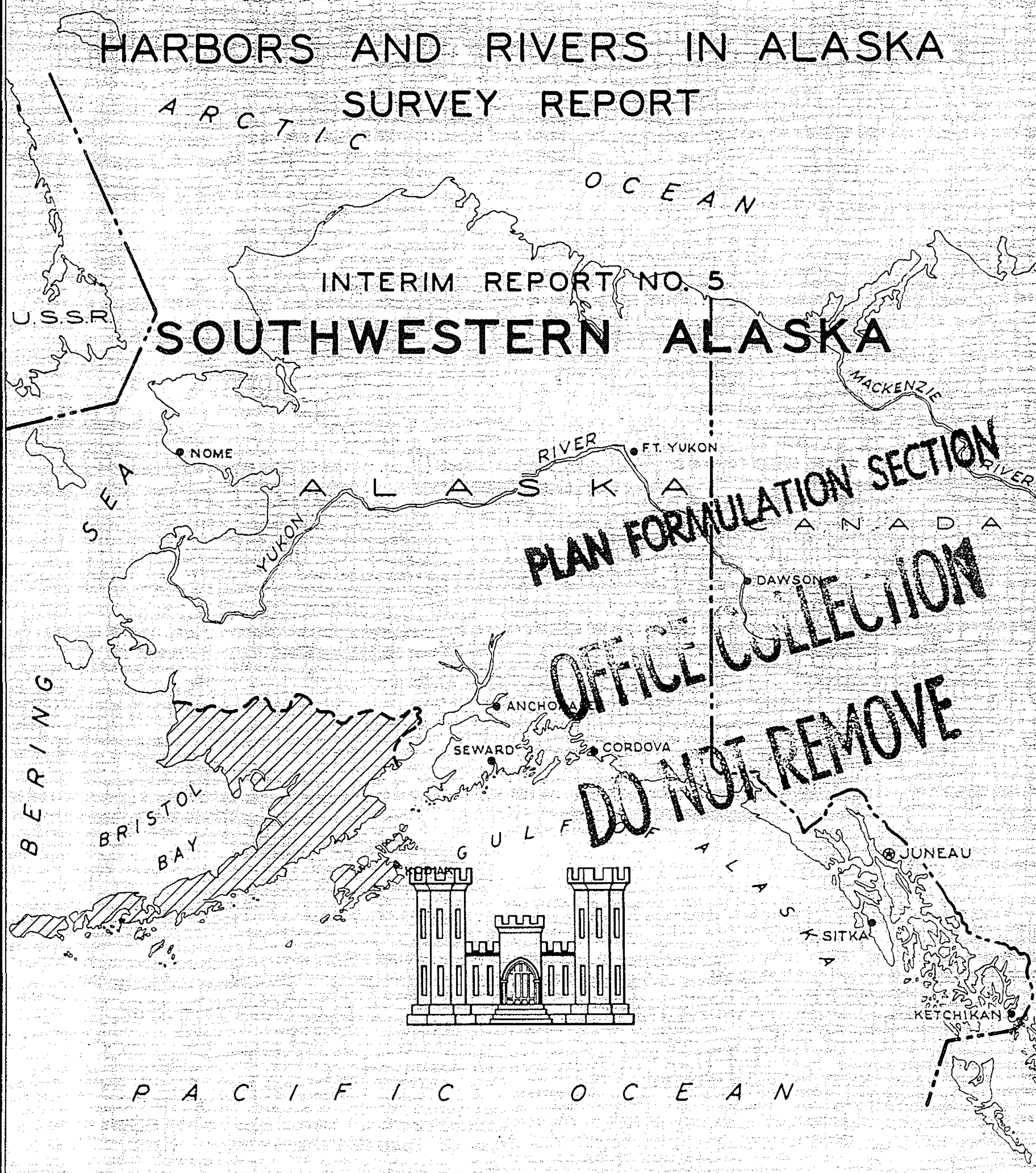
# HARBORS AND RIVERS IN ALASKA
## SURVEY REPORT

### INTERIM REPORT NO. 5
# SOUTHWESTERN ALASKA



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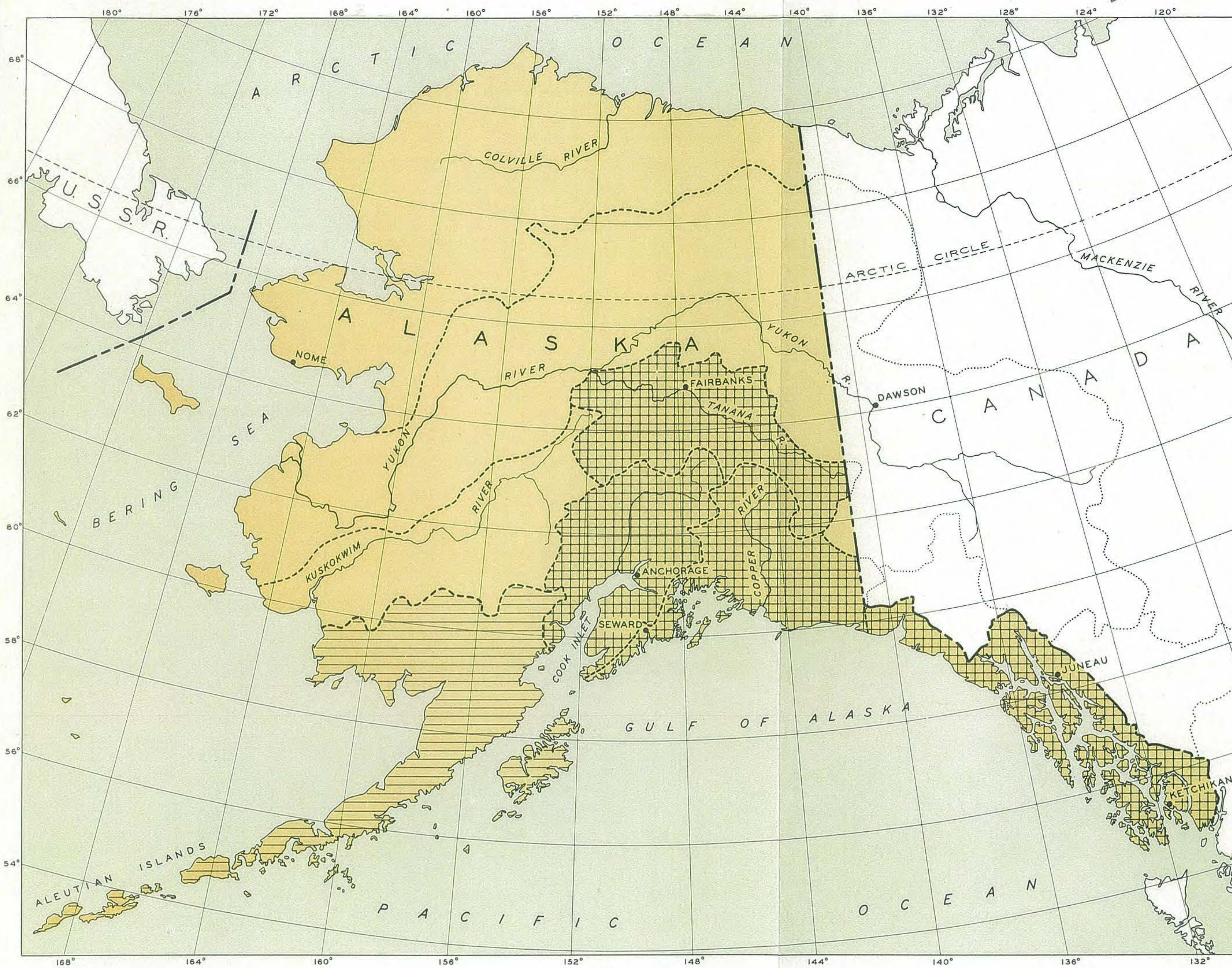
Prepared by
Alaska District, Corps of Engineers
Dated January 20, 1954

Army-Port Dist., Oreg.

CORPS OF ENGINEERS U.S. ARMY






LEGEND

COMPLETED REPORT

CURRENT REPORT

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

## STATUS OF INTERIM REPORTS

SCALE IN MILES
50 0 50 100 150 200

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. MacDuffee
ENGINEER

RECOMMENDED: A. L. Denny
CHIEF, SPECIAL SURVEY BRANCH

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COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

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TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-1

PLATE I

# SYLLABUS

Southwestern Alaska includes the Alaska Peninsula and adjacent mainland draining into Bristol Bay; and the Aleutian, Kodiak, and Pribilof Islands. The Aleutian Islands are the outstanding geographic features of the area as they form an island chain extending westerly in a sweeping arc for 1100 miles from the end of the Alaska Peninsula to a point within 1000 miles of Japan. The entire area is remote from world trade routes and entirely dependent upon water and air transportation.

Southwestern Alaska is rich in natural resources. The streams and lakes provide exceptional spawning grounds for salmon which has resulted in Bristol Bay becoming world famous for its fisheries. Offshore areas support shellfish, halibut, and numerous other species of bottom fish. Other valuable resources include the many minerals known to occur, the wild life and outstanding scenic attractions, and a large hydroelectric power potential.

Development of the economy of the area has been adversely affected by the harsh climate and general lack of transportation facilities. Fishing has been the principal source of wealth and will continue to rank high in importance. Little further growth of the salmon industry may be expected since the catch now approaches the maximum consistent with sustained yield but exploitation of the other fish species offers large growth possibilities. The taking of fur seals in the Pribilof Islands is an important industry that is rigidly controlled and may be expected to continue at its present rate of production. Mining within the area is not currently an important industry and future development will depend upon rich new strikes and improved accessibility.

The district engineer has conducted an investigation of the water resources of Southwestern Alaska to determine the advisability of improvements in the interest of navigation, flood control, hydroelectric power and related water uses. As a result of these studies, he finds that there is no present need for flood control measures nor for improvements in the interest of ocean-going traffic other than those projects previously authorized or recommended; that the region would be benefited by improvements in the interest of small boat traffic at certain localities, and that numerous comparatively low cost hydroelectric possibilities exist, the development of which would greatly benefit the local economy and which are available for construction when justified by growth of the power load.

The district engineer recommends construction of a small boat basin at Dillingham and improvement to the channel of Naknek River at a total cost to the Federal Government of $360,000 for new work.

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CORPS OF ENGINEERS, U. S. ARMY
Office of the District Engineer
Alaska District
Anchorage, Alaska

NPADP

SUBJECT: Interim Report No. 5 on Survey of Harbors and Rivers in Southwestern Alaska

TO: Division Engineer
North Pacific Division
Corps of Engineers
500 Pittock Block
Portland 5, Oregon

## SECTION I - INTRODUCTION

1. Authority - Section 204 of the Flood Control Act of 1948, (Public Law 858 - 80th Cong.) reads in part:

> "The Secretary of the Army is hereby authorized and directed to cause preliminary examinations and surveys for flood control and allied purposes * * * to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its Territorial possessions, which include the following named localities: * * * Harbors and Rivers in Alaska, with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power, and related water uses * * *."

2. The foregoing authorization was amended and confirmed by Section 208 of the Flood Control Act of 1950, (Public Law 516, 81st Cong. 2nd sess.) which provides:

> "Section 204 of the Flood Control Act of 1948 is hereby amended by adding to the item therein for harbors and rivers in Alaska the following: 'and that Federal investigations and improvements of rivers and other waterways in Alaska, for navigation, flood control, hydroelectric power, and allied purposes shall be continued under the jurisdiction of and shall be prosecuted by the Department of the Army under the direction of the Secretary of the Army and the supervision of the Chief of Engineers'."

3. Further authorization is contained in Section 6 of the Rivers and Harbors Act approved March 2, 1945, Public Law 14, Seventy-ninth Congress, first session, which reads in part:

> "Sec. 6. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys at the following named localities - Kodiak Harbor, Alaska . . . Upper Kvichak River, Alaska * * * * *".

4. Pursuant to the will of the Congress as expressed in the enactments above cited, the Chief of Engineers has directed that results of the surveys and investigations be submitted in a series of interim reports, of which the subject report is the fifth.

5. Status of Investigations - Partial Preliminary Examination and Interim Survey report dated December 30, 1949, covering navigation problems at certain locations in Southeastern Alaska lying east of the 141st Meridian was prepared by the District Engineer, Seattle, Washington, and concurred in by the Chief of Engineers on 12 November 1953. Interim Report No. 1 dated February 15, 1952 expands the above report to give comprehensive coverage to Southeastern Alaska and was prepared by the North Pacific Division, Portland, Oregon, and concurred in by the Board of Engineers for Rivers and Harbors on November 20, 1953. Interim Report No. 2 gave coverage to that portion of Alaska tributary to the tidal waters of Cook Inlet and was prepared by the District Engineer, Anchorage, Alaska, submitted January 20, 1950 and concurred in by the Chief of Engineers on December 10, 1953. Interim Report No. 3, dated October 30, 1950, treating that portion of Alaska which is drained by the Copper River and including the adjacent coastal regions which drain directly into the Gulf of Alaska between the 141st Meridian and the southern extremity of the Kenai Peninsula in west Longitude 152°, was ~~submitted May 1, 1951 by the Alaska District Engineer~~, concurred in by the Chief of Engineers

on July 29, 1952, forwarded to Congress June 10, 1953, and published in House Document No. 182, Eighty-third Congress, first session. Interim Report No. 4 dated May 1, 1951, contains a comprehensive study of the Tanana River Basin, which lies north of the Alaska Range in the central interior of the Territory, and was prepared by the North Pacific Division, Portland, Oregon and concurred in by the Board of Engineers for Rivers and Harbors on October 15, 1953. Partial Interim Report No. 5, dated October 1, 1951, recommending construction of a small boat harbor at Kodiak, was prepared by the District Engineer, Alaska District and concurred in by the Board of Engineers for Rivers and Harbors on November 20, 1953. The subject report, Interim Report No. 5 covers the Alaska Peninsula, Kodiak and Aleutian Islands, and Bristol Bay drainage herein called Southwestern Alaska. The areal extent, geographic location, and relative position of the region under consideration in this report with respect to previous and future theatres of investigation are shown on Plate 1.

6. Scope - The water resources of the area have been studied to determine the need for improvements in connection with immediate and foreseeable problems of navigation, flood control, hydroelectric power and related water uses. Paucity of basic hydrologic and meteorologic data, as well as the lack of data available from previous technical investigations, have limited the accuracy of the hydrologic studies. As additional data are collected and assembled, modifications of the report findings may be desirable, and if so, corrections will be incorporated in subsequent reports.

7. Prior Reports have been prepared by the Corps of Engineers in response to Congressional requests. These reports, specifically described in subsequent paragraphs, considered improvements in the interest of navigation.

8. The following unpublished, preliminary examination reports were recommended unfavorably by the Chief of Engineers:

a. English Bay, St. Paul Island - Report dated March 1, 1923, authorized by the Rivers and Harbors Act of September 22, 1922, considering improvements to the harbor was submitted to Congress December 8, 1923.

b. Afognak, Ocean Frontage - Report dated November 5, 1927, authorized by the Rivers and Harbors Act of March 3, 1925, giving consideration to providing a harbor was submitted to Congress February 10, 1928.

c. Portage - Report dated November 5, 1927, authorized by Rivers and Harbors Act of March 3, 1925 considering a harbor in connection with oil wells was submitted to Congress February 7, 1928.

d. Wedge Cape, Nagai Island - Report dated December 1931, authorized by Rivers and Harbors Act of July 3, 1930 considering a jetty and dredged channel was submitted to Congress April 29, 1933.

e. Unga Harbor - Report dated August 16, 1938 authorized by River and Harbor Act of August 26, 1937 considering construction of a breakwater was submitted to Congress May 8, 1939.

9. A report published in House Document No. 51, Seventy-third Congress, first session, outlines the adopted plan of improvement on Egegik River in the interest of navigation.

10. House Document No. 208, Seventy-second Congress, first session and House Document No. 332, Seventy-sixth Congress, first session outlines the adopted plans to improve the channel at the wharves in Kodiak Harbor.

