c: Flood Hazard Potential of the Ikpikpuk River

Maps

USGS 1:250,000 Topographic Map: Ikpikpuk River Quadrangle
USGS 1:50,000 Advance Proof Topographic Maps: Ikpikpuk River: C-3, C-4, D-3, D-4

Map 1c: continued

Williams, John R. and Others (1977) Preliminary Surficial Deposits Map of NPR-A. USGS Open File Report 77-868.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

NASA Color Infrared Aerial Photography: Alaska 60 CIR, August 1980
Roll 2925, Frame Numbers: 8304, 8305.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9659, 9660, 9686, 9687, 9688, 9689.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, August 1982
Roll 3114, Frame Numbers: 986, 987, 988.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 14, Frame Numbers: 14, 15, 16, 17, 18, 96, 97, 98, 154, 155, 156.
Roll 87, Frame Numbers: 139, 140, 141, 142, 143.

Landsat Satellite Imagery

Date	Image Number	MSS Band
07/12/77	2902-21175	5
02/25/79	21495-21231	7
03/07/79	30367-21404	7
06/05/79	30457-21401	7
05/16/81	22306-21372	7
05/29/83	40317-21424	4
06/10/84	50101-21290	7
06/17/84	50108-21352	7
06/17/84	50108-21352	5

Map 1d: Flood Hazard Potential of the Ikpikpuk River.

Maps

USGS 1:250,000 Ikpikpuk River Quadrangle
USGS 1:50,000 Advance Proof Topographic Maps: Ikpikpuk River: B-3, B-4, C-3, C-4

Williams, John R. and Others (1977) Preliminary Surficial Deposits Map of NPR-A. USGS Open File Report 77-868.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

NASA Color Infrared Aerial Photography: NASA/JSC 364, August 1977
Roll 25, Frame Numbers: 166, 167, 168, 224, 225.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2786, Frame Numbers: 2176, 2177, 2236, 2237, 2238.

Appendix B: Sources of Mapping Data

Landsat Satellite Imagery

Date	Image Number	MSS Band
06/11/76	2506-21340	7
07/12/77	2902-21175	5
05/16/81	22306-21372	7
06/10/84	50101-21290	7
06/17/84	50108-21352	7
06/17/84	50108-21352	5

Map 2a: Flood Hazard Potential of the Meade and Usuktuk Rivers.

Maps

USGS 1:250,000 Topographic Map: Meade River Quadrangle
USGS 1:250,000 Topographic Map: Teshekpuk Quadrangle
USGS 1:63,360 Topographic Maps: Meade River: C-1, C-2, C-3, D-1, D-2, D-3
Teshekpuk: C-5, D-5

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Meade River Quadrangle. USGS Open File Report 83-294.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Meade River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 46, 47, 48, 49, 50, 51.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3096, 3097, 3098, 3099, 3100, 3147, 4148, 3149, 3150, 3151, 3192, 3193, 3194, 3195, 3290, 3291, 3292.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 22, Frame Numbers: 52, 53, 54, 77, 78, 79.
Roll 23, Frame Numbers: 91, 92, 93, 94, 95.
Roll 147, Frame Numbers: 11, 12, 13, 44, 45, 46.
Roll 175, Frame Numbers: 85, 86, 87, 114, 115, 116, 117.
Roll 181, Frame Numbers: 124, 125, 126, 127, 128, 129.
Roll 197, Frame Numbers: 112, 113, 114, 154, 155, 156, 157.
Roll 300, Frame Numbers: 194, 195, 196.
Roll 302, Frame Numbers: 154, 155, 156, 157.

2) Usuktuk River

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3289, 3290, 3291, 3192.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 147, Frame Numbers: 11, 12.

Appendix B: Sources of Mapping Data

Landsat Satellite Imagery Used for Map 2a

Date	Image Number	MSS Band
06/13/76	2508-21450	7
06/13/76	2508-21450	5
07/12/77	2902-21175	5
07/14/77	2904-21291	5
03/07/79	30367-21404	7
05/02/79	30423-21502	7
06/05/79	30457-21401	7
05/16/81	22306-21372	7
05/29/83	40317-21422	4
05/16/84	50076-21342	7
06/01/84	50092-21344	7
06/08/84	50092-21410	7
06/08/84	50092-21410	5
06/15/84	50406-21472	7
06/17/84	50108-21350	7
06/17/84	50108-21350	5
07/01/84	50122-21473	7
07/01/84	50122-21473	5

Map 2b: Flood Hazard Potential of the Meade and Usuktuk Rivers

Maps

USGS 1:250,000 Topographic Map: Meade River Quadrangle
USGS 1:63,360 Topographic Maps: Meade River: A-2, A-3, B-2, B-3

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Meade River Quadrangle. USGS Open File Report 83-294.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Meade River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 212, 213, 298, 290, 291.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3290, 3291, 3292, 3331, 3332, 3333.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9620, 9621, 9622, 9714, 9715, 9716.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 147, Frame Numbers: 67, 68, 69, 103, 104, 105, 106, 120, 121, 122, 123, 124, 183, 184, 185.
Roll 148, Frame Numbers: 52, 53, 54, 55, 66, 67, 68, 69, 71, 72, 73.
Roll 244, Frame Numbers: 117, 118, 119, 120.
Roll 269, Frame Numbers: 6, 7, 8, 54, 55, 56.

Remote Sensing Data continued

2) Usuktuk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 46, 47, 48, 49, 50, 51, 289, 290, 291, 292.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3289, 3290, 3291, 3292, 3332, 3333, 3334.