11. House Document No. 543, Seventy-fifth Congress, third session, outlines the adopted plan for improvement of Unalaska (Iliuliuk) Harbor.

12. A preliminary examination report dated July 1, 1951 submitted to the Division Engineer, North Pacific Division, recommended a survey of Upper Kvichak River, in the interest of navigation. The findings are included in this report.

13. Cooperation with Other Agencies - The Federal Agencies listed below cooperated by furnishing background information and statistics:

U. S. Fish and Wildlife Service

Bureau of Reclamation

Bureau of Land Management

U. S. Forest Service

U. S. Coast Guard

U. S. Coast and Geodetic Survey

U. S. Geological Survey

Bureau of Mines

Alaska Road Commission

Bureau of Indian Affairs

Army Transportation Service

Army Map Service

Civil Aeronautics Administration

Alaska Development Board

## SECTION II - DESCRIPTION

14. <u>Geography and Topography</u> - The area covered by this report is shown on plates 13 and 14. The greater part of this area is the mainland portion of Southwestern Alaska which lies between approximately 55° and 61° north Latitude and between 153° and 162° west Longitude and includes the Alaska Peninsula, the Bristol Bay drainage and a small adjacent area draining into the lower reaches of Kuskokwim Bay. The balance of the area is composed of four island groups consisting of the 26 islands in the Kodiak group, 94 islands offshore of the Peninsula, the 80 islands of the Aleutian chain which extends some 1100 miles westward from the end of the Alaska Peninsula, and the four islands of the Pribilof group. The total land area is about 71,000 square miles with 58,000 square miles on the mainland, 6,000 square miles in the Kodiak group, 7,000 square miles in the offshore and Aleutian Islands, and 200 square miles in the Pribilof group.

15. The divides and drainage patterns of the mainland area are determined by four mountain groups which encircle the Bristol Bay region. The Ahklun Mountain Range, which includes the Kilbuck Mountains, the Tikchik Mountains and the Nushagak Hills, marks the northern boundary, extending southwesterly into Bering Sea to form the Peninsula between Kuskikwim Bay and Bristol Bay. The Alaska Range, sweeping southwest from its crowning peak, Mount McKinley, projects some 50 miles into northeastern corner of the report area. The Chigmit Mountains extend for about 100 miles southerly from the northeast corner of the area to make an offset connecting link between the Alaska Range and the beginning of the Aleutian Range in the vicinity of Lake Iliamna. The Aleutian Range forms the backbone of the Alaska Peninsula as it swings southwestward toward the Aleutian Islands

and continues at lower elevations out into the ocean where only the tops of the higher peaks emerge from the sea to form the islands of the chain.

16. The higher peaks in the Ahkun Mountains are in the Kilbuck group northwest of Tikchik Lakes where the highest is at about 5,400 feet. The higher peaks in the Tikchik Mountains and Nushagak Hills rise to 3,200 and 3,224, respectively. In the southern extension of the Alaska Range, within the report area, the highest peak reaches to about elevation 9,350 with several others standing above 8,000 feet. The highest peak in the Chigmit Mountains attains an elevation of about 7,000 feet. The higher peaks in the Aleutian Range lie in groups. Mount Douglas, 7,054 feet, is the highest of the group southeast of Iliamna Lake and Mount Dennison, elevation 7,630, is the highest of eight or ten peaks around Katmai volcano in the Katmai National Monument area. Isolated individual peaks provide the high points west of Mount Katmai. The principal peaks in this area are Mount Peulik, a dormant volcano south of Becharof Lake, elevation 5,000, Mount Chiginagak, south of Ugashik Lakes, elevation 6,955, the rim of Aniakchak Crater, east of Port Heiden, elevation 4,420, Veniaminof Crater, east of Port Moller, elevation 8,400 feet, and Pavlof Volcano, west of Port Moller, the highest peak in the mainland Aleutian Range at elevation 8,900.

17. The Alaska Range and Chigmit Mountains contain many active glaciers, and the higher portions of the Kilbuck Mountains and the Aleutian Range contain many smaller or fragmental glaciers. The mountains ranges were principally volcanic by origin and in only the Ahklun Range has the activity ceased.

18. The combination of the four mountain ranges form a drainage divide shaped roughly like a fish hook with the Aleutian Peninsula forming the shank, the peninsula between Kuskokwim Bay and Bristol Bay the point, and the Bristol Bay drainage within the hook. Determined by the outlet waters, the hook divides the mainland area into three general basin areas consisting of those streams that flow into Kuskokwim Bay, those that flow into Bristol Bay, and the streams that discharge into the Pacific Ocean.

19. Extensive lake systems exist in all regions. Large glacial lakes in the mountain regions feed into the river systems and smaller, shallower tundra lakes, for which neither inlet nor outlet streams exist, dot the flat lands of the coastal benches.

20. Climate - From the standpoint of climatology, Southwestern Alaska may broadly be divided into two parts, the islands and the mainland. The range between the average July and average January temperatures of the true maritime climate of the islands is about 20°F which is comparable to but approximately 10°F lower than that of the Washington coast. Although often classified as maritime, the climate of the mainland portion varies considerably because of continental influence. Here the range between the January average and July average is about 40°F, comparable to that in Eastern Washington, but about 15° lower. On the basis of records at low level stations, annual precipitation varies from less than 25 inches in inland portions to over 60 inches at many coastal stations. Much greater amounts occur at high elevations, as well as at low level stations having unusual topographic features. The above amounts are somewhat comparable to those occurring along the Washington coast.

21. Climatological data are largely confined to elevations near sea level. U. S. Weather Bureau records have been maintained at

52 stations, many of which are not continuous or are of short duration. The longest records, 49 and 59 years for temperature and precipitation, respectively, are at Kodiak. Only 15 stations were active at the end of 1951. Plate 2 shows the period of record of all stations for which records have been published in climatological bulletins by the U. S. Weather Bureau. Locations of all climatological stations are shown on plates 3 and 4.

22. Precipitation throughout the area is largely the result of orographic lifting and frontal activity, both of which are associated with the semi-permanent Aleutian low pressure area, commonly known as the Aleutian Low. Within the main low pressure center are numerous smaller lows together with their associated fronts. The frequency and intensity of these lows at various seasons largely determine the seasonal pattern of precipitation over the area. Their effects are most pronounced during late summer and autumn over the mainland of Southwestern Alaska, resulting in high precipitation during these seasons. Over 15 percent of the annual precipitation occurs during the month of August, and over 50 percent occurs during the four months July through October. The remaining 50 percent is quite evenly distributed over the other eight months, with average monthly amounts of about one inch at low-level stations. Average annual amounts at most of these stations range between 20 and 30 inches, the lower amounts occurring at stations north of topographic barriers. Such decreases are accounted for by depletion of moisture in the air as it travels in a northerly component over successive topographic barriers. Of considerable significance is the effect of continental air masses over the mainland. This factor accounts for the comparatively low precipitation amounts during the November through June period. By contrast, Kodiak Island is not significantly influenced

by continental air masses and, therefore, is characterized by high precipitation throughout the year, an average of three inches or more occurring during each month of the year even at low-level stations.

23. Over the Aleutian Islands where there is very little or no continental effect, the seasonal precipitation pattern is somewhat different. At Atka, a station with a 25-year record representative of the Aleutian Islands, average monthly amounts range from 3.5 inches in June to 8.2 inches in November with a gradual transition in amounts during the intervening months. The average annual amount is 66.5 inches, compared with amounts ranging between 50 inches and 70 inches at other island stations. Greater amounts occur at higher levels throughout the area as a result of orographic lifting.

24. Table 1 shows precipitation data for all stations. Bar charts illustrating annual distribution of precipitation are shown on plates 3 and 4. The following tabulation shows the annual variation in precipitation at a few selected climatological stations:

| Station | Length of Record Years | Av. Annual Precipitation Inches | Maximum Year | | Minimum Year | |
|---|---|---|---|---|---|---|
| | | | Inches | % of Av. | Inches | % of Av. |
| Atka | 25 | 66.5 | 97.4 | 146 | 42.0 | 63 |
| Dillingham | 35 | 25.9 | 36.6 | 141 | 19.0 | 73 |
| Dutch Harbor | 28 | 60.6 | 83.0 | 137 | 40.9 | 67 |
| Kodiak | 55 | 61.9 | 86.2 | 139 | 43.6 | 70 |
| Naknek | 27 | 22.9 | 31.5 | 138 | 16.6 | 72 |

25. The number of days per year with .01 inch or more of precipitation is high throughout the area, particularly over the islands and the peninsula where the average is about 200 days per year. No records are available for the mainland area but on the basis of records throughout Alaska, it is estimated that the number is between 150 and 200, depending to some extent upon the local topographic features. By comparison, in Eastern United States, 100 to 140 days per year have 0.1 or more

TABLE 1

PRECIPITATION DATA
FOR PERIOD OF RECORD

| STATION | ELEVATION | LENGTH OF RECORD 1/ YEARS | PRECIPITATION IN INCHES | | | | | | | | | | | | | | | | | AVERAGE ANNUAL SNOWFALL, INCHES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | AVERAGE ANNUAL | MAXIMUM YEAR | | MINIMUM YEAR | | |
| | | | | | | | | | | | | | | | | INCHES | YEAR | INCHES | YEAR | |
| Adak | 15 | 6 | 5.54 | 4.76 | 4.25 | 3.34 | 2.67 | 1.62 | 2.74 | 4.80 | 4.89 | 5.73 | 6.40 | 7.05 | 53.79 | 86.18 | 1949 | 52.45 | 1950 | 55.1 |
| Afognak | 8 | 19 | 3.86 | 4.53 | 2.90 | 3.65 | 6.53 | 4.22 | 3.16 | 3.50 | 3.66 | 7.27 | 5.50 | 4.51 | 53.29 | 85.49 | 1926 | 37.20 | 1935 | 34.1 |
| Alitak | 23 | 1 | - | - | - | 3.75 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Amchitka | 202 | 3 | 2.86 | 2.76 | 2.31 | 2.48 | 2.20 | 1.42 | 3.72 | 4.51 | 3.56 | 3.60 | 3.35 | 4.25 | 37.02 | 55.47 | 1949 | 36.60 | 1950 | 53.6 |
| Atka | 36 | 25 | 5.88 | 4.73 | 5.02 | 4.62 | 4.57 | 3.52 | 4.91 | 5.19 | 6.46 | 7.31 | 8.21 | 6.07 | 66.49 | 97.44 | 1884 | 41.99 | 1924 | 59.1 |
| Attu | 59 | 16 | 4.94 | 2.59 | 5.17 | 3.94 | 4.96 | 4.40 | 4.73 | 5.33 | 6.14 | 10.44 | 8.57 | 5.97 | 67.18 | - | - | - | - | 100.8 |
| Belkofski | 50 | 4 | 11.81 | 9.30 | 9.78 | 7.47 | 6.32 | 5.39 | 1.56 | - | 10.93 | 4.59 | 5.43 | 5.32 | - | - | - | - | - | 50.3 |
| Bering Islands | 20 | 5 | 0.70 | 1.59 | 0.91 | 1.13 | 0.96 | 1.66 | 2.46 | 2.09 | 2.50 | 2.60 | 2.96 | 1.62 | 21.18 | 23.92 | 1883 | 20.11 | 1884 | - |
| Brooks Lake | 44 | 1 | - | - | - | - | 1.08 | 1.93 | 0.40 | 2.39 | - | - | - | - | - | - | - | - | - | - |
| Bruin Bay | 51 | 1 | 2.14 | 0.86 | 1.07 | 0.52 | 6.10 | 4.10 | - | - | - | - | - | - | - | - | - | - | - | - |
| Cape Sarichef L.S. | - | 0 2/ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Chernofski Hbr. | 25 | 13 | 5.36 | 3.87 | 4.18 | 3.47 | 4.45 | 2.87 | 2.29 | 3.73 | 5.06 | 6.02 | 5.90 | 5.26 | 52.46 | 64.03 | 1929 | - | - | 30.9 |
| Chignik | 10 | 5 | 19.19 | 15.51 | 5.55 | 4.20 | 17.07 | 13.35 | 5.82 | 7.79 | 18.76 | 15.35 | 17.11 | 11.74 | 151.44 | 172.47 | 1929 | 139.21 | 1930 | 58.8 |
| Coal Harbor | 30 | 16 | 3.72 | 4.51 | 3.68 | 5.56 | 3.23 | 2.44 | 3.10 | 3.78 | 4.44 | 4.71 | 5.25 | 4.09 | 48.51 | 64.36 | 1905 | 26.74 | 1904 | 57.2 |
| Cold Bay | 99 | 4 | 2.72 | 3.44 | 1.49 | 1.06 | 1.75 | 1.76 | 1.63 | 3.47 | 3.69 | 4.41 | 4.41 | 2.65 | 32.48 | 41.52 | 1948 | 20.80 | 1950 | 51.5 |
| Dillingham | 83 | 35 | 1.75 | 1.32 | 1.75 | 1.24 | 1.69 | 1.73 | 2.74 | 3.91 | 3.86 | 2.78 | 1.69 | 1.40 | 25.86 | 36.65 | 1882 | 19.02 | 1933 | 63.6 |
| Dutch Harbor (a) | 47 | 19 | 5.86 | 5.29 | 4.99 | 4.03 | 3.53 | 2.76 | 1.98 | 2.35 | 4.55 | 6.94 | 5.48 | 6.69 | 54.45 | 65.55 | 1935 | 39.81 | 1917 | 73.7 |
| Dutch Harbor (b) | 22 | 28 | 6.44 | 6.31 | 4.93 | 4.28 | 4.44 | 3.03 | 2.19 | 2.48 | 5.73 | 7.32 | 6.45 | 7.00 | 60.60 | 82.97 | 1936 | 40.95 | 1916 | 70.1 |
| False Pass | 12 | 3 | 6.94 | 13.00 | 3.08 | 2.23 | 10.65 | 5.86 | 4.42 | 3.18 | 9.25 | 4.10 | 3.05 | 15.20 | 80.96 | - | - | - | - | 38.8 |
| Geese Islands | 15 | 6 | 4.10 | 4.11 | 5.96 | 4.35 | 4.12 | 2.66 | 4.20 | 3.15 | 6.03 | 10.93 | 5.49 | 4.65 | 59.75 | - | - | - | - | 14.1 |
| Goodnews Bay | 20 | 8 | 1.14 | 1.28 | 0.81 | 1.00 | 2.19 | 1.13 | 2.79 | 3.17 | 2.31 | 1.98 | 1.25 | 0.72 | 19.77 | - | - | - | - | 32.9 |
| Herendeen Bay | 15 | 2 | 1.86 | 4.09 | 2.55 | 1.09 | 2.37 | - | 2.37 | 4.77 | 5.99 | - | - | - | - | - | - | - | - | - |
| Iliamna CAA | 115 | 16 | 1.68 | 1.09 | 1.29 | 1.18 | 1.51 | 1.47 | 3.13 | 5.06 | 3.91 | 4.02 | 1.31 | 2.23 | 27.88 | 37.29 | 1946 | 21.70 | 1950 | 68.1 |
| Kalsin Bay | 20 | 4 | 9.56 | 6.31 | 6.63 | 5.87 | 10.98 | 6.99 | 5.02 | 7.42 | 8.42 | 11.12 | 12.48 | 9.02 | 99.82 | 116.10 | 1929 | 81.15 | 1930 | 22.3 |
| Kanatak | 23 | 5 | 1.12 | 5.92 | 3.93 | 6.81 | 5.15 | 2.44 | 7.60 | 6.02 | 7.00 | 3.49 | 1.79 | 3.52 | 54.79 | - | - | - | - | 56.0 |
| Karluk Lake | 365 | 3 | 1.03 | 1.76 | 3.21 | 2.06 | 1.40 | 4.31 | 2.07 | 2.48 | 4.81 | 4.47 | 3.49 | 2.47 | 33.56 | - | - | - | - | - |
| Kiukpalik Island | - | 2 | 4.40 | 8.31 | 1.80 | 2.23 | 10.86 | 6.18 | 8.08 | 9.56 | 6.35 | 7.04 | 4.06 | 6.84 | 75.71 | - | - | - | - | 46.8 |
| Kodiak (a) | 21 | 27 | 4.93 | 5.13 | 3.88 | 4.24 | 5.94 | 4.87 | 3.65 | 4.82 | 5.71 | 7.46 | 5.57 | 5.94 | 62.14 | 91.09 | 1943 | 42.59 | 1948 | 38.6 |
| Kodiak (b) | 152 | 55 | 4.83 | 4.88 | 3.94 | 4.20 | 5.94 | 4.86 | 3.56 | 5.04 | 5.48 | 7.45 | 5.60 | 6.17 | 61.95 | 86.18 | 1940 | 43.58 | 1921 | 47.3 |
| Lake Aleknagik | 55 | 2 | 2.89 | 5.44 | 1.81 | 5.48 | 4.75 | 5.15 | 2.19 | 9.65 | 11.37 | 5.80 | 2.16 | 3.30 | 59.99 | - | - | - | - | 175.3 |
| Lake Nerka | 65 | 0 2/ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Larsen Bay | 15 | 4 | 1.24 | 2.32 | 0.28 | 0.21 | - | - | - | - | - | 3.45 | 0.92 | 1.52 | - | - | - | - | - | 12.4 |
| Mosquito Point | 55 | 2 | - | - | - | - | - | 5.15 | 2.19 | 8.04 | - | - | - | - | - | - | - | - | - | - |
| Naknek | 49 | 27 | 0.94 | 1.20 | 1.17 | 0.87 | 1.32 | 1.62 | 3.07 | 4.06 | 3.50 | 2.70 | 1.25 | 1.19 | 22.89 | 31.55 | 1935 | 16.57 | 1944 | 37.8 |
| Nikolski | - | 5 | 4.51 | 4.30 | 1.84 | 2.19 | 2.07 | 3.37 | 3.49 | 2.66 | 4.16 | 2.86 | 6.22 | 4.34 | 42.01 | - | - | - | - | - |
| Olga | - | 1 | - | - | - | - | - | - | - | 10.03 | 5.59 | - | - | - | - | - | - | - | - | - |
| Pilot Point | 60 | 7 | 1.20 | 0.84 | 0.71 | 0.94 | 1.10 | 1.46 | 1.93 | 2.86 | 2.81 | 3.25 | 1.10 | 1.44 | 19.64 | 21.36 | 1943 | 17.19 | 1944 | 37.8 |
| Platinum | 20 | 13 | 1.15 | 1.07 | 1.05 | 0.52 | 1.02 | 0.87 | 1.43 | 3.34 | 3.20 | 2.64 | 1.30 | 1.03 | 18.62 | 28.41 | 1947 | 15.08 | 1950 | 51.8 |
| Port Heiden | 95 | 7 | 0.85 | 0.49 | 0.72 | 0.40 | 0.77 | 1.33 | 1.83 | 3.16 | 2.96 | 3.67 | 1.69 | 1.05 | 18.92 | - | - | 15.06 | 1950 | 30.1 |
| Port Moller | 18 | 3 | 1.58 | 2.21 | 2.53 | 2.70 | 0.59 | 0.22 | 0.10 | 1.39 | 1.17 | 1.82 | 2.30 | 3.02 | 19.63 | - | - | - | - | 85.9 |
| Sand Point | 50 | 4 | 4.45 | 6.29 | 2.91 | 5.05 | 5.96 | 4.13 | 2.70 | 6.79 | 3.68 | 9.21 | 6.22 | 4.96 | 62.35 | - | - | - | - | 43.0 |
| Scotch Cap | 56 | 6 | 3.82 | 3.55 | 2.46 | 2.72 | 4.20 | 2.80 | 4.48 | 6.84 | 6.22 | 5.55 | 4.37 | 3.80 | 50.81 | 67.85 | 1938 | 46.69 | 1939 | 30.3 |
| Shearwater | 0 | 1 | - | - | - | - | - | - | - | - | 13.27 | 10.72 | 8.00 | 2.91 | - | - | - | - | - | - |
| Shemya | 92 | 4 | 2.10 | 2.18 | 1.83 | 1.51 | 1.52 | 1.04 | 2.38 | 2.67 | 2.26 | 2.88 | 2.69 | 2.43 | 25.49 | 31.92 | 1948 | 15.52 | 1951 | 68.2 |
| St.Paul I.WB AP | 22 | 54 | 2.13 | 1.51 | 1.66 | 1.29 | 1.44 | 1.40 | 2.67 | 3.16 | 3.50 | 3.32 | 2.83 | 2.26 | 27.17 | 47.08 | 1875 | 15.33 | 1939 | 55.8 |
| Tanaga | 145 | 3 | 3.73 | 4.73 | 4.25 | 3.34 | 1.50 | 0.16 | 3.69 | 4.66 | 3.29 | 4.01 | 4.64 | 4.26 | 42.26 | - | - | - | - | - |
| Tanalian Point | 308 | 8 | 1.25 | 1.06 | 1.32 | 0.66 | 0.83 | 0.94 | 1.98 | 5.02 | 3.00 | 2.92 | 1.34 | 1.33 | 21.65 | 26.68 | 1946 | 18.51 | 1947 | 54.7 |
| Uganik Bay | 50 | 1 | - | - | - | - | - | - | - | 3.14 | 2.93 | 5.51 | 6.41 | 1.86 | - | - | - | - | - | - |
| Ugashik | 25 | 3 | 1.44 | 0.50 | 1.04 | 1.14 | 1.50 | 1.14 | 2.90 | 4.14 | 5.52 | 2.70 | 1.22 | 1.38 | 24.62 | 25.66 | 1885 | 23.21 | 1884 | - |
| Umnak | 131 | 3 | 2.89 | 4.19 | 3.95 | 1.44 | 1.81 | 2.67 | 4.86 | 7.05 | 6.13 | 6.44 | 5.28 | 9.35 | 56.06 | - | - | 53.41 | 1948 | 64.3 |
| Unga | 60 | 1 | 3.43 | 1.07 | 4.90 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Wosnesinski | 36 | 3 | 0.47 | 2.71 | 1.37 | 4.30 | 1.97 | 2.20 | 4.93 | 3.13 | 6.67 | 2.49 | 4.52 | 2.54 | 37.30 | - | - | - | - | 6.0 |