Landsat Satellite Imagery Used for Map 2b

Date	Image Number	MSS Band
06/11/76	2506-21340	7
06/13/76	2508-21450	7
06/13/76	2508-21450	5
07/12/77	2902-21175	5
07/14/77	2904-21291	5
03/07/79	30367-21404	7
05/02/79	30423-21520	7
06/05/79	30457-21401	7
05/16/81	22306-21372	7
05/29/83	40317-21422	4
05/29/83	40317-21424	4
05/16/84	50076-21342	7
06/08/84	50099-21410	7
06/08/84	50099-21410	5
06/17/84	50108-21352	7
06/17/84	50108-21352	5
07/01/84	50122-21472	7
07/01/84	50122-21472	5

Map 2c: Flood Hazard Potential of the Meade River

Maps

USGS 1:250,000 Topographic Map: Lookout Ridge Quadrangle
USGS 1:63,360 Advance Proof Topographic Maps: Lookout Ridge: C-2, C-3
USGS 1:50,000 Advance Proof Topographic Maps: Lookout Ridge: D-2, D-3

Yeend, Warren (1983) Engineering-Geologic Maps of Northern Alaska, Lookout Ridge Quadrangle. USGS Open File Report 83-279.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

NASA Color Infrared Aerial Photography: NASA/JSC 264, July 1977
Roll 23, Frame Numbers: 212, 213.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9643, 9644, 9645.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, August 1982
Roll 3114, Frame Numbers: 923, 924, 925, 972, 973.

Landsat Satellite Imagery

Date	Image Number	MSS Band
06/11/76	2506-21340	7
05/02/79	30423-21520	7
05/29/83	40317-21424	4
06/17/84	50108-21352	7
06/17/84	50108-21352	5

Map 3: Flood Hazard Potential of the Kugrua River

Maps

USGS 1:250,000 Topographic Map: Wainwright Quadrangle
USGS 1:250,000 Topographic Map: Meade River Quadrangle
USGS 1:63,360 Topographic Maps: Wainwright: C-1, D-1
Meade River: B-5, C-5, D-5

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Meade River Quadrangle. USGS Open File Report 83-294.

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 58, 59, 60, 61.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3166, 3167, 3177, 3178, 3179, 3298, 3299.

U.S. Navy Black & White Aerial Photography: BAR, July 1949
Roll 171, Frame Numbers 1, 2, 3, 4, 5, 6, 7.

Landsat Satellite Imagery

Date	Image Number	MSS Band
06/13/76	2508-21450	7
06/13/76	2508-21450	5
07/14/77	2904-21291	5
05/02/79	30423-21520	7
07/01/84	50122-21473	7
07/01/84	50122-21473	5

Map 4a: Flood Hazard Potential of the Kuk and Ivisaruk Rivers

Maps

USGS 1:250,000 Topographic Map: Wainwright Quadrangle
USGS 1:63,360 Topographic Maps: Wainwright: B-1, B-2, B-3, C-1, C-2, C-3

Map 4a: continued

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Kuk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 76, 77, 269, 270, 271, 272.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1979
Roll 2790, Frame Numbers: 3305, 3306, 3307.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, August 1982
Roll 3088, Frame Numbers: 8649, 8650, 8651.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 168, Frame Numbers: 201, 202.
Roll 330, Frame Numbers: 53, 54, 55.

2) Ivisaruk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 78, 79, 80, 81.

Landsat Satellite Imagery

Date	Image Number	MSS Band
06/13/76	2508-21450	7
06/13/76	2508-21450	5
07/14/77	2904-21291	5
05/02/79	30423-21520	7
07/01/84	50122-21473	7
07/01/84	50122-21473	5

Map 4b: Flood Hazard Potential of the Kuk, Ivisaruk and Kaolak Rivers.

Maps

USGS 1:250,000 Topographic Map: Wainwright Quadrangle
USGS 1:250,000 Topographic Map: Utukok River Quadrangle
USGS 1:63,360 Topographic Maps: Wainwright: A-2, A-3
Utukok River: D-3
USGS 1:50,000 Advance Proof Topographic Map: Utukok: D-2

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Appendix B: Sources of Mapping Data

Remote Sensing Data

1) Kuk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 76, 77, 114, 115, 116.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 315, Frame Numbers: 124, 125.

2) Ivisaruk River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 78, 79, 80, 81, 110, 111, 112, 113, 155, 156, 157, 158, 187, 188.

3) Kaolak River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 115, 116, 117, 152, 153, 154, 190, 191, 192, 193, 194, 236, 237, 238.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 315, Frame Numbers: 124, 125.

Landsat Satellite Imagery Used for Map 4b

Date	Image Number	MSS Band
07/14/77	2904-21291	5
05/02/79	30423-21520	7
05/28/84	50088-21594	7

Map 4c: Flood Hazard Potential of the Avalik and Ketik Rivers

Maps

USGS 1:250,000 Topographic Map: Wainwright Quadrangle
USGS 1:250,000 Topographic Map: Meade River Quadrangle
USGS 1:250,000 Topographic Map: Utukok River Quadrangle
USGS 1:250,000 Topographic Map: Lookout Ridge Quadrangle
USGS 1:63,360 Topographic Maps: Wainwright: A-1, A-2
Meade River: A-4, A-5
USGS 1:50,000 Advance Proof Topographic Maps: Utukok River: D-1, D-2
Lookout Ridge: D-4, D-5

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Meade River Quadrangle. USGS Open File Report 83-294.