Note:
Except as indicated by 2/, dash indicates insufficient continuous record.

1/ To January 1952. For period of record see Plate 2.
2/ No record prior to 1952.

inches of precipitation. The seasonal distribution of days with precipitation is in general conformity with amounts received at various seasons.

26. Maximum 24-hour amounts of record are 3.48 inches at Atka, 3.75 inches at Dutch Harbor, and 4.48 inches at Kodiak. These amounts appear representative of the low elevations of the general area in which the stations are located. As in the case of annual precipitation, the maximum daily amounts increase with elevation.

27. Because of the absence of severe convective-type storms, the area is not subject to unusually high short-duration precipitation rates. No records are available to show actual hourly precipitation but depth-duration studies in areas having similar meteorological characteristics indicate that the maximum rates would probably be less than one inch per hour at most sea-level stations. Greater amounts may occur at points having unusual topographic features or in areas of higher elevation.

28. The percentage of precipitation occurring as snow varies with location and elevation. At sea level in the Aleutian Islands and Kodiak Island, the percentage is generally less than 10, increasing to 20 percent toward the north over the peninsula and to about 25 percent over the low levels of the mainland. No records are available for higher elevations, but amounts for various levels may be estimated by use of the relationship between January mean temperature and percentage of precipitation occurring as snow. Using an average lapse rate of $3^{\circ}$ per 1000 feet, temperatures at higher levels may be approximated. These temperatures are then applied to the temperature-percentage relationship to determine the percentage of precipitation occurring as snow at any given level. The following tabulation shows precipitation, snowfall, and percentage of precipitation occurring as snow at selected stations.

| Station | Elevation | Length of Record (Years) | Annual Precip. (Inches) | Annual Snowfall (Inches) | *Snowfall: Precip. (Percent) |
|---|---|---|---|---|---|
| Afognak | 8 | 19 | 53.29 | 34.1 | 6.4 |
| Atka | 36 | 25 | 66.49 | 59.1 | 8.9 |
| Attu | 59 | 16 | 67.18 | 100.8 | 15.0 |
| Dillingham | 83 | 35 | 25.86 | 63.6 | 24.6 |
| Dutch Harbor | 22 | 28 | 60.60 | 70.1 | 11.6 |
| Kodiak | 152 | 55 | 61.95 | 47.3 | 6.2 |
| Naknek | 49 | 27 | 22.89 | 37.8 | 16.5 |
| St. Paul Island | 22 | 54 | 27.17 | 55.8 | 20.5 |

* Assuming density of new-fallen snow at 10%

29. Although temperatures over the area as a whole are characteristically maritime, considerable variation exists within the different portions of the area. The Aleutian Islands are not significantly affected by continental air masses and, therefore, are not subject to the wide variations of temperature characteristic of continental influence. Daily variations are small, the range between the mean daily maximums and mean daily minimums for any given month being only about 10 degrees. Absolute maximum temperatures of record at most stations are from 70° to 80°, and absolute minimums are generally between 5° and 10°. Available records do not reveal any temperatures below zero in the Aleutian Islands.

30. On the Alaska Peninsula and Kodiak Island the range between mean daily maximum and minimum temperatures for any given month is about 15°, becoming 20° or more at inland stations toward the north. Absolute maximum and minimum of record at Kodiak are 85° and minus 12°, respectively. Similar extremes have been recorded on the Peninsula. Farther to the north, particularly at inland stations, wide extremes in temperature have been recorded. Temperature extremes of plus 89° and minus 54° have been recorded at Dillingham, a coastal station on the mainland. It is probable that even greater

extremes have occurred at some inland locations. These extremely cold temperatures are the result of continental polar air mass spreading over the area from the north. Such air masses do not move south of Bristol Bay, except in a modified form, thus accounting for the absence of extremely low temperatures toward the south.

31. The number of days with freezing temperature varies somewhat in accordance with mean minimum temperatures. Over the Aleutian Islands the average number of days with freezing temperatures is 140. Over the peninsula the number of days increases progressively toward the north to about 220 near Naknek. Over the mainland the number increases to more than 240 in the northernmost portion of the interior. The number of days with freezing temperature on Kodiak Island ranges from 140 at the southern tip to 180 at the northern tip.

32. Of importance to agricultural interests is the number of successive days without killing frost. On the basis of short records it is estimated that the average frost-free period over the Aleutian Islands is about 160 days. Over the Alaska Peninsula there is considerable variation in frost-free period due to the influence of topographic features, the number ranging from 78 at Chignik to 131 days at Kanatak. The number of frost-free days is probably less than 100 in the interior portion of the mainland. Since most stations having temperature records are at or near sea level, figures given above represent low elevations only. Because of normal decrease in temperature with increase in elevation, frost-free periods are generally shorter at high elevations. Inland stations, particularly those in valleys, have shorter frost-free periods than coastal stations due to a greater frequency of temperature inversions of the former. Temperature and frost data for all stations are shown in Table 2. Graphs depicting average frost-free seasons at selected stations are shown on plates 3 and 4.

TABLE 2

TEMPERATURE DATA

FOR PERIOD OF RECORD

| STATION | ELEVATION | LENGTH OF RECORD 1/ YEARS | TEMPERATURE IN DEGREES FAHRENHEIT | | | | | | | | | AVERAGE FROST-FREE PERIOD | MINIMUM FROST-FREE PERIOD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | AVERAGE | | | | | MAXIMUM OF RECORD | | MINIMUM OF RECORD | | | LAST FROST | FIRST FROST |
| | | | JAN | MAY | JULY | SEPT | ANNUAL | DEGREES | YEAR | DEGREES | YEAR | DAYS | IN SPRING | IN FALL |
| Adak | 15 | 6 | 32.5 | 39.6 | 48.6 | 47.5 | 40.0 | 70 | 1950 | 12 | 1947 | 161 | June 8 | Oct 18 |
| Afognak | 8 | 19 | 28.8 | 42.4 | 53.1 | 48.9 | 40.1 | 83 | 1926 | - 9 | 1927 | 106 | June 22 | Sept 7 |
| Alitak | 23 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Amchitka | 202 | 3 | 31.1 | 38.5 | 45.7 | 46.1 | 38.6 | 60 | 1949 3/ | 20 | 1949 | 195 | May 8 | Oct 29 |
| Atka | 36 | 23 | 33.2 | 40.5 | 49.2 | 47.5 | 40.2 | 77 | 1949 | 12 | 1925 3/ | 161 | May 25 | Aug 28 |
| Attu | 59 | 15 | 30.8 | 39.1 | 49.3 | 48.4 | 38.9 | 77 | 1946 3/ | 10 | 1942 | 150 | June 2 | Sept 13 |
| Belkofski | 50 | 4 | 33.8 | 42.3 | 52.8 | 48.8 | 40.7 | 63 | 1941 | 4 | 1940 | 175 | May 21 | Oct 22 |
| Bering Islands | 20 | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Brooks Lake | 44 | 1 | - | - | 56.4 | - | - | 83 | 1951 | - | - | - | June 7 | - |
| Bruin Bay | 51 | 1 | 23.6 | 42.4 | - | - | - | - | - | -18 | 1944 | - | Apr 18 | - |
| Cape Sarichef L.S. | - | 0 2/ | - | - | - | - | - | - | - | - | - | - | - | - |
| Chernofski Hbr. | 25 | 13 | 33.4 | 39.6 | 49.1 | 48.9 | 40.0 | 77 | 1936 | 10 | 1938 | 130 | June 22 | Sept 23 |
| Chignik | 10 | 5 | 32.4 | 39.2 | 50.0 | 46.9 | 37.1 | 75 | 1930 | -6 | 1927 | 78 | June 30 | Sept 4 |
| Coal Harbor | 30 | 23 | 28.0 | 40.8 | 52.6 | 49.1 | 39.1 | 80 | - | -19 | - | 131 | June 14 | Sept 16 |
| Cold Bay | 99 | 4 | 27.9 | 39.3 | 49.6 | 46.9 | 37.5 | 78 | 1948 | -9 | 1950 | 144 | May 25 | Sept 29 |
| Dillingham | 83 | 36 | 15.6 | 41.5 | 55.4 | 47.2 | 34.3 | 89 | 1926 | - 54 | - | 99 | 4/ | 4/ |
| Dutch Harbor (a) | 47 | 19 | 32.0 | 40.8 | 51.3 | 48.3 | 40.4 | 80 | 1929 | 6 | 1919 3/ | 140 | June 14 | Sept 5 |
| Dutch Harbor (b) | 22 | 39 | 32.0 | 40.1 | 51.4 | 48.6 | 40.5 | 80 | 1950 3/ | 5 | 1947 3/ | 140 | June 6 | July 17 |
| False Pass | 12 | 3 | 34.9 | 39.3 | 51.5 | 47.6 | 39.3 | 70 | 1929 | 2 | 1927 | 127 | June 21 | Sept 28 |
| Geese Islands | 15 | 4 | 34.8 | 43.4 | 51.8 | 50.0 | 42.0 | 66 | 1925 | 5 | 1925 | 188 5/ | May 8 | Nov 13 |
| Goodnews Bay | 20 | 7 | 12.9 | 37.9 | 53.4 | 43.0 | 32.1 | 81 | 1919 | -52 | 1919 | 96 | May 31 | Aug 31 |
| Herendeen Bay | 15 | 2 | 19.1 | 33.5 | 53.6 | 50.0 | 38.0 | 70 | 1919 | -18 | 1919 | - | - | Sept 30 |
| Iliamna CAA | 145 | 16 | 16.4 | 41.3 | 54.0 | 46.1 | 33.8 | 82 | 1951 | -47 | 1947 | 108 | 4/ | 4/ |
| Kalsin Bay | 20 | 4 | 34.0 | 41.1 | 52.1 | 48.7 | 39.9 | 80 | 1930 | -1 | 1930 3/ | 130 | June 1 | Sept 15 |
| Kanatak | 23 | 5 | 24.8 | 49.4 | 54.2 | 49.1 | 41.6 | 75 | 1940 | -20 | 1941 | 131 | May 20 | Sept 28 |
| Karluk Lake | 365 | 3 | 29.6 | 42.0 | 51.0 | 49.0 | 40.4 | 74 | 1951 | 6 | 1938 | 128 5/ | May 18 | Sept 24 |
| Kiukpalik Island | - | 2 | 31.0 | 42.6 | 51.8 | 47.4 | 38.9 | 75 | 1927 | -3 | 1928 | 156 | May 1 | Oct 4 |
| Kodiak (a) | 21 | 27 | 30.2 | 43.0 | 54.1 | 50.0 | 41.0 | 84 | 1944 | -6 | 1919 | 155 | May 23 | Sept 20 |
| Kodiak (b) | 152 | 47 | 30.1 | 43.1 | 54.3 | 50.1 | 40.8 | 85 | - | -12 | - | 156 | June 13 | Sept 7 |
| Lake Aleknagik | 55 | 2 | 2.4 | 43.2 | 55.4 | 46.9 | 33.1 | 73 | 1951 | -48 | 1951 | 114 | May 27 | Sept 8 |
| Lake Nerka | 65 | 0 2/ | - | - | - | - | - | - | - | - | - | - | - | - |
| Larsen Bay | 15 | 4 | 31.9 | - | - | - | - | - | - | 0 | 1940 | - | - | - |
| Mosquito Point | 55 | 2 | - | - | 55.4 | - | - | 86 | 1951 | - | - | 35 | July 2 | Aug 1 |
| Naknek | 49 | 31 | 14.3 | 43.0 | 54.9 | 48.3 | 34.4 | 86 | 1951 | -43 | 1919 | 115 | June 10 | Sept 2 |
| Nikolski | - | 5 | 32.6 | 38.8 | 44.2 | 44.6 | 38.4 | 57 | 1938 | 14 | 1928 | 116 | June 9 | Sept 16 |
| Olga | - | 1 | - | - | - | 50.7 | - | 68 | 1951 | - | - | - | - | Sept 15 |
| Pilot Point | 60 | 7 | 23.2 | 42.8 | 53.1 | 49.6 | 37.1 | 77 | 1942 | -30 | 1942 | 121 | May 31 | Sept 9 |
| Platinum | 20 | 13 | 15.8 | 39.3 | 51.7 | 46.0 | 32.6 | 73 | 1950 | -34 | 1947 | 126 | June 3 | Aug 22 |
| Port Heiden | 95 | 7 | 23.7 | 39.2 | 51.0 | 48.1 | 36.2 | 76 | 1948 | -18 | 1951 3/ | 98 | June 30 | July 29 |
| Port Moller | 18 | 3 | 21.1 | 40.5 | 51.1 | 48.2 | 38.0 | 75 | 1924 | -19 | 1925 | 155 | May 12 | Oct 14 |
| Sand Point | 50 | 4 | 29.4 | 40.8 | 49.8 | 47.8 | 39.3 | 70 | 1946 | 1 | 1947 | 82 | June 1 | Aug 22 |
| Scotch Cap | 56 | 7 | 34.2 | 40.5 | 49.2 | 48.2 | 40.5 | 74 | 1938 | 9 | 1940 3/ | 157 | May 19 | Oct 9 |
| Shearwater | 0 | 1 | - | - | - | - | - | - | - | 11 | 1951 | - | - | Sept 9 |
| Shemya | 92 | 4 | 31.2 | 39.0 | 46.3 | 47.5 | 38.8 | 58 | 1951 3/ | 18 | 1949 | 187 | May 9 | Oct 30 |
| St.Paul I.WB AP | 22 | 41 | 24.8 | 35.0 | 45.7 | 45.2 | 34.7 | 64 | 1941 3/ | -26 | 1919 | 126 | July 21 | Sept 1 |
| Tanaga | 145 | 3 | 31.7 | 38.8 | 44.5 | 46.8 | 39.0 | 61 | 1948 | 22 | 1949 | 164 | May 19 | Oct 22 |
| Tanalian Point | 308 | 8 | 18.0 | 45.0 | 55.9 | 45.4 | 35.2 | 85 | 1948 | -52 | 1947 | 86 | July 12 | Aug 4 |
| Uganik Bay | 50 | 1 | - | - | - | 53.1 | - | 81 | 1951 | - | - | - | - | Sept 29 |
| Ugashik | 25 | 0 | - | - | - | - | - | 86 | - | -38 | - | - | - | - |
| Umnak | 131 | 3 | 30.4 | 39.1 | 48.6 | 46.3 | 39.1 | 74 | 1949 | 16 | 1950 3/ | 136 | May 30 | Sept 25 |
| Unga | 60 | 4 | 26.3 | 40.8 | 56.1 | 51.8 | 40.5 | 79 | 1919 | 7 | 1920 | - | - | Aug 30 |
| Wosnesinski | 36 | 2 | 32.6 | 43.7 | 52.6 | 50.0 | 42.2 | 69 | 1940 | -10 | 1941 | 158 | May 20 | Oct 25 |

Note:
Except as indicated by 2/, dash indicates
insufficient continuous record.

1/ To January 1952. For period of record see Plate 2.
2/ No record prior to 1952.
3/ Occurred also in other years.
4/ Killing frost in every month of year 1931.
5/ From last frost in spring to first frost in fall.

33. Fog is common during portions of the year throughout the area. In the Aleutian Islands, fog is present about 15 percent to 25 percent of the time during the period April through August, and about 3 percent to 6 percent of the time during the remainder of the year. A similar sequence occurs over the coastal areas of the Alaska Peninsula and mainland; however, the April through August percentages over the Peninsula coast and mainland coast are about 10 percent and 5 percent, respectively. In interior areas fogs are most prevalent during the coldest months, December through February, the warm summer months rarely having fog. Figures given above are based on very short records and are not necessarily reliable.

34. Clouds are present on about 90 percent of the days over the Aleutians and 80 percent of the days over the Peninsula and Kodiak Island, with no pronounced seasonal pattern. In the interior, clouds are present on about 70 percent of the days of the year, with greatest amounts occurring during late summer and winter, and lesser amounts during the spring and early summer.

35. Winds of gale force are common throughout the coastal areas, particularly during the winter months. At Kodiak, according to a 5-year record, the average annual frequency is 20, of which 13 occur duing the November through February period. No occurrences have been recorded during June or July. Long-period wind records are not available for the Aleutian Islands but the 9-year record at St. Paul Island shows an occurrence of 74 gales per year. Average monthly frequencies are highest in January with 12.6, gradually decreasing to 0.2 in July, then gradually increasing during the remainder of the year. It is probable that the above figures are applicable to the unsheltered locations in the Aleutian Islands. Topographic features may result in considerable variation in wind velocity, either decreasing it by

sheltering effect or increasing it by funneling action. Direction of gale-force winds is variable, depending upon the path of the low pressure center with respect to the station.

36. Winds of lesser intensity are common during all months throughout the area. A 21-year record at Dutch Harbor shows an average wind velocity of 10 to 12 miles per hour during the May through October period, 5 miles per hour in January, 13 miles per hour in March and 8 to 9 miles per hour during the remaining months. At Kodiak a 7-year record shows an average velocity of 6 miles per hour during the June through August period, and an 8 to 10 miles per hour average during the remainder of the year.

37. Thunderstorm activity is generally limited to the interior areas during the summer months. Their frequency is less than one per year and, because of their mild intensity, they are of little significance. Thunderstorms rarely occur in the Aleutian Islands, Kodiak Island, or on the Alaska Peninsula.

38. Geology - Alaska has a complex geological history. The earliest known rocks were formed in the Paleozoic Era, and the passage from this era into the Mesozoic Era apparently was not marked by vast violent upheavals whereby a spectacular break between the two ensued. Sedimentary rocks of Jurassic and Cretaceous Ages are widely distributed and here and there terrigenous and marine deposits alternate in the sequence, showing successive occupation and withdrawal of different areas by oceans of the past. The events marking the passage from the Jurassic to the Cretaceous are not well recorded in the Alaskan areas that have been studied in most detail. It is thought that the land mass was worn down to a low relief by the end of the Jurassic Period and the seas were largely filled with sediments. In the early part of the Cretaceous Period the sinking of part of the

land led to invasions by the sea, followed by oscillations of greater or lesser amounts at various times during the Cretaceous, so that in the course of the period practically all of Alaska was at some time under the sea, though at no one time were all parts of it submerged coincidentally.

39. In Alaska during Cenozoic time there were movements of the crust, amounting in places to thousands of feet of displacement with profound faulting and intense crumpling which here and there deformed beds deposited as flat lying sheets until they stand vertical or are even overturned. It appears on the surface that the present major features were blocked out at the beginning of the Cenezoic Era; however, information is not available from which to reconstruct the successive stages by which the changes have been brought about.

40. Geological investigations in Southwestern Alaska have been very meager, consisting in the main of reconnaissance surveys only. Information on the geological formations is therefore very incomplete and inconclusive and can only be generalized.

41. The formations of the Ahklun and Kilbuck Mountain region are predominantly sedimentary with minor bodies of igneous and volcanic rock. The sedimentary rocks consist of chert, cherty grit, conglomerate, quartzite, slate, argillite, limestones, graywacke, and shale with gradational materials among the various types. The volcanic rocks are basic lava flows and the igneous are intrusives of a granitic nature. On Lakes Chauekuktuli and Nuyakuk Paleozoic rocks of Permian and pre-Permian age forms the country rocks, but from Lake Nuyakuk southward to the low land of Nushagak Bay a great thickness of Mesozoic rocks is exposed and is believed to be Cretaceous in age.

42. The bedrock in the Nushagak Hills is predominantly Upper Cretaceous, similar to the formations of the Ahklun Range. The surface deposits of the remainder of the district, and the lowlands of the Nushagak River, consist of unconsolidated or slightly consolidated deposits of Tertiary Marine sediments and Quaternary morainal debris, outwash deposits and stream-laid alluvium. In the Bristol bay areas tide-flat deposits consist of silty mud.

43. The rock types in the Southern Alaska Range region include a great variety of materials, among which are normal sediments and their metamorphic equivalents, deep seated intrusives and volcanic lavas and tuffs. The entire succession is nowhere exposed in a single section. This fact and the scarcity of fossils make correlation difficult and leaves some doubt as to the correctness of interpretation.

44. The oldest rocks of this region, presumed to be early Paleozoic and in part possibly pre-Cambrian in age, are a group of highly metamorphosed sediments now appearing as gneisses, mica schists and quartzites. Lower Jurassic lava flows are widely distributed throughout the area. Throughout the southern Alaska Range Mesozoic metamorphosed sediments, believed to be mainly of Jurassic and Cretaceous age and consisting of argillite, slate and graywacke, are of widespread occurence and constitute one of the major elements of the mountain mass. Tertiary lavas and tuffs occur at various places in the western and southwestern section of the area. Thicknesses between 2,000 and 3,000 feet have been observed in the upper reaches of the Chilikadrotna River. The most conspicuous single group of rocks in the southern Alaska Range, on account of its widespread distribution and of the rugged topographic forms produced from it by erosion, is that which includes the granitic intrusive rocks probably of late Mesozoic age. The unconsolidated Quaternary deposits consist of glacial morain and outwash

materials, lacustrine and marine deposits, volcanic ash and talus accumulations.

45. In the Alaska Peninsula and Aleutian Chain region, the oldest known sedimentary rocks are presumed to be Triassic in age. These rocks consisting of thin-bedded limestone and calcareous shale more than 1,000 feet thick are intruded by basaltic dikes and sills. Calcareous sandstone, sandy shale and limestone at Cold Bay and Alinchak Bay are approximately 2,300 feet thick and are considered to be Lower Jurassic in age. The Kialagvik formation probably of Middle Jurassic age is more than 500 feet thick near Wide Bay and consists of sandstone and sandy shale. The Shelikof formation of Upper Jurassic Age is from 5,000 to 7,000 feet thick and consists of sandstone, with minor amounts of conglomerate and shale as the lower member, and black shale as the upper 700 to 1,000 feet. The Naknek formation, also of Upper Jurassic, consists of conglomerate and arkosic sandstone at the base which is overlain by sandstone and conglomerate. The thickness of this formation is approximately 5,000 feet. The Upper Cretaceous, Chignik formation is 400 to 800 feet thick and consists of sandstone, conglomerate, shale and coal seams. Rocks classed as Eocene in age and approximately 2,000 feet thick consisting of fine conglomerate, sandstone, shale and thin beds of lignite are found near Mount Chiginagak. The igneous rocks of the Alaska Peninsula and the Aleutian Chain are, in the main, results of volcanic action and consist of andesitic and basaltic lava flows. The minor intrusives are quartz diorite and granite, and are of post-Jurassic age. Quaternary deposits consisting of terminal moraines, glacial erratics, mountain outwash, stream gravel, silt, beach deposits and volcanic ash form the coastal plain of the Bristol Bay region.

46. On Kodiak and adjacent islands, the greenstone-schist group contains rocks that include schists of Palezoic or possibly even pre-Cambrian age, greenstone that may range from Carboniferous to Triassic, and cherts and tuffs of Lower Jurassic age. Overlying the greenstone-schist group is the slate-graywacke group of probably Cretaceous age. Sandstones, shales and conglomerates that are obviously younger than the slate-graywacke group, are correlated with the Eocene age beds on Kenai Peninsula. Marine sandstones of Miocene or Pliocene age have been recognized on eastern Kodiak Island. The central axis of Kodiak Island is occupied by a granitic mass that is some 70 miles long and averages 8 miles wide. In addition there are many outlying satellites of granitic material on Kodiak and the adjacent islands. The granititic intrusion is regarded as having occurred at the end of the Mesozoic Era. The Quaternary sediments consist of glaciofluvial, stream and beach deposits.

47. Most of the projects under consideration for power development are in areas where sound bedrock may be expected at a reasonable depth. Any of the bedrock, when unaltered, with the possible exception of some shales and tuffs, are satisfactory for foundations. Tunnels through the unaltered bedrock should be driven without difficulty but penetration of altered rock may greatly influence the cost of the construction. The presence of deep deposits of unconsolidated materials that occur adjacent to some of the lakes should be avoided where tunneling or location of a heavy structure is required.

48. From information now available it is evident that although extensive volcanism occurred during the entire Mesozoic Era, it was much more widespread and intense during the early part of the era. Lofty modern volcanoes overshadow all the other topographic features and are dominant in almost every landscape in the region. There are 30 active

or recently active volcanoes on the Alaska Peninsula and the Aleutian Islands. Mount Veniaminof erupted in 1892 and pumice was spread over a fairly wide area. Mount Katmai erupted in 1912 and a thick layer of ash was spread widely over the Alaska Peninsula and Kodiak Island. During 1953 Mount Spurr, immediately north of the report area, and Mounts Trident and Cleveland were in active eruption; and Mounts Katmai and Iliamna were exuding fresh lava flows. Six or seven others are emitting steam or smoke from their vents but otherwise show little activity.

49. Glaciation in Alaska was not restricted to the Pleistocene epoch but has been more or less continuous throughout the Quaternary period, down to the present day. In the main the present as well as the past glaciation has centered in the mountain regions and extended down into the lower valley regions gouging out the present lake beds of the Tikchik lakes and Lake Iliamna and scoring the upper river courses. Cycles of variable temperature and precipitation caused these glaciers to recede and advance and this process was repeated many times. Great quantities of materials were deposited in the lower valleys. On the southern coastal side of the Alaska Peninsula the materials were discharged directly into the ocean and dissipated. On the north side the ice extended down the mountains and built up a wide coastal plain, which contains several large morainal lakes. Only remnants exist at present and are in the form of valley glaciers on the higher mountain peaks.