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Avalik River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 115, 116, 117, 118, 144, 145, 146, 147, 148, 201, 202, 203, 204, 205, 206.

NASA Color Infrared Aerial Photography: Alaska 60 CIR, July 1982
Roll 3101, Frame Numbers: 9637, 9638, 9639.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 315, Frame Numbers: 124, 125, 126, 127.

2) Ketik River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 115, 116, 117, 149, 150, 151, 195, 196, 232, 233.

NASA Color Infrared Aerial Photography: NASA/JSC 264, August 1977
Roll 25, Frame Numbers: 251, 252, 253, 291, 292, 293.

U.S. Navy Black & White Aerial Photography: BAR, 1948-1949
Roll 315, Frame Numbers: 125, 126, 127.

Landsat Satellite Imagery Used for Map 1c

Date	Image Number	MSS Band
07/14/77	2904-21291	5
05/02/79	30423-21520	7
05/29/83	40317-21424	4

Map 4d: Flood Hazard Potential of the Ketik River

Maps

USGS 1:250,000 Topographic Map: Utukok River Quadrangle
USGS 1:63,360 Topographic Maps: Utukok River: C-1
USGS 1:50,000 Advance Proof Topographic Maps: Utukok River: C-2, D-1, D-2

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Williams, John R. and Others (1977) Preliminary Surficial Deposits Map of NPR-A. USGS Open File Report 77-868.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 232, 233.

NASA Color Infrared Aerial Photography: NASA/JSC 364, August 1977
Roll 25, Frame Numbers: 251, 252, 253, 291, 292, 293.

Appendix B: Sources of Mapping Data

Landsat Satellite Imagery

Date	Image Number	MSS Band
04/28/84	50088-21594	7

Map 5: Flood Hazard Potential of the Tunalik, Ongorakvik and Nokotlek Rivers

Maps

USGS 1:250,000 Topographic Map: Wainwright Quadrangle
USGS 1:63,360 Topographic Maps: Wainwright: A-3, A-4, A-5, B-3, B-4, B-5, B-6

Williams, John R. (1983) Engineering-Geologic Maps of Northern Alaska, Wainwright Quadrangle. USGS Open File Report 83-457.

Beikman, H.M. and Lathram, E.H. (1976) Preliminary Geologic Map of Northern Alaska. USGS Miscellaneous Field Studies Map MF-789.

Remote Sensing Data

1) Tunalik River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 90, 91, 101, 102, 103, 104, 105.

U.S. Navy Black & White Aerial Photography: BAR, August 1948
Roll 36, Frame Numbers: 155, 156, 157.
Roll 37, Frame Numbers: 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125.

2) Ongorakvik River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 84, 85, 86, 106, 107, 263, 264.

U.S. Navy Black & White Aerial Photography: BAR, August 1948, July 1949
Roll 36, Frame Numbers: 15, 16, 17, 64, 65, 93, 94.
Roll 335, Frame Numbers: 30, 31, 32.

3) Nokotlek River

NASA Color Infrared Aerial Photography: NASA/JSC 364, July 1977
Roll 23, Frame Numbers: 83, 84, 85, 107, 108, 109, 263, 264.

U.S. Navy Black & White Aerial Photography: BAR, August 1948, July 1949
Roll 36, Frame Numbers: 18, 19, 59, 60, 99, 100.
Roll 335, Frame Numbers: 27, 28, 29.

Landsat Satellite Imagery Used for Map 5

Date	Image Number	MSS Band
06/13/76	2508/21450	7
06/13/76	2508-21450	5
07/14/77	2904-21291	5
05/02/79	30423-21520	7

Appendix C. River Channel Profile Data

Ikpikpuk River channel profile data from Smith Bay

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
25.0	10.0	0.4
36.0	25.0	1.4
42.5	50.0	3.9
48.0	57.0	1.3
85.4	65.6	0.2
98.0	98.4	2.6
105.5	131.2	4.4
151.3	164.0	0.7
156.0	180.4	3.5
162.7	196.8	2.5
181.3	213.3	0.9

Average channel gradient is 1.2 ft./mi.
Data from USGS topographic maps; see appendix B.

Meade River channel profile data from Admiralty Bay

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
60.5	25.0	0.4
99.2	65.6	1.0
111.0	98.4	2.8
119.3	131.2	4.0
145.9	164.0	1.2
150.4	200.0	8.0

Average channel gradient is 1.3 ft./mi.
Data from USGS topographic maps; see appendix B.

Usuktuk River channel profile data from the junction with the Meade River

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
97.0	50.0	0.26

Average channel gradient is 0.26 ft./mi.
Data from USGS topographic maps; see appendix B.

Appendix C. River Channel Profile Data

Alaktak River channel profile data from Pittalukruak Lake

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
34.5	10.0	0.3
43.5	25.0	1.7

Average channel gradient is 0.6 ft./mi.
Data from USGS topographic maps; see appendix B.

Chipp/Oumalik River channel profile data from Admiralty Bay

	Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
Chipp R.	11.0	10.0	0.9
	35.0	25.0	0.6
	50.0	50.0	1.7
	62.0	57.0	0.6
Oumalik R.	102.0	75.0	0.5

Average channel gradient of the Chipp River is 0.9 ft./mi.
Average channel gradient of the Oumalik River is 0.5 ft./mi.
Data from USGS topographic maps; see appendix B.

Kuk/Avalik River channel profile data from the Chukchi Sea

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
53.0	25.0	0.5
74.6	32.8	0.4
79.7	49.2	3.2
85.2	65.6	3.0
104.9	98.4	1.7

Average channel gradient is 0.9 ft./mi.
Data from USGS topographic maps; see appendix B.