50. Broadly speaking the permanently frozen ground, commonly called permafrost, in Alaska may be considered as having an areal extent measured in thousands of square miles and a thickness in places of hundreds of feet. The presence or absence of permafrost is directly related to the mean annual temperature and the upper limit of this

layer is determined by the surface of the country and the depth below that surface to which seasonal melting takes place, usually a matter of a very few feet where the mat of vegetation is unbroken. The lower limit is controlled by a complex relation between several factors, of which one of the most influential is the upward migration of heat from the earth's interior. The permafrost layer embraces all kinds of material including solid rocks, deposits of sand, gravel, silt and clay. The southern limit of the permafrost zone coincides very roughly with the 0°C mean annual temperature isotherm and is generally considered to be the Alaska Range and thus embraces a large majority of Southwestern Alaska with the exception of the western and southern portions of the Alaska Peninsula, the Aleutian Islands and Kodiak and adjacent islands.

51. The most complete geological reports available for Southwestern Alaska are USGS Bulletin Nos. 485, 755D, 862, 880C and 903.

52. Seismology - The faulting and deformation of the rock structure in the Alaska Territory is a continuing process but probably at a decreasing rate as the formations become more stable. Earthquakes of violent intensity are still experienced quite frequently, but they are seldom accompanied by excessive displacements. Since 1899 there have been eight or ten earthquakes, which shook the Bristol Bay area, with an intensity greater than five on the Rossi-Forel scale, but their epicenters were located in other districts of the territory. Shocks with an intensity less than five are of common occurrence. Minor shocks and earth tremors are frequently felt and may occur several times in a year. These may be a prelude to or accompanied by volcanic eruptions or to minor shifting of the earth's crust. The epicenter of many of these is in the Alaska Peninsula or out along the Aleutian Island chain as readjustments take place in the ocean floor.

53. Earthquake damage in the report area has been almost completely lacking due primarily to the paucity of population and structures to be damaged. Future construction should anticipate a continuation of the severe seismic activity, particularly in the Alaska Peninsula and Aleutian Islands where major land movements may occur in the future. Although major movements are not apt to occur in the more stable Ahklun Mountains and southern Alaska Range, the movements occurring in the Aleutian Range and Island chain may cause earth shocks of violent intensity over all of Southwestern Alaska.

54. Hydrology - The mountain ranges in Southwestern Alaska divide the streams into three general groups determined by the waters into which they discharge. The northwest group consists of the streams originating on the west slope of the Ahklun Range which flow westerly and discharge into lower Kuskokwim Bay. The central group is the most important economically and includes the streams draining into Bristol Bay. The third group originates on the eastern slopes of the Alaska Range and Chigmit Mountains, and the southeastern and southern slopes of the Aleutian Range and discharges into lower Cook Inlet, the Gulf of Alaska, or the Pacific Ocean.

55. Characteristically, the streams discharging into Kuskokwim Bay are short or of moderate lengths, and have one or more lakes in their tributary system. The streams discharging into Bristol Bay have much the same characteristics as those in the Kuskokwim region except that most of the streams and lakes are larger. This group of rivers includes the principal rivers and lakes in the area. Stream profiles are generally steep above the regulatory lakes and quite moderate in the lower reaches where the streams meander through braided channels across the wide coastal plains. Condensed profiles of the

three largest rivers of this group are shown on plates 5 and 6. The rivers in the third group are generally short and steep. They flow in sharply cut canyon courses down the sides of the mountains and dump into the ocean waters. Only a few of them have lakes of any size on their stream courses or enter the ocean over coastal plains or river deltas.

56. The following tabulation lists the named rivers of the region tabulated in geographical order from north to south.

| Stream | Tributary to | Point of Discharge | Point of Origin | Approxi. Length (Miles) | Approx. Drainage Basin Area (Sq.Miles) |
|---|---|---|---|---|---|
| Kanektok | Kuskokwim Bay | 59° 45' N.Lat. | Kilbuck Mts. (Ahklun Rge.) | 90 | 870 |
| Arelik | " | 59° 40' N.Lat. | " | 35 | 535 |
| Indian | " | Carter Bay | " | 15 | 60 |
| Tunulik | " | Goodnews Bay | " | 12 | 55 |
| Goodnews | " | Goodnews Bay | " | 60 | 1050 |
| Goodnews (Middle Fk) | Goodnews Riv. | Mile 5 | " | 45 | 284 |
| Goodnews (South Fk) | " | Mile 4 | " | 25 | 142 |
| Smalls Riv. | Kuskokwim Bay | S.Spit Goodnews Bay | " | 6 | 35 |
| Salmon | " | 58° 52' N.Lat. | " | 10 | 31 |
| Kinegnak | " | Chagvan Bay | " | 20 | 155 |
| Unaluk | Kinegnak Riv. | Mile 2 | " | 15 | 63 |
| Slug | Bristol Bay | Nanarak Bay | " | 18 | 64 |
| Osviak | " | Hagemeister Str. | " | 35 | 216 |
| Matogak | " | " | " | 30 | 160 |
| Nisua | Matogak Riv. | Mile 1 | " | 8 | 21 |
| Quigmy | Bristol Bay | Togiak Bay | " | 30 | 106 |
| Kurluk | " | " | " | 8 | 22 |
| Togiak | " | " | " | 95 | 1935 |
| Kashaiak | Togiak Riv. | Mile 29 | " | 28 | 200 |
| Naroguram | " | Mile 32 | " | 35 | 235 |
| Ongivinuk | " | Mile 41 | " | 30 | 216 |
| Ungalukuk | Bristol Bay | Togiak Bay | " | 30 | 188 |
| Kukayachagak | Ungalukuk Riv. | Mile 5 | " | 28 | 76 |
| Kulukak | Bristol Bay | Kulukak Bay | " | 37 | 240 |
| Igushik | " | Nushagak Bay | Amanka Lake | 75 | 840 |
| Ongoke | Igushik Riv. | Amanka Lake | Kilbuck Mts. | 20 | 180 |
| Weary | Bristol Bay | Nushagak Bay | " | 63 | 438 |
| Snake | Weary Riv. | Mile 7 | " | 40 | 246 |
| Nushagak | Bristol Bay | Nushagak Bay | Ahklun Range & Alaska Range | 230 | 14,100 |

| Stream | Tributary to | Point of Discharge | Point of Origin | Approxi. Length (Miles) | Approx. Drainge Basin Area (Sq.Miles) |
|---|---|---|---|---|---|
| Wood | Nushagak Riv. | Mile 1 | Lake Aleknagik | 18 | 1,415 |
| Agulowak | Wood River | Lake Alknagik | Nerka Lake | 4 | 860 |
| Agulukpak | " | Nerka Lake | Lake Beverley | 2 | 500 |
| Peace | " | Lake Beverley | Mikchalk Lake | 2 | 310 |
| Wind | " | Mikchalk Lake | Lake Kulik | 2 | 307 |
| Muklung | " | Mile 10 | Muklung Hills | 25 | 140 |
| Little Muklung | Nushagak Riv. | Mile 2 | " | 23 | 120 |
| Iowithla | " | Mile 50 | " | 40 | 200 |
| Kokwok | " | Mile 66 | Bench Lands E. of Kulik Lake | 70 | 670 |
| Mulchatna | " | Mile 100 | Turquoise Lake in Alaska Rge. | 185 | 4300 |
| Nuyakuk | " | Mile 120 | Tikchik Lake | 30 | 2060 |
| King Salmon | " | Mile 155 | Tikchik Mts. of Ahklun Rge. | 48 | 430 |
| Chichitnok | " | Mile 165 | Nushagak Hills of Ahklun Rge. | 33 | 310 |
| Chilikadrot-na | Mulchatna R. | Mile 106 | Twin Lakes in Alaska Range | 56 | 655 |
| Koktuli | " | Mile 39 | S. End of Alaska Range | 60 | 625 |
| Tikchik | Nuyakuk Riv. | Tikchik Lake | Nishlik Lake in Kilbuck Mts. | 45 | 533 |
| Allen | " | Lake Chauekuktuli | Chikuminuk Lake in Kilbuck Mts. | 10 | 303 |
| Kakhtul (Swan) | Mulchatna | Mile 26 | S. End of Alaska Range | 55 | 300 |
| Chilchitna | " | Mile 96 | Alaska Range | 35 | 180 |
| Kvichak | Bristol Bay | Kvichak Bay | Iliamna Lake | 57 | 7730 |
| Newhalen | Kvichak Riv. | Iliamna Lake | Six Mile Lake (Lake Clark) | 25 | 3700 |
| Tazimina | Kvichak Riv. | Six Mile Lake | Chigmit Mts. | 50 | 350 |
| Tanalian | " | Lake Clark | Kontrashibuna L. | 4 | 209 |
| Chulitna | Kvichak Riv. | " | Foot Hills S.End of Alaska Range | 75 | 1180 |
| Koksetna | Chulitna Riv. | Mile 14 | Alaska Range | 50 | 405 |
| Kijik | Kvichak Riv. | Lake Clark | Ingersol Lake | 18 | 287 |
| Tlikakila | " | " | Alaska Range | 50 | 650 |
| Chokotonk | " | Little Lake Clark | " | 22 | 183 |
| Pile | " | Iliamna Lake | Chigmit Mts. | 25 | 140 |
| Iliamna | " | " | " | 20 | 203 |
| Copper | " | " | (Meadow Lake in Chigmit Mts.) | 22 | 126 |
| Kakhonak | " | " | Kakhonak Lake in Chigmit Mts. | 5 | 140 |
| Alagnak | Bristol Bay | Kvichak Bay | Kukaklek Lake in Aleutian Range | 71 | 1390 |

| Stream | Tributary to | Point of Discharge | Point of Origin | Approxi. Length (Miles) | Approx. Drainage Basin Area (Sq.Miles) |
|---|---|---|---|---|---|
| Nonvianuk | Alagnak Riv. | Mile 52 | Nonvianuk Lake in Aleutian Rge. | 12 | 396 |
| Naknek | Bristol Bay | Kvichak Bay | Naknek Lake in Aleutian Range | 34 | 3730 |
| Savonoski | Naknek Riv. | Iliuk Arm Naknek Lake | Aleutian Range (Katmai Area) | 37 | 1285 |
| Ukak | " | " | Valley of 10,000 Smokes | 30 | 330 |
| Egegik | Bristol Bay | Egigik Bay | Becharof Lake | 30 | 2740 |
| King Salmon | Egegik Riv. | Mile 3 | Aleutian Range | 95 | 990 |
| Kejulik | " | Becharof Lake | " | 40 | 302 |
| Ugashik | Bristol Bay | Ugashik Bay | Lower Ugashik Lake | 34 | 1620 |
| Dog Salmon | Ugashik Riv. | Mile 5 | Aleutian Rge. | 71 | 430 |
| King Salmon | Bristol Bay | Ugashik Bay | Mother Goose | 34 | 625 |
| Cinder | Bristol Bay | 57° 20' N.Lat. | Aleutian Rge. | 45 | 425 |
| Meshik | " | Port Heiden | Meshik Lake S. Side Aniakchak Crater | 35 | 530 |
| Bear | " | 56° 10' N.Lat. | Bear Lake | 14 | 300 |
| Caribou | " | Nelson Lagoon Port Moller | Aleutian Rge. Pavlof Vol. Area | 65 | 610 |
| Cathedral | " | Cape Leonte-vitch 55°37' N.Lat. | " | 23 | 145 |
| Grecian | Cook Inlet | Tuxedni Bay | Chigmit Mts. Vic. Redoubt. Vol. | 35 | 259 |
| Johnson River | " | Iliamna Point | Chigmit Mts. Vic. Iliamna Vol. | 13 | 100 |
| Iniskin | " | Iniskin Bay | Chigmit Mts. | 8 | 46 |
| Paint | " | Akjemguiga Cove Kamishak Bay | Aleutian Rge. | 20 | 196 |
| McNeil | " | McNeil Cove Kamashak Bay | " | 15 | 100 |
| Little Kamishak | " | Akumwarvik Bay Kamishak Bay | " | 23 | 170 |
| Kamishak | " | " | " | 39 | 320 |
| Douglas | " | " | " | 24 | 214 |
| Katmai | Shelikof Str. | Katmai Bay | Aleutian Rge. Vic. Katmai Vol. | 27 | 290 |
| Aniakchak | Pacific Ocean | Aniakchak Bay | Aniakchak Crater | 41 | 175 |
| Chignik | " | Chignik Bay | Black Lake | 32 | 579 |
| Beaver | " | Beaver Bay | Hoodoo Mt. Area Aleutian Range | 11 | 37 |
| Canoe Bay | " | Canoe Bay of Pavlof Bay | Hoodoo Mt. Area Aleutian Rge. | 13 | 50 |

57. The larger lakes in the river system are generally of glacial origin, long, comparatively narrow, and very deep as the basins in which they lie were gouged in many cases to several hundred feet below sea level by the ice. These lakes are the only named lakes in the region and are in contrast to the many thousands of smaller unnamed tundra lakes that dot all of the flat lands. Lakes in this latter group are small and shallow and conform to no drainage pattern as most of them have neither inlet nor outlet. They cover a large percentage of all the flat lands and make summer travel over land areas virtually impossible. A third type of lake occurs occasionally in the craters of extinct volcanoes. Very few of these have inlet or outlet streams.

58. The following tabulation lists the named lakes in the continental area, placing them in respect to river basins and gives the pertinent available data. The data given is from surveys of reconnaissance type with elevations obtained from aneroid or altimeter readings. The elevations, although carefully measured, may be subject to correction when more accurate surveys are made at some future time.

NAMED LAKES - BRISTOL BAY AREA AND ALASKA PENINSULA

| Lake Name | River Basin | Outlet Stream | Dimensions Length: Miles | Width: Miles | Depth: Feet | Area Square Miles | Surface Elevation |
|---|---|---|---|---|---|---|---|
| Aleknagik | Nushagak | Wood River | 20 | 3 | 330 | 34 | 34 |
| Amanka | Igushik | Igushik River | 8 | 5 | - | 14 | 30 |
| Battle | Alagnak | Into Kukaklek L. | 9 | 1 | - | - | 870 |
| Bear | Bear | Bear River | 6 | 2 | - | - | - |
| Becharof | Egegik | Egegik River | 38 | 15 | - | 450 | 50 |
| Beverley | Nushagak-Wood | Agulukpak Riv. | 22 | 3.5 | 500 | 38 | 100 |
| Black | Chignik | Chignik River | 6 | 3 | - | - | - |
| Brooks | Naknek | Brooks L. Outlet | 11 | 3 | - | 27 | 110 |
| Chauekuktuli | Nushagak-Nuyakuk | Nuyakuk Lake | 23 | 2 | 700 | 33 | 324 |
| Chikuminuk | " | Allen Riv. | 16 | 5 | - | 36 | 630 |
| Chignik | Chignik | Chignik Riv. | 6 | 3 | - | 27 | 110 |
| Clark | Kvichak | Newhalen Riv. | 50 | 4 | 606 | 143 | 220 |
| Coville | Naknek | Savonoski Riv. | 10 | 3 | - | 17 | 166 |
| Gibraltar | Kvichak | Into Iliamna L. | 7 | 1 | - | - | 160 |