Appendix C. River Channel Profile Data

Topagoruk River channel profile data from Admiralty Bay

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
20.0	12.0	0.6
33.5	25.0	1.0
51.5	50.0	1.4
54.0	75.0	10.0
101.5	100.0	0.5

Average channel gradient is 1.0 ft./mi.
Data from USGS topographic maps; see appendix B.

Ketik River channel profile data from the junction with the Avalik River

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
13.5	32.8	2.4
25.3	49.2	1.4
41.5	65.6	1.0
60.8	98.4	1.7

Average channel gradient is 1.6 ft./mi.
Data from USGS topographic maps; see appendix B.

Ivisaruk River channel profile data from the junction with the Kuk River

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
46.5	25.0	0.5
51.0	50.0	5.6
56.0	100.0	10.0

Average channel gradient is 1.8 ft./mi.
Data from USGS topographic maps; see appendix B.

Kugrua River channel profile data from Kugrua Bay

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
18.5	25.0	1.4
24.0	50.0	4.5
39.0	75.0	1.7

Average channel gradient is 1.9 ft./mi.
Data from USGS topographic maps; see appendix B.

Appendix C. River Channel Profile Data

Kaolak River channel profile data from the junction with the Avalik River

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
13.5	49.2	3.6
26.1	65.6	1.3
43.7	98.4	0.9

Average channel gradient is 2.3 ft./mi.
Data from USGS topographic maps; see appendix B.

Nokotlek River channel profile data from Kasegaluk Lagoon

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
10.5	25.0	2.4
18.0	50.0	3.3

Average channel gradient is 2.8 ft./mi.
Data from USGS topographic maps; see appendix B.

Tunalik River channel profile data from Avak Inlet

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
6.0	25.0	4.2
7.5	50.0	16.7
22.5	75.0	1.7
27.5	100.0	5.0

Average channel gradient is 3.6 ft./mi.
Data from USGS topographic maps; see appendix B.

Ongorakvik River channel profile data from Kasegaluk Lagoon

Channel Length Measured (miles)	Elevation of Channel (feet)	Gradient (feet per mile)
11.5	25.0	2.2
13.0	50.0	16.7
15.0	75.0	12.5
16.5	100.0	16.7

Average channel gradient is 6.1 ft./mi.
Data from USGS topographic maps; see appendix B.

Appendix D. Active Channel Material Samples

Map 1c, Ikpikpuk Active Channel Material Sample (A.C.M.S.) No. 1

A representative material sample taken from an active channel bar.
Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1″	25.4 mm	98.7
½″	12.7 mm	85.0
4	4.75 mm	49.2
10	2.0 mm	49.2
40	0.425 mm	8.9
200	0.075 mm	1.3

Map 1c, Ikpikpuk Active Channel Material Sample (A.C.M.S.) No. 2

A representative material sample taken from an active channel bar.
Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1″	25.4 mm	100.0
½″	12.7 mm	98.0
4	4.75 mm	72.0
10	2.0 mm	37.5
40	0.425 mm	13.3
200	0.075 mm	0.3

Note: The channel material downstream of the junctions of the Ikpikpuk, Price and Titaluk Rivers is fine to medium sand.