| Lake Name | River Basin | Outlet Stream | Dimensions Length Miles | Width Miles | Depth Miles | Area Square Miles | Surface Elevation |
|---|---|---|---|---|---|---|---|
| Goodnews | Goodnews | Goodnews River | 5 | 1 | - | - | 420 |
| Grant | Nushagak-Wood | Into Lake Kulik | 3.5 | 1.5 | - | 3.5 | 510 |
| Grosvenor | Naknek | Savonoski River | 19 | 2.5 | - | 30 | 165 |
| Iliamna | Kvichak | Kvichak River | 77 | 20 | - | 1115 | 50 |
| Ingersol | " | Kijik River | 4 | 1 | - | 3 | 120 |
| Kagati | Kanektok | Kanektok River | 4 | 2 | - | - | - |
| Kakhonak | Kvichak | Kakhonak River | 13 | 1 | - | - | 210 |
| Kontrashibuna | " | Tanalian River | 19 | 1.5 | - | 10 | 435 |
| Kukaklek | Alagnak | Alagnak River | 19 | 7 | - | 70 | 800 |
| Kulik | Nushagak-Wood | Wind River | 17 | 1.5 | - | 24 | 140 |
| Kulik | Alagnak | Alagnak River | 12 | 1.5 | - | - | 690 |
| Long | Kvichak | Chulitna Riv. | 5 | 1 | - | - | 279 |
| Meadow | " | Copper River | 3 | 1 | - | - | 490 |
| Meshik | Meshik | Meshik River | 1.5 | 0.75 | - | - | - |
| Mikchalk | Nushagak-Wood | Peace River | 2 | 0.5 | - | 0.5 | 120 |
| Moose | Kvichak | Kakhonak River | 3 | 1 | - | - | 600 |
| Mother Goose | Ugashik | King Salmon Riv. | 6 | 3 | - | - | - |
| Naknek | Naknek | Naknek River | 45 | 8 | - | 239 | 80 |
| Nonvianuk | Alagnak | Alagnak River | 18 | 5 | - | - | 630 |
| Nerka | Nushagak-Wood | Agulowak River | 25 | 4.5 | 475 | 78 | 70 |
| Nikabuna | Kvichak | Chulitna River | 6 | 1.5 | - | - | 300 |
| Nishlik | Nushagak-Nuyakuk | Tikchik River | 7 | 3 | - | 14 | 1035 |
| Nunavaugaluk | Weary | Snake River | 14 | 3 | - | 28 | 45 |
| Nuyakuk | Nushagak-Nuyakuk | Nuyakuk River | 27 | 5 | 930 | 71 | 312 |
| Pickerel-Upper | Kvichak | Into Middle Pickerel | - | - | - | - | 290 |
| Pickerel-Middle | " | Into Lake Clark | - | - | - | - | 280 |
| Surprise | Aniakchak | Aniakchak Riv. | 2 | 1.5 | - | - | - |
| Tazimina-Upper | Kvichak | Tazimina River | 7 | 1 | - | 7 | 620 |
| Tazimina-Lower | " | " | 10 | 0.5 | 6 | 6 | 620 |
| Tikchik | Nushagak-Nuyakuk | Nuyakuk River | 10 | 4 | - | 25 | 312 |
| Togiak | Tigiak | Togiak River | 14 | 2 | - | 15 | 230 |
| Turquoise | Nushagak | Mulchatna Riv. | 5 | 1 | - | - | - |
| Tutna | Nushagak-Mulchatna | Nikadavana Cr. | 3 | 2 | - | - | 850 |
| Twin-Upper | Nushagak | Chilikadrotna Riv. | 5 | 0.5 | - | - | - |
| Twin-Lower | " | " | 5 | 1 | --- | - | - |
| Ualik | Igushik | Into Ongoke Riv. | 9 | 2 | - | 17 | 50 |
| Ugashik-Upper | Ugashik | Ugashik River | 16 | 6 | - | 86 | 10 |
| Ugashik Lower | " | " | 12 | 8 | - | 74 | 10 |
| Upnuk | Nushagak-Nuyakuk | Tikchik River | 10 | 4 | - | 24 | 830 |

59. Prior to 1951 no stream flow measurements were made on any of the streams in the report area. During the summer of 1951 gaging stations were placed on the Tanalian and Newhalen Rivers in the Lake Clark, region and on the Uganik River on Kodiak Island, and the following year a station was placed on the Nuyakuk below the outlet of Tikchik Lake. The locations are shown on plate 7. Records of one year's duration have been obtained from the three initial stations and a partial record from the other.

60. Accurate runoff estimates cannot be made from the sketchy stream flow data so far obtained, nor can they be accurately derived from the precipitation records, as all of the climatological stations are located along the coastal regions in the lesser rainfall belt, while the headwater regions may receive from 2 to 5 times as much precipitation. Runoff estimates have generally been obtained from drainage area relationships and judicial application of the small amount of data available and must be considered as approximations only.

61. The annual stream flow pattern of the streams in the Bristol Bay area vary with the amount of storage present. When lake storage is minor or non-existant, high flows may occur during the months of May, June, and July, but when large lakes exist in the river system, high flows occur in late July or August. During the winter when the streams are frozen over, the only contribution to flow is from the natural lake storage and from ground water supplies. Between the freeze-up in the fall and the spring break-up of the ice, the flow is more nearly constant but gradual recession occurs as the source of supply becomes depleted. Following the spring break-up, flows increase rapidly and continue to rise with further increase in temperatures into the early summer. Peak flows generally occur with the optimum combination of maximum temperatures and areal extent of snow cover contributing to the

flow. Minor fluctuations in flow occur with day-to-day temperature variation or from runoff produced by warm rains. Late in the summer flows gradually recede, and by the time of the fall freeze-up they are down to base flow, characteristic of the winter season.

62. Variation in the stream flow pattern between streams depend upon various factors, the most important being elevation and exposure of the drainage basin; amount of glacier area contributing to runoff; general geologic structure of the basin; natural storage in lakes; and opportunity for warm late summer and fall rains. Quantitative evaluation of these several factors is not possible, but in general there are qualitative time relationships which can be used as a guide in estimating the runoff pattern to be expected in any particular basin.

63. High elevation basins generally have later high runoff periods and smaller unit runoff during the winter than low elevation basins. The exposure, in reference to the moisture laden prevailing winds, will affect the relative amount of precipitation the basin will receive. Also, flows in low basins have a tendency to be sustained during the fall as a result of storms which produce rain in lower areas but snow at higher elevations. Runoff from glaciers reaches a maximum in late June or July and remains high during the summer.

64. The geology of the region is important in evaluating the infiltration capacity of the respective basins and influences the proportion of the precipitation contributing to the ground water. It is doubtful whether any large ground water storages exist in many of the basins in the Bristol Bay area because much of the region is still in the permafrost zone which reduces the seepage of surface water. In the middle and southern reaches of the Bristol Bay area the permafrost is in various stages of decomposition, with alternating lenses of frozen and unfrozen ground. This is shown by the log of wells that have been drilled in the area. In the Nushagak area lenses of ice have been found to depths of 375 feet below sea level, but the unfrozen ground between ice lenses is sometimes water bearing.

65. Located in the area are many lakes whose natural storage tends to regulate the runoff into the streams which drain them. The amount of retardation depends upon the size of the lake and the outlet conditions.

66. Runoff from rain is important in those basins which are below 4000 feet and are subject to heavy fall rains. The runoff from these rains may produce a secondary rise in flow following the summer discharge of ice and snow melt in the headwaters.

67. Estimates of average annual runoff were made for the streams on which sites for possible future power developments exist and upon some of the more important navigation and fish propagating streams. The estimates were derived by weighted comparson with drainage areas on which some data are available. The tabulation below lists areas and runoff values for portions of the various river basins used in the power analyses in this report.

ESTIMATED ANNUAL RUNOFF FROM BASIN AREAS

| Basin | Applicable Drainage Area (Sq. Miles) | Runoff in inches |
|---|---|---|
| Nishlik Lake Outlet | 46 | 40 |
| Upnuk Lake Outlet | 100 | 40 |
| Chikuminuk Lake Outlet (Allen Riv.) | 290 | 40 |
| Tikchik Lake Outlet (Nuyakuk River) | 1486 | 38 |
| Grant Lake Outlet | 50 | 30 |
| Lake Kulik Outlet (Wind River) | 219 | 37 |
| Agulowak River (Inlet to Aleknagik Lake) | 845 | 35 |
| Lake Clark Basin above Newhalen River gage | 3600 | 35 |
| Kontrashibuna Lake drainage | 205 | 36 |
| Tazimina Lakes drainage | 330 | 36 |
| Kukaklek Lake drainage | 470 | 35 |
| Grosvenor Lake drainage | 630 | 30 |
| Brooks Lake drainage | 250 | 25 |
| Kijik River (at Ingersol Lake) | 152 | 38 |
| Grecian River (at forks) | 224 | 42 |
| Terror River (above Lake) Kodiak Island | 17 | 80 |
| Uganik Lake drainage-Kodiak Island | 97 | 75 |
| Spiridon Lake drainage-Kodiak Island | 22 | 50 |
| Frazier Lake drainage-Kodiak Island | 40 | 65 |
| Makushin River-Unalaska Island | 30 | 57 |
| Attu Island-End of Aleutians | All | 75 |

68. Data for the determination of flood flows or flood frequencies are lacking due principally to the small number of inhabitants in the region. By far the greater majority of the streams have large lakes in the path of flow and these regulate and moderate what flood flows occur in the headwater regions. Flood damages have been of minor importance due to the lack of structures to damage. Erosion occurs only along the cut banks of the streams as the other areas are covered with the tundra growth of vines and mosses which are not damaged by inundation nor removed to any great extent by scour. Erosion of the river channels in places and aggradation in others is a continuing process along all the streams that flow in the wide glacial outwash filled valleys and over the coastal plain. The streams flow in braided channels sometimes many miles wide, with dozens of semi-parallel channels lacing the valley bottom. Even a major flood in such a channel would have little effect upon the region under existing conditions.

69. Sedimentation - All of the headwater tributary streams carry a perceptible silt load and bed load. Many of the headwater valleys are occupied by receding valley glaciers that impart a silt and gravel load into the bed of the outwash stream. Where glaciers do not exist the action is continued by the melting snow fields until practically all of the headwater streams are colored by the silt content. The short steep streams of the Eastern Chigmit Mountains and southern slopes of the Aleutian Range carry their silts and gravels directly to ocean waters and in general they discharge into deep water where the ocean soon disperses the material. The longer streams of the central region are generally intercepted by a lake large enough to settle out both the bed and silt loads so that the streams emerging from the lakes are clear. These streams will in time fill the lake basins but many of the lakes are so large that geologic ages will be required to accomplish

the task. Probably the heaviest siltation is taking place in the Iliuk arm of Naknek Lake where the Savonoski River and its southern tributary, the Ukak, are transporting silt and volcanic ash and pumice from the Katmai area into the lake. These streams will be successful in filling the Iliuk arm in the not too distant future but the main body of the lake will be only slightly affected. Similar sedimentation is present at the heads of all the lakes in the Tikchik-Wood River chain and in the lakes in the western Ahklun Mountains but in all cases the lakes completely intercept the sediment and the outlet streams flow clear.

70. In general, the few streams that do not pass through large lakes, carry a seasonal load of silt, and during the periods of major flow, the silt will be accompanied by a bed load movement. The largest stream in this category is the King Salmon River which empties into Egegik Bay. There are several similar streams on the lower Alaska Peninsula. These streams carry their silt into the tidal estuaries and deposit it in the bays and along the shore line in a saturated unstable bed which is incapable of supporting a load of any type. Wave and tidal action continually stir up the mass so that the beach water in these locations is always muddy.

## SECTION III - ECONOMIC DEVELOPMENT

71. Introduction - Based upon the explorations of Vitus Bering in 1728 and 1741, Russia laid claim to that portion of northwestern North America which is now Alaska. Soon after Bering's second voyage the Russian fur traders advanced along the Aleutian Islands in quest of sea otter. The first headquarters settlement was established in 1784, at Three Saints Bay on Kodiak Island. These headquarters were transferred about 1789 to the present location of the town of Kodiak because of its good harbor and proximity to good building timber. The settlement of Kodiak also became the capitol for a Russian company which was organized in 1799 to administer Alaska, to encourage exploration, to promote commerce and agriculture, and to extend the sphere of Russian Orthodox faith and influence. Under the managership of Count Alexander Baranof this corporation ruled with absolute domination and extended the Russian influence from Bristol Bay as far south as northern California. In 1806 the capitol was moved from Kodiak to Sitka. During the Crimean War, Russia became fearful that the British might seize Alaska and sold this part of North America to the United States.

72. The Karluk River became known to the Russians as one of the most prolific of the salmon streams on Kodiak Island and in 1793 a depot was established there to supply hunting parties with dried fish. Salting of salmon for local supply was begun about 1850. At about this time a demand for ice was created in the growing city of San Francisco and the Russian company formed a partnership with American capitalists to develop the ice trade. A wharf and terminal facilities, to handle this commodity, were built on Woody Island near Kodiak. This trade continued, furnishing employment for men and ships, until about 1880. By 1860 the Americans were entering the region, competing in the fur trade, prospecting for gold, and fishing for cod and salmon.

73. Population and Employment - Estimates obtained from Russian reports indicate that the population of Southwestern Alaska in 1860 totaled about 7700 persons of whom only 75 were Caucasion. From a partial census taken in 1890-1891 it was estimated that the population had increased to about 10,000, including 1000 white people. This count was based principally upon figures furnished by traders and missionaries and cannot be considered reliable. The first complete census under Congressional authority was taken in 1929, resulting in a count of 6388 persons residing in the area. By 1939, when the next census was taken, the population had increased to 6976. Shortly after the compilation of these figures, the impact of war was felt in Southwestern Alaska, as in the rest of the Territory, and many people moved into the area. By 1950 the count showed a population of 16,055, or a gain of 130 percent in eleven years. There are indications that continued defense activities have maintained this upward trend.

74. A tabulation of the Southwestern Alaska population by Judicial Divisions and minor Civil Districts for the 1929, 1939, and 1950 Census appears as follows:

SOUTHWESTERN ALASKA

POPULATION BY JUDICIAL DIVISIONS & MINOR CIVIL DISTRICTS
1929, 1939 & 1950 CENSUS

| Judicial Division | Minor Civil District | Population 1929 | 1939 | 1950 1/ | Percentage increase or decrease from 1939 to 1950 |
|---|---|---|---|---|---|
| Third | Aleutian Islands | 1,116 | 1,298 | 5,600 | +331 |
| Third | Bristol Bay | 1,289 | 993 | 1,636 | +64.8 |
| Third | Iliamna | 358 | 399 | 368 | -7.7 |
| Third | Kodiak | 1,729 | 2,094 | 6,264 | +199 |
| Third | Kvichak | 551 | 600 | 752 | +25.3 |
| Third | Unga Peninsula | 1,115 | 1,141 | 1,069 | -6.3 |
| Fourth | Goodnews Bay | 230 | 451 | 366 | -18.8 |
| Totals within report area | | 6,388 | 6,976 | 16,055 | +130 |

1/ Preliminary estimates taken from advance reports of 1950 Census.

75. The fishing industry has provided the principal source of employment in Southwestern Alaska since the turn of the century. It is a highly seasonal operation lasting only a few weeks in the early summer, and local residents have been unable to meet the labor needs at peak production. This has required importation of additional workers. Of a total of about 6,000 men presently employed in the fishing industry in the Bristol Bay area, 4,000 are brought in from the United States; 1,000 are recruited from other parts of the Territory; and only 1,000 are provided locally. These workers are able to earn a satisfactory annual income for their few weeks of work when the fish catch is normal. Since little opportunity exists for employment of the imported workers in other fields, a general exodus occurs at the end of the fishing season.

76. During and since the war, construction of defense facilities within the area has caused a great change by furnishing employment almost equal to that of the fishing industry. Many additional workers have been imported, and opportunity has been provided for local residents to augment their income by working in one of the many phases of the construction program.

77. Mining, as presently developed within this area, provides work for about 100 men. Other fields where limited opportunity exists are in prospecting, fur trapping, recreation, and service industries.

78. Any great gain in population in the area is unlikely in the near future if consideration is given only to existing industries. The fishing industry may expand as additional types of fish are exploited, but this would have little effect on population as these activities would probably be performed through a longer work season by people already resident. Further expansion of the defense plan is

not expected, and some curtailment is probable as the current program nears completion in 1954. Occupation of the completed defense facilities is expected to offset the movement of the construction workers to other areas.

79. Of the many people imported for the defense construction program, a few have chosen to become permanent residents. As better access and transportation facilities are developed, it may reasonably be expected that more will do so, and some gain will occur from this source.

80. The development of recreational opportunities is still in initial stages, and exploitation of the exceptional hunting, fishing, and recreational features of the area will probably be an important factor in growth. The transportation and servicing of this industry should increase the resident population materially.

81. A small gain in population may be expected from the combined growth of these industries, together with certain service industries which supply them, but for any large gains, new enterprises must be brought into existence. Among possible new developments which would furnish increased employment and add to the population are increased mining based upon new discoveries or increased production of minerals now known to exist but requiring rise in world prices to become profitable; discovery of oil and gas as a result of field explorations now being conducted; development of the large hydroelectric power resources of the area and new industry which the power could serve; and utilization of lands suitable for agriculture and further development for recreation.

82. To forecast the population gain by 1975 within this area can be little more than speculative. If the growth during the defense program is discounted, and it is assumed that the earlier rate of

growth will apply, a population of between 18,000 and 20,000 may be expected; but if one of the possibilities mentioned above were to come about, a population in excess of 25,000 could easily be realized.

83. Transportation - The economy of Southwestern Alaska is primarily dependent upon air and water for transportation. Construction of land transportation routes has been impractical because of sparse population, lack of development, and rugged terrain. Existing transportation routes are shown on plate 9. The following tabulation shows the distances in statute miles from Anchorage, Alaska, and Seattle, Washington to Kodiak, Unalaska, and Dillingham.

| | Water Routes | | |
|---|---|---|---|
| | Kodiak (miles) | Unalaska (miles) | Dillingham (miles) |
| Anchorage, Alaska | 280 | 845 | 1,165 |
| Seattle, Washington | 1,490 | 1,720 | 2,035 |

| | Air Routes | | |
|---|---|---|---|
| | Kodiak (miles) | Unalaska (miles) | Dillingham (miles) |
| Anchorage, Alaska | 255 | 780 1/ | 360 1/ |
| Seattle, Washington (Via Anchorage) | 1,705 | 2,230 | 1,810 |

1/ Via King Salmon

84. No roads or railroads connect Southwestern Alaska to the rest of the territory, and the only contact by land with other portions of the territory is by trail or winter sled route, methods of travel used principally by natives and trappers. An equal deficiency of roads exists within the district, as only short pieces of road have been built in the vicinity of the populated centers, and, as a result, much of the area is inaccessible throughout most of the year.

85. Water-borne transportation has been the basic factor contributing to the development of the area. While mail and passengers are, for the most part, carried by airplane, movement of general cargo continues to depend upon water transportation. Practically all food stuff, building material, clothing, petroleum products, and cannery supplies are imported via water; and exports, which consist principally of fish products, are transported similarly.

86. Steamship companies from United States Pacific ports provide service throughout the year to ports on the south side of the Alaska Peninsula and to ports in the Bristol Bay area during the ice-free period. One combination freight and passenger boat calls at Kodiak every two weeks, and a mail boat, sailing from Seward once a month, serves the communities along the south side of the Peninsula and as far out the Aleutian Island chain as the village of Nikolski on Umnak Island. Vessels owned by private fishing interests carry large quantities of supplies for their own operations. Government owned ships and barges transport a large portion of the equipment and supplies destined for Government installations.

87. Transhipment by barge and small boat is important to the local transportation system, especially in the Bristol Bay region where there are no deep water harbors and it is necessary to lighter all cargo from ship to shore. Cargo destined for King Salmon is transported by barge via Naknek River and ports on Iliamna Lake are served by barge via Kvichak River. Other inland areas depend on shallow-draft river boats for transportation.

88. There has been some transportation by a combination of land and water routes across the Alaska Peninsula. A road between Iliamna Bay on Cook Inlet and Pile Bay on Iliamna Lake provides a link in the route

between Cook Inlet and Kvichak Bay via Iliamna Lake. Another road connects Lake Clark and Iliamna Lake, and at one time a road existed between Becharof Lake and the native village of Kanatak on the south coast, which provided a route between Egegik Bay and Skelikof Strait via Egegik River.

89. The following tabulation of civilian cargo transported by water during 1951 is indicative of the amount of freight handled in a normal year.

SUMMARY TABULATION OF WATER-BORNE TRAFFIC, 1951
(Short tons)

| Ports | Trans-Pacific Coastwise | | | Domestic Intra-Territory | | | Total 1/ all traffic |
|---|---|---|---|---|---|---|---|
| | Receipts | Shipments | Total | Receipts | Shipments | Total | |
| Kodiak Harbor | 12,905 | 1,655 | 14,560 | 8,094 | 71 | 8,165 | 22,725 |
| Iliuliuk Harbor | 40,950 | - | 40,950 | - | 28,478 | 28,478 | 69,428 |
| Aleutian Island Ports 2/ | 12,007 | 2,306 | 14,313 | - | - | - | 14,313 |
| Alaska Peninsula (South Side) 3/ | 40,308 | 29,159 | 69,467 | 10,271 | 776 | 11,047 | 80,514 |
| Alaska Peninsula (North Side) 4/ | 22,573 | 6,032 | 28,605 | 11,323 | - | 11,323 | 39,928 |
| Pribilof Islands | 4,432 | - | 4,432 | - | - | - | 4,432 |
| Totals | 133,175 | 39,152 | 172,327 | 29,688 | 29,325 | 59,013 | 231,340 |

1/ Local freight traffic not included.
2/ Aleutian Island Ports include all harbors in the Aleutian Islands westward of Unimak Pass, excepting Iliuliuk Harbor on Unalaska Island.
3/ Alaska Peninsula (South Side) includes all harbors on the southerly side of the Peninsula from Tuxedni Bay to Unimak Pass.
4/ Alaska Peninsula (North Side) includes all harbors on the northerly side of the Peninsula east of Unimak Pass, Bristol Bay and Goodnews Bay.

90. Transportation by air to and within Southwestern Alaska contributes immensely to the economy of the area. One company schedules two daily flights between Anchorage and Kodiak. Two companies schedule daily flights between Anchorage and King Salmon with connecting flights to Dillingham and flag stops at Iliamna and Iguigig. Another company provides service between Kodiak or Anchorage and points on the Alaska

Peninsula and the Aleutian Island chain. Transcontinental flights between Anchorage and the Orient refuel at Shemya, near the western end of the Aleutian chain.

91. Numerous airlines and private operators within the area act as feeders to the scheduled flights and provide charter service to almost any location. Some fifteen landing strips shown on plate 9 are available, and it is common practice for small wheel planes to use the ocean beach for a landing strip to reach many other localities. The numerous lakes, rivers, and bays make possible the extensive use of amphibious or pontoon-equipped planes where landing strips are not available. Cold weather does not seriously hamper the planes since they are readily equipped with skis for winter operation. The fishing industry utilizes air transportation particularly for carrying personnel to and from the various scenes of operations each year. The U. S. Fish and Wildlife Service operates a fleet of amphibious and pontoon planes in connection with enforcement of fishing regulations and control of propagation.

92. Fisheries - Soon after acquisition of Alaska, Americans started developing the fishing industry in Southwestern Alaska by salting salmon for market at Karluk. From this beginning the industry grew until by the year 1890 there were five canneries operating and producing an annual average output of about 500,000 cases of canned salmon. This expansion continued to the point where the average annual pack from 1942 to 1951 amounted to 1,784,000 cases valued at more than $32,000,000. This was 41 percent of the pack for all of Alaska during the same period.

93. Salmon fishing is the only natural resource that has been extensively developed. It is worthy of note that this development has

been by interests outside the Territory with practically all non-resident ownership of canneries and more than two-thirds of the personnel connected with the industry imported each year for the duration of the fishing activities.

94. The species of salmon found are, in order of preponderance, sockeye (red or blueback), pink (humpback), chum (kita or dog), coho (silver), and king (chinook). This resource owes its existence to the many lakes and river systems which combine to form ideal spawning grounds for the salmon runs. The size of these runs fluctuates widely, but they continue to survive in sufficient numbers to support the industry and furnish the native population with their basic food supply. However, Aquatic Biologists have expressed the opinion that the catch can not be increased and maintained on a sustained yield basis without exercising absolute control of the escapement necessary to maintain the spawning grounds at their maximum capacity. Some increase in yield could be achieved by opening new spawning areas, by removal of natural barriers, and by providing fish ladders at strategic points.

95. The fishing grounds have been divided into five geographical fishing districts for statistical purposes. They are designated as Bristol Bay district, which includes the estuaries of Nushagak, Kvichak, Naknek, Egegik and Ugashik Rivers; Alaska Peninsula Northside district, which includes the water on the north side of the Peninsula westward from the Bristol Bay district; Alaska Peninsula Southside district, which includes the water along the southside of the Peninsula except the Chignik Bay area; Chignik district includes the waters in the vicinity of Chignik Bay; and Kodiak district includes all of the waters contiguous to the Kodiak Island group.

96. The Bristol Bay district produces approximately 47 percent of the volume and 55 percent of the value of salmon packed in Southwestern Alaska. The fact that over 90 percent of the pack are sockeye (reds), which command a higher price, accounts for the greater percent of value. In 1952 there were operating in the area 22 land-based canneries, 4 floating canneries, 19 freezer ships and 3 mild-cure salteries. The total canned salmon pack for the district in 1952 amounted to some 748,000 cases, which was about 90 percent of the 10-year averages from 1942 to 1951. The commercial season usually opens the latter part of June and extends for about 30 days with intermittent closures to permit escapement. Thus the activities are concentrated in a short period of time.

97. Over 1000 fishing boats are annually engaged in this district, 90 percent of which are owned by the cannery companies. Prior to 1951, the use of power boats was prohibited. Removal of this restriction now permits the use of any type of boat and, with the introduction of gasoline powered boats, a shift to private ownership is taking place. With more privately-owned boats, local interests are anticipating expansion to include offshore bottom fishing. This would extend fishing throughout the ice free period of each year and provide increased revenue and add to the nation's food supply.

98. The Alaska Peninsula Northside district contains one land based cannery and one floating cannery, both located at Port Moller. The average annual output of these two canneries amounts to about 39,000 cases of predominately red salmon. The 1952 pack amounted to 88,500 cases.

99. The Alaska Peninsula, Southside, exclusive of the Chignik Bay area, supports canneries at False Pass, King Cove, Unga, Sand Point and Kukak. In addition two floating canneries usually operate

within this district. The average annual pack for the period 1942 to 1951 amounts to about 285,000 cases of which 130,000 were pink and 71,000 red salmon. In 1952 the pack totaled 249,000 c ases.

100. Two canneries are operated in the Chignik Bay district, accounting for an average annual pack of about 97,000 cases of which 60,000 are red salmon. The 1952 pack was 88,500 cases, of which 50,000 were chums, 23,500 pinks, and 15,000 reds.

101. The Kodiak district is the second most productive district. The average annual contribution of canned salmon is about 30 percent of the total for Southwestern Alaska. This district consists of 18 companies operating 16 processing and packing plants. The average annual production is about 527,000 cases, of which 69 percent are pink salmon. The 1952 pack totaled some 482,000 cases.

102. Landings of halibut from this district have been recorded, beginning in 1944 with 2.5 million pounds increasing to 4 million pounds in 1951. During the same year 100,000 gallons of fish oil and 700 tons of fish meal were produced. Production of canned clams started in 1951 with 17,000 cases of 48 one-half pound flat and 105 cases of 48 one-pound tall tins. Further development of the clam industry is being delayed by a prolonged dispute between fishermen and cannery operators as to an equitable price for the unprocessed clams.

103. The following tabulation shows the average annual pack of canned salmon, over the 10-year period from 1942 to 1951 inclusive, by volume and value, and the comparison by volume and value for all of Alaska.

SOUTHWESTERN ALASKA AVERAGE ANNUAL CANNED SALMON PACK

From Tabulations in

Pacific Fisherman 1952 Yearbook
10-Year Period 1942-1951

Cases - 48 1-pound cans

| District | Reds | Pinks | Chums | Cohoes | Kings | Total |
|---|---|---|---|---|---|---|
| Bristol Bay | 784,196 | 2,130 | 35,482 | 2,541 | 11,357 | 835,706 |
| Alaska Peninsula - North Side | 27,325 | 1,075 | 9,970 | 1,024 | 135 | 39,529 |
| Alaska Peninsula - South Side | 70,841 | 129,822 | 74,896 | 8,372 | 845 | 284,776 |
| Chignik | 59,686 | 23,643 | 12,929 | 864 | 242 | 97,364 |
| Kodiak Area | 97,374 | 363,637 | 58,744 | 6,300 | 882 | 526,937 |
| Total 10-Year Average Ann. | 1,039,422 | 520,307 | 192,021 | 19,101 | 13,461 | 1,784,312 |
| Percent | 58.3 | 29.2 | 10.7 | 1.1 | 0.7 | 100 |

Comparison of Southwestern Alaska to Total Alaska Average Annual Pack - Volume

| | | | | | | |
|---|---|---|---|---|---|---|
| Total Alaska | 1,320,000 | 1,994,000 | 738,000 | 224,000 | 51,000 | 4,327,000 |
| Southwestern Alaska | 1,039,000 | 520,000 | 192,000 | 19,000 | 14,000 | 1,784,000 |
| Percent - Southwestern Alaska | 78.7 | 26.0 | 26.0 | 8.5 | 27.5 | 41.2 |

Comparison of Southwestern Alaska Average Annual Pack - Value in dollars

| | | | | | | |
|---|---|---|---|---|---|---|
| Total Alaska | 28,617,0000 | 26,780,000 | 9,389,000 | 4,206,000 | 1,145,000 | 70,137,000 |
| Southwestern Alaska | 22,525,000 | 6,984,000 | 2,442,000 | 357,000 | 314,000 | 32,622,000 |
| Percent - Southwestern Alaska | 78.7 | 26.0 | 26.0 | 8.5 | 27.5 | 46.5 |

Average value per case

| | |
|---|---|
| Total Alaska | $16.20 |
| Southwestern Alaska | $18.28 |

104. The Pribilof Islands, important as the breeding grounds of the Pacific Ocean fur seal, have been included in the subject report area, although they are located in the Bering Sea, about 250 miles northwesterly from Dutch Harbor in the Aleutians and about 310 miles southwesterly from Cape Newenham on the mainland. St. Paul and St. George are the only inhabited islands of this group and gain their economic importance from the fur seal industry that has been established thereon.

105. When the Pribilof Islands were discovered in 1787, the number of seals in the herd was approximately 3 million animals. During the next century intensive sealing reduced the herd almost to extinction. The annual catch declined from 165,000 in 1868 to only 13,000 in 1910. This was due chiefly to pelagic sealing, or killing the seals at sea, which resulted not only in the death of the mother seals but of the pups as well, from starvation.

106. In order to reestablish the fur seal herd, the United States Government took over its direct management in 1910 and on July 11, 1911, the United States, Great Britain, Russia and Japan reached an agreement known as the North Pacific Sealing Convention, which outlawed pelagic sealing. Japan, claiming that the seals were damaging her fishing industry, abrogated this agreement on October 23, 1941. In December of 1942 the United States and Canada entered into an agreement to protect the seals. Under this international agreement the United States is responsible for the fur seal industry, and 20 percent of the skins taken go to Canada.

107. The U. S. Fish and Wildlife Service conducts the scientific studies of the migratory and feeding habits of the fur seals and manages the annual operations of slaughtering, skinning, and extracting the meal

and oil by-products, which is done on the islands. Male seals, chiefly three-year-olds, are selected for killing. The slaughtering and skinning is done by Aleut Indians who live on St. Paul and St. George Islands. A private company in St. Louis, Missouri, under contract with the Government, cures, dresses, dyes, and finishes the skins, which are then sold at public auctions held in St. Louis twice yearly.

108. The 1952 take of skins was 63,870, approximately equal to the average annual yield over the past 10 years of 64,264 skins. In the year ending June 30, 1952 a total of 47,042 skins was sold which brought a gross sum of $4,035,531.46. In addition, 39,866 gallons of seal oil and 351 tons of meal brought gross returns of $36,996.44 and $39,318.17, respectively. Since 1910 gross returns from the fur seals, and more recently seal oil and meal, have amounted to more than 26 million dollars.