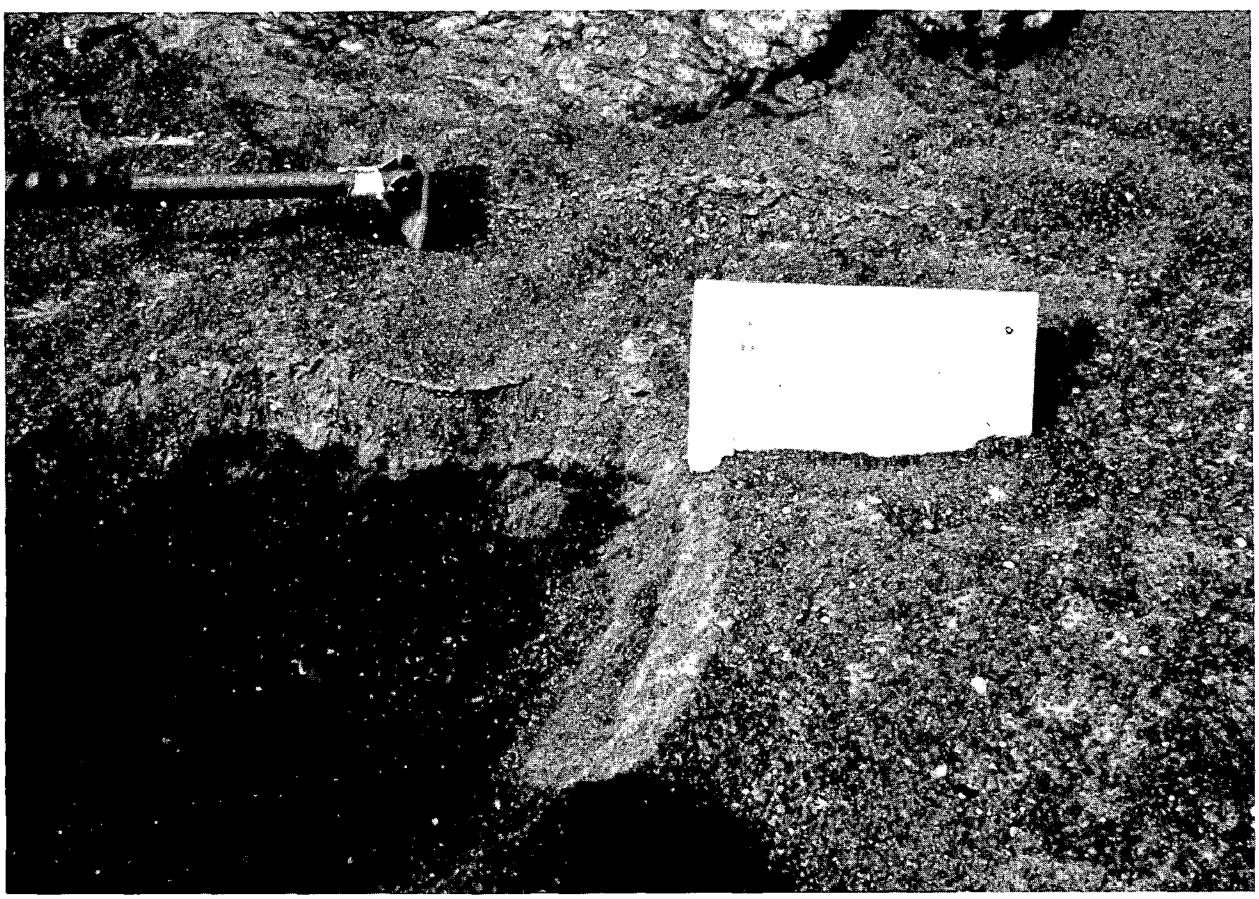

Figure D-1.
Ikpikpuk Active Channel Material Sample site (A.C.M.S.) No. 1 (Map 1c). A representative material sample taken from an active channel bar. The scale bar is in inches and centimeters.

Figure D-2.
Ikpikpuk Active Channel Material Sample site (A.C.M.S.) No. 2 (Map 1c). A representative material sample taken from an active channel bar. The scale bar is in inches and centimeters.

Appendix D. Active Channel Material Samples

Map 1b, Topagoruk Active Channel Material Sample (A.C.M.S.) No. 1

A representative material sample taken from an active channel bar.
Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1"	25.4 mm	100.0
½"	12.7 mm	100.0
4	4.75 mm	100.0
10	2.0 mm	100.0
40	0.425 mm	99.2
200	0.075 mm	5.3

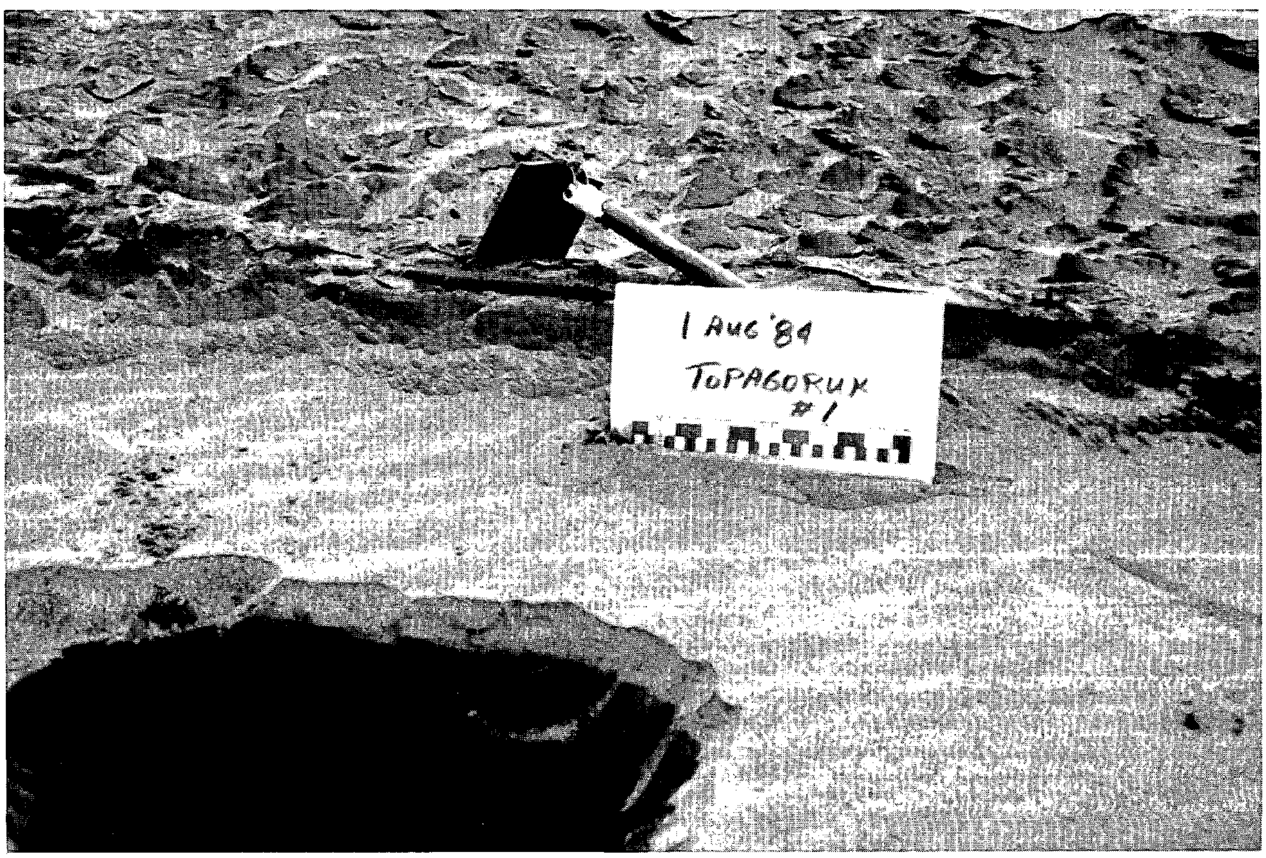

Figure D-3.
Topagoruk Active Channel Material Sample site (A.C.M.S.) No. 1 (Map 1b). A representative material sample taken from an active channel bar. The scale bar is in inches and centimeters.

Map 2b, Meade Active Channel Material Sample (A.C.M.S.) No. 1

A representative material sample taken from an active channel bar.
Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1″	25.4 mm	100.0
½″	12.7 mm	97.3
4	4.75 mm	82.2
10	2.0 mm	47.3
40	0.425 mm	7.7
200	0.075 mm	0.6

Map 2b, Meade Active Channel Material Sample (A.C.M.S.) No. 2

No sample was taken at this site. Material is fine to medium sand with small pebble sized pieces of coal.

Figure D-4.
Meade Active Channel Material Sample site (A.C.M.S.) No. 1 (Map 2b). A representative material sample taken from an active channel bar. The scale bar is in inches and centimeters.

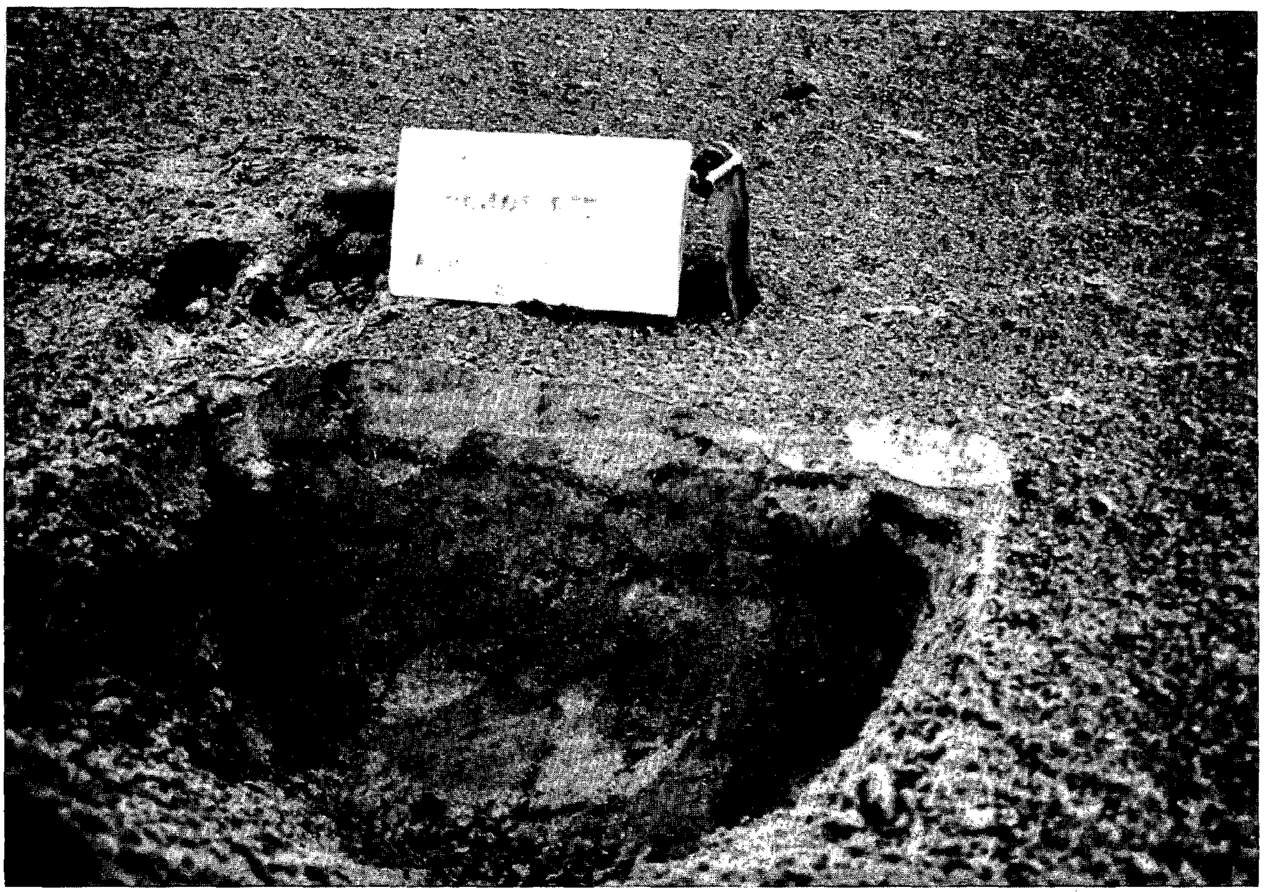

Figure D-5.
Meade Active Channel Material Sample site (A.C.M.S.) No. 2 (Map 2b). No sample was taken at this site. The river's bed load material is fine to medium sand with small pebble sized pieces of coal. The scale bar is in inches and centimeters.

Map 4b, Ivisaruk Active Channel Material Sample (A.C.M.S.) No. 1

A representative material sample taken from an active channel bar.
Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1"	25.4 mm	98.1
4	4.75 mm	60.2
10	2.0 mm	42.1
40	0.425 mm	34.5
200	0.075 mm	2.5

Figure D-6.
Ivisaruk Active Channel Material Sample site (A.C.M.S.) No. 1 (Map 4b). A representative material sample taken from an active channel bar. The scale bar is in inches and centimeters.

Appendix D. Active Channel Material Samples

Map 5, Material Site (M.S.) No. 1

A representative sample taken from an Mb_1 deposit related to a Pelukian shoreline adjacent to the channel of the Ongorakvik River.

Gradation Test (AASHTO T87-70 and T88-70)

Sieve Mesh No.	Sieve Aperture	% Passing
1"	25.4 mm	98.1
4	4.75 mm	60.2
10	2.0 mm	42.1
40	0.425 mm	34.5
200	0.075 mm	2.5

Note: Fines are available at this site from a 2 ft. thick layer of silt and organic matter (roots) that overlie the deposit.

Figure D-7.
Material Site (M.S.) No. 1 (Map 5). A representative sample taken from an Mb_1 deposit related to a Pelukian shoreline adjacent to the channel of the Ongorakvik River. The scale bar is in inches and centimeters. See also Figure D-8.

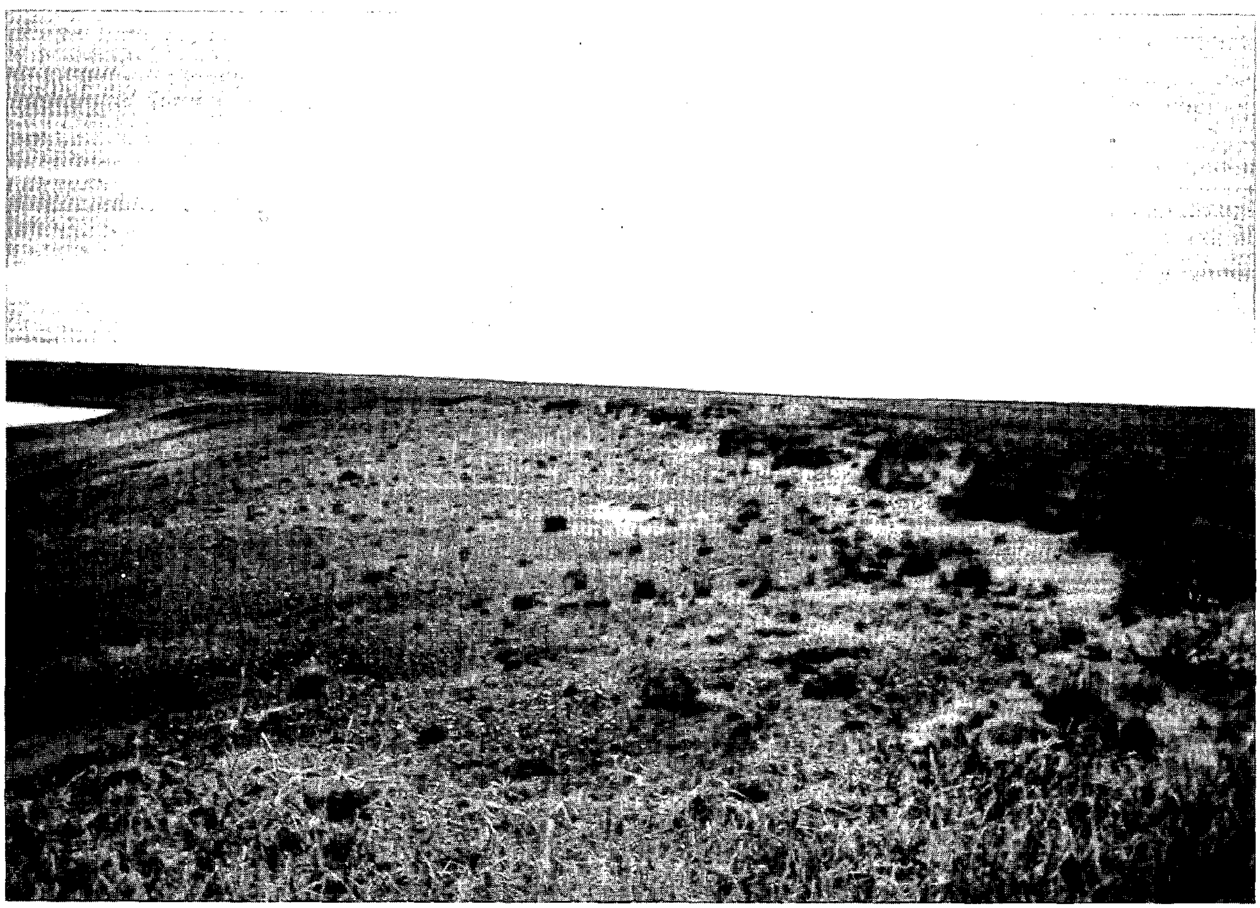

Figure D-8.
Looking south along the Mb_1 deposit of Material Site (M.S.) No. 1 (Map 5). Notice the two foot thick layer of silt and organic matter (right middle ground) that overlies the sand and gravel of the deposit (center).

Appendix E. List of Map Units

Map 1a: Flood Hazard Potential of the Ikpikpuk, Chipp, Alaktak, Migualkiak, Piasuk and Topagoruk Rivers.

Potential Flood Hazard Units

1	Low magnitude-high frequency flooding. Includes talik lakes connected to active river channels.
2	Intermediate magnitude-intermediate frequency flooding.
3	High magnitude-low frequency flooding.
4	Rarely floods. Very high magnitude-very low frequency flooding. May contain areas that do not flood.
5	No flooding.
6	High floodplain terrace or eolian dune on the floodplain; no flooding.
Fd	Fluvial delta deposits, subject to ocean storm surge flooding.

Terrain Units

L	Talik lake.
Lt	Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Es	Eolian sand; non-flood unit.
Mc	Marine sand; non-flood unit.
Mf	Marine silt and clay; non-flood unit.
F	Fluvial deposits; non-flood unit.
Fd	Fluvial delta deposits, subject to ocean storm surge flooding.

Map 1b: Flood Hazard Potential of the Ikpikpuk, Chipp, Oumalik and Topagoruk Rivers.

Potential Flood Hazard Units

1	Low magnitude-high frequency flooding.
2	Intermediate magnitude-intermediate frequency flooding.
3	High magnitude-low frequency flooding.
4	Rarely floods. Very high magnitude-very low frequency flooding.
5	No flooding.
6	High floodplain terrace or eolian dune on the floodplain; no flooding.
7	Very high floodplain terrace, no flooding.
Fpm	Undifferentiated floodplain of meandering river. Contains both flooding and non-flooding areas.

Appendix E. List of Map Units

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Es Eolian sand; non-flood unit.
Elx Upland silt; non-flood unit.
Fpm Meander floodplain.

Map 1c: Flood Hazard Potential of the Ikpikpuk River.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.
5 No flooding.
6 High floodplain terrace, no flooding.
7 Very high floodplain terrace, no flooding.
Fpm Undifferentiated floodplain of meandering river. Contains both flooding and non-flooding areas.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Es Eolian sand; non-flood unit.
Elx Upland silt; non-flood unit.
Fsa Sandy retransported deposits; non-flood unit.
Fpm Meander floodplain.

Map 1d: Flood Hazard Potential of the Ikpikpuk River.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.

Map 1d: continued

6 High floodplain terrace, no flooding.
7 Very high floodplain terrace, no flooding.
Fpm Undifferentiated floodplain of meandering river. Contains both flooding and non-flooding areas.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Elx Upland silt; non-flood unit.
Fsa Sandy retransported deposits; non-flood unit.
Fpm Meander floodplain.
Bx Undiferentiated bedrock.

Map 2a: Flood Hazard Potential of the Meade and Usuktuk Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.
5 No flooding.
6 High floodplain terrace or eolian dune on the floodplain; no flooding.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Es Eolian sand; non-flood unit.
Mc Marine sand; non-flood unit.

Maps 2b and 2c: Flood Hazard Potential of the Meade and Usuktuk Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.

Maps 2b and 2c: continued

3 High magnitude-low frequency flooding.

4 Rarely floods. Very high magnitude-very low frequency flooding.

5 No flooding.

6 High floodplain terrace or eolian dune on the floodplain; no flooding.

Fpm Undifferentiated floodplain of meandering river. Contains both flooding and non-flooding areas.

Terrain Units

L Talik lake.

Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.

Es Eolian sand; non-flood unit.

Elx Upland silt; non-flood unit.

Fpm Meander floodplain.

Kn Bedrock.

Map 3: Flood Hazard Potential of the Kugrua River.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.

2 Intermediate magnitude-intermediate frequency flooding.

3 High magnitude-low frequency flooding.

Terrain Units

L Talik lake.

Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.

Mc Marine sand; non-flood unit.

Mb Marine beach, bar and spit deposits; subject to ocean storm surge flooding.

Mb_1 Pelukian shoreline marine beach, offshore bar and barrier island deposits; non-flood units.

Map 4a: Flood Hazard Potential of the Kuk and Ivisaruk Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding. Includes talik lakes connected to active river channels.

Map 4a: continued

2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Very high magnitude-very low frequency flooding.
5 High floodplain terrace, no flooding.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Mc Marine sand; non-flood unit.
Mb Marine beach, bar and spit deposits; subject to ocean storm surge flooding.
Mb_1 Pelukian shoreline marine beach, offshore bar and barrier island deposits; non-flood unit.

Map 4b: Flood Hazard Potential of the Kuk, Ivisaruk and Kaolak Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.
5 High floodplain terrace, no flooding.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Mc Marine sand; non-flood unit.
Elx Upland silt; non-flood unit.
Kn Bedrock.

Map 4c: Flood Hazard Potential of the Avalik and Ketik Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.

Map 4c: continued

3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.
5 High floodplain terrace, no flooding.

Terrain Units

L Talik lake.
Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Mc Marine sand; non-flood unit.
Elx Upland silt; non-flood unit.
Kn Bedrock.

Map 4d: Flood Hazard Potential of the Ketik River.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.
4 Rarely floods. Very high magnitude-very low frequency flooding.
5 High floodpalin terrace, no flooding.

Terrain Units

Lt Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Elx Upland silt; non-flood unit.
Kn Bedrock.

Map 5: Flood Hazard Potential of the Tunalik, Ongorakvik and Nokotlek Rivers.

Potential Flood Hazard Units

1 Low magnitude-high frequency flooding.
2 Intermediate magnitude-intermediate frequency flooding.
3 High magnitude-low frequency flooding.

Appendix E. List of Map Units

Terrain Units

L	Talik lake.
Lt	Thaw-lake (talik) and thaw-lake deposits; non-flood unit.
Mc	Marine sand; non-flood unit.
Elx	Upland silt; non-flood unit.
Mb	Marine beach, bar and spit deposits; subject to ocean storm surge flooding.
Mb_1	Pelukian shoreline marine beach, offshore bar and barrier island deposits; non-flood unit.
Mb_2	Pre-Illinoian or Kotzebuan shoreline marine beach, offshore bar and barrier island deposits; non-flood unit.