109. <u>Furs and Trapping</u> - Trapping of fur animals provides a large part of the income earned by the native Indians, Eskimos, and Aleuts as well as many of the white residents of Southwestern Alaska. Although the residents engage in various occupations, principally incidental to the salmon fisheries, trapping, hunting and fishing still remain the major sources of food, clothing and cash income.

110. The principal animals hunted and trapped for fur are: black, glacier, polar and brown bear; beaver; coyote; blue,cross, red, silver, and white fox; hare; lynx; marmot; marten; mink; muskrat; otter; squirrel; weasel; wolf and wolverine.

111. The highest prices are received for marten, mink, beaver, otter, and silver fox, followed by wolf, coyote, and wolverine; but the major portion of income is derived from mink, beaver, marten, and muskrat due to the greater abundance of these species. The fur of the wolf and wolverine have little commercial value in the fur market but

are utilized by the Alaskans for parka trimming. Numerous fur farms have been established for raising mink and foxes. Many of these farms are on isolated islands to avoid cross breeding and provide safety from predators.

112. Exports and values fluctuate widely from year to year due to varying demands in the fur market and conservation regulations.

113. Minerals and Mining - The mineral resources of Southwestern Alaska remain undeveloped to any great extent, due primarily to the difficulties of transportation and lack of power. Known deposits of precious and base metals and non-metallic minerals include gold, platinum, mercury, silver, lead, copper, limestone, sulphur, pumicite and coal. Several areas may be potential petroleum fields capable of producing oil and gas in commercial quantities. Two wells were drilled about 1926 south of Becharof Lake on the southeasterly side of the Alaska Peninsula to depths of 3,000 feet and 5,000 feet without penetrating oil bearing formation. While these explorations did not result in the discovery of oil or gas, they can not be taken as conclusive evidence of non-existence of petroleum in other parts of the Peninsula. Recently, interest in petroleum has been renewed and, at present, field investigations are being carried on by private companies and drilling at several geologically favorable locations, is scheduled before the end of 1954.

114. Active current mining operations employ about 100 men and include the following:

a. Placer mining for platinum, by dredge, on the Salmon River, near Goodnews Bay. This is the only active platinum dredge mining operation in the Territory or the United States. Overburden of the work area is removed by dragline and actual mining is done by bucket dredge which processes an average of 7,500 cubic yards daily during an 8-month working season. The dragline and dredge are operated electrically with power generated at a centrally located diesel-electric plant. The entire operation furnishes employment for about 70 men.

b. Development and exploration, by trenching, of a large deposit of cinnabar near Dillingham, samples of which contain as high as 62 percent mercury. This work is being done with the assistance of a Defense Minerals Exploration Administration loan.

c. Placer mining for gold by bulldozer-hydraulic method on Portage Creek, a tributary of Lake Clark.

d. Two beach placer gold mining operations near Olga Bay, on Kodiak Island.

e. A small lode gold mining operation at Terror Bay, on Kodiak Island.

f. Development of a lead-silver lode prospect on the Kijik River, a tributary of Lake Clark.

g. Extensive development work on a copper lode prospect on Sitkalidak Island, which indicates ore in commercial quantities.

h. Stripping and mining of pumicite at Geographic Bay, within Katmai National Monument. Work on this deposit was begun in 1951 as a source of material for cement blocks being made in Anchorage.

115. Under present economic conditions only the richest portions of gold placer grounds and the highest grade lode deposits can be worked profitably. This is due to high taxes and costs of equipment and supplies, undependability and high costs of labor and the fixed price of gold, together with the lack of adequate transportation and power.

116. Coal has been found in both Upper Cretaceous and Eocene formations in the Alaska Peninsula. Partial development of lignitic and bituminous coal beds has been made at Herendeen Bay, Chignik Bay, and Unga Island. In addition, lignitic coals have been found at Kukak Bay and at other places on the Peninsula. Veins of a good quality of bituminous coal are also found on Tugidak Island of the Kodiak group. The coals of the Peninsula occur in beds which are practically horizontal, as at Unga, or thrown into open folds with some faulting, as in the Herendeen Bay and Chignik fields. The proven bituminous coal lands of the Peninsula cover an area of about 30 square miles and the known area of bituminous coal bearing formations cover about 90 square miles. The known areas of lignite bearing formation amount to about 60 square miles. These figures are, however, not significant, as but a small fraction of the total area of the Peninsula has been surveyed. It is quite possible that the total area of the coal fields may amount to many hundred square miles.

117. The commercial coal beds measure 2 to 5 feet in thickness in Herendeen Bay field, but in the Chignik field they are somewhat thinner. Lignite coal beds up to 3 feet in thickness have been found on Unga Island. Coal has been mined for many years at Chignik, and some has been taken out at Herendeen Bay for local use, but the total production from the Peninsula has not exceeded 20,000 tons.

118. Coal mining elsewhere in the Territory, has increased to where it ranks second to gold in importance. Increased plant capacities, both military and civilian, used an estimated 850,000 tons in 1953 and will require about 950,000 tons in 1954. New mines must be developed and put into production to meet these demands and it is possible that some of the coal deposits on the Peninsula may be

utilized. Another market for this coal may develop as Japan looks to Alaska as a possible source of supply to meet its growing needs.

119. The future development of the potential mineral resources of Southwestern Alaska will depend upon the creation of incentives for investment, new discoveries, improvement of transportation and development of low cost power.

120. Forestry - Forest areas are limited to portions of the drainage basins of the Wood, Nushagak, and Kvichak Rivers in the Bristol Bay region, and to Afognak Island and a small portion of Kodiak Island in the vicinity of the town of Kodiak. Of these comparatively small timbered areas, only Afognak Island has been included in the Chugach National Forest, one of Alaska's two national forests.

121. The forest of Afognak and Kodiak Islands is of the "Coast" type, which consists chiefly of western hemlock and Sitka spruce with some western red cedar and Alaska cedar. Of these, Sitka spruce is the most valuable because it has a multiplicity of uses ranging from pulp, logs, construction timbers, and lumber, to interior finish. Hemlock is used in the form of dimension lumber and timbers for buildings and makes very good flooring. Locally, the tree is in demand for piling for fish traps and wharves, where long, straight trunks are required.

122. The occurrence of this coastal type of forest on the northeasterly portion of Kodiak Island was responsible for the Russians establishing their original headquarters in Alaska at Kodiak, as this forest provided good building timber.

123. The National Forests of Alaska are administered by the Forest Service of the Department of Agriculture, with a Regional Forester headquartered in Juneau. Management of the timber resource is on a sustained-yield basis. The standing timber is offered for sale while title to the land is retained in the United States.

124. The timber located on the mainland area tributary to Bristol Bay is of the "Interior" type. Although the forests of interior Alaska are of great local value, they do not rank high in commercial importance, as do the forests of the coastal areas. They are of the woodland type and are composed of a variety of species. The most prevalent growth is a mixture of white spruce and Alaska white birch, with some aspen and balsam poplar. Timber growth is slow and the stands are light and scattered. The diameter of the old growth trees ranges from 6 to 12 inches, with a few reaching 20 inches. The best of these forests occupy the better drained soils of the valley floors, benches, and lower slopes of the mountains and seldom occur above 800 to 1,000 feet in elevation. A non-commercial type, which is predominanatly black spruce less than 6 inches in diameter, with some intermixed stunted tamarack, white spruce, and Alaska white birch, occurs on some lowland areas. Various willows also grow along the banks of streams.

125. While no extensive studies of the interior forests have been made to date, the presence of this resource within the isolated region is of great local value as it furnishes many of the pioneer needs, including logs and lumber for cabins, mining timbers, fuel, and other homestead materials.

126. Alaska birch is important, as it is one of the hardwoods with a fine grain, even texture, and is moderately heavy and strong. It finishes well and is satisfactory for furniture, flooring, molding, woodenware, and many other manufactured articles. This is the only species of the interior forest that could become of commercial importance should future demands for use of high grade birch veneers develop.

127. Practically all of the timbered areas not included within the National Forest are on public domain lands, administered by the Bureau of Land Management, United States Department of the Interior.

Free use of timber on public domain lands, outside of the National Forest, is permitted settlers, miners, and residents for their own use, but not for resale.

128. Agriculture - General agricultural crop production has not been practiced to any great extent in any of the areas covered by this report. Small gardens provide evidence that certain cultivated crops could be produced in some localities on the mainland and on some of the islands of the Kodiak group.

129. Several reasons exist for the lack of agricultural development and the principal ones are:

a. Primarily, residents have been employed in the fishing industry which occupies most of their time during the summer growing season.

b. The limited requirements of the local population have been met with fresh produce from individual home gardens and with similar produce shipped in from the United States.

c. The eruption of Mount Katmai in 1912 covered the most heavily populated eastern part of Kodiak Island with a layer of volcanic ash up to about 6 inches in depth blanketing large areas of the potential agricultural lands.

d. Executive Order No. 8344, dated February 10, 1940, withdrew the entire Kodiak Island from any form of entry, and thus has prevented further homesteading even though the combined civil and military population has increased greatly since that date.

130. In recent years the Army at Fort Greeley, and home gardeners as well, have found that excellent crops of berries and hardy vegetables can be grown after deep ploughing has mixed some of the original heavy organic soils with the present surface layer of porous volcanic ash.

131. Grazing - Meat producing livestock was first introduced to Alaska during the period of Russian colonization. Records indicate that Siberian cattle were able to subsist on natural forage with little or no care. The first American importation of cattle and sheep began in 1853 when whalers landed small herds on islands in the Aleutians to supply fresh meat for the whaling crews. These herds were abandoned within a few years, but the livestock continued to survive and in some instances multiplied despite occasional depredation. An outstanding case is the one on Chirikof Island where descendants of the original four cows and two bulls now number approximately 1,000. A company now slaughters some of these animals and ships the meat by air to Palmer for sale. Importation of new breeding stock is expected to improve the herd and it is believed that 2,000 head of cattle can be supported on the island with little or no supplemental feed. Other islands have similar possibilities and six of them each support from 50 to 100 cattle. A small beef industry has been developed on Kodiak Island. Six producers are presently engaged in this industry and run about 500 or 600 head. Marketing is a cooperative effort and the beef is consumed locally.

132. Domestic sheep were shipped to Umnak and Unalaska Islands during the 1920's by corporations in the United States, but the ventures were generally unsuccessful because of lack of interest by the non-resident owners. The experiments proved that most of the Aleutian Islands are climatically suitable for raising sheep but that the many predators consisting of bear, wolves, coyotes, foxes, and eagles are a menace to successful operations. Federal grazing authorities have stated that for the present no extensive stock raising should be attempted on the Alaska Peninsula, but should be confined to the

predator-free islands. There are currently about 5,000 head of sheep on Umnak Island, 2,000 on Unalaska Island, and about 250 on Sitkalidak, Popof, and Harvester Islands.

133. Range surveys covering that portion of Kodiak Island lying east of the Kodiak National Wildlife Refuge, Sitkalidak Island, Shumagin Island group, Sanak Island and Unalaska Island, have been made, and the total grazing potential estimated. The portion of Kodiak Island east of the wildlife refuge could support a base herd of 4,000 breeding cows in addition to marketing 3,000 head of long yearlings (20 months old) annually. Sitkalidak, Sitkinak, Spruce, Whale, and Raspberry Islands, just off the coast of Kodiak Island, would possibly carry a combined total of 4,500 breeding cows, which would produce about 3,300 head of long yearlings annually. Chirikof Island could carry 2,000 head of breeding stock and produce 1,000 head of long yearlings annually. The islands of the Shumagin group, together with Umnak and Unalaska Islands in the Aleutians could support about 4,500 head of cattle or about 27,000 sheep.

134. Cooled, unfrozen fresh meat can be transported by air from Kodiak Island to Anchorage for 4.4 cents per pound. Anchorage merchants charge 15 to 20 cents extra for unfrozen meat flown from the United States, indicating a margin of approximately 10 to 15 cents per pound in favor of Kodiak meat. Beef from Chirikof Island would have practically the same favorable margin, when operating facilities are developed.

135. It appears that a potential market for meat produce from Kodiak and vicinity exists in the interior areas of Alaska that could eventually result in a 2 or 3 million dollar annual industry.

136. Communications - The Alaska Communications System, established by Congress in 1900 as a part of the United States Army Signal Corps, processes all commercial communications to and from Alaska and

between Alaskan points. Its facilities include submarine cable telegraph, land line telephone, overseas radiophone, and radio teletype, all connected with facilities of United States and Canadian telephone and telegraph companies. Installation and business offices of the Alaska Communication System in Southwestern Alaska are located at Adak, Cold Bay, Unalaska, Kodiak, Naknek, King Salmon, Shemya, and Umnak. Radio-telephone service is available between Kodiak and Adak.

137. There are no commercial land line telephone or submarine cables directly connected to any point in Southwestern Alaska. The town of Kodiak is served by a local telephone company. The Navy and Air Force each maintain a separate communication system. The Civil Aeronautics Administration operates radio-telephone services for airplane operation and services many localities where there are no other means of communication. There is also considerable inter-communication by amateur radio-telephone operators.

138. Miscellaneous Manufacturing. - Although there has been a rapid population growth during recent years, it has not been due to, nor has it resulted in, the establishment of any basic manufacturing industries. The area possesses potential resources in the form of certain types of timber in a portion of the area, deposits of various minerals, coal and waters capable of power generation.

139. Establishment of heavy industry and manufacturing will require a supply of low cost power and improvement of transportation facilities. In the event such power is made available, new opportunities would be created for industries such as the manufacture of lumber products, milling and smelting of base ores and minerals and fabrication of some of these materials. Water transportation is available at many locations for the shipment of raw materials and products from and to world markets.

140. Miscellaneous Service Industries - The present service industries located in the principal communities of Southwestern Alaska furnish the essential but limited requirements of the populace. Some of the more recent establishments are due to military activities and depend to a great extent upon the trade of the military personnel for their existence. This has resulted in a ratio of service to non-service industries which is higher than the usual average of 1.2 to 1.

141. Kodiak, the only first class city in the report area, was incorporated in 1940 and has all of the facilities usually found in a city of its size. Dillingham is the second largest town and has two hotels, two restaurants, three general stores, one hardware and appliance store, and one bakery. Outside of these two principal communities the smaller settlements and villages are generally served by a trading post or general store where the bare essentials may be obtained. Meals and lodging can generally be had at roadhouses.

142. Transportation lines, both air and water, are of prime importance as they provide the only means of ready access to and from the otherwise isolated areas. These services are available in nearly all of the larger settlements and planes or boats may be chartered for trips to out of the way places. Air transportation has, in recent years, been expanding and should continue to do so as there is a definite need for this type of service. The time saved in transportation of perishables, spare parts, mail and passengers is becoming more important to the expanding communities. The future development of this portion of Alaska is dependent, to a great extent, upon the extension of this service.

143. Limited opportunities exist for the establishment of a few small service industries as practically all manufactured goods are imported. The few exceptions are the custom made parkas, moccasins,

jackets and gloves produced in small shops and the ivory carvings of the natives. Boatbuilding, furniture making and manufacturing of various wooden products could be established in certain locations where spruce and birch timber is available. A growing need exists for lodges and improvement of facilities and incidental services in the outlying areas in order to accommodate the increasing tourist trade. As the few miles of interior roads are extended, a greater opportunity for automotive travel will be afforded necessitating service stations, garages, and motels.

144. Recreation - Southwestern Alaska possesses unusual attractions for the tourist, sportsman, and recreationalist and the possibilities for development along these lines are practically unlimited. The scenic grandeur of the glacier rimmed high mountains peaks, Katmai National Monument with its active volcanoes, many large lakes, numerous streams and rivers and rugged coast lines combined with the wildlife afford varied interests for all classes of travelers.

145. Hunting the Kodiak or Alaska brown bear attracts many nonresident sportsmen, and it has been estimated that from 140 to 180 of these prized trophies are taken in the vicinity annually and that each hunter spends about $1,800 while in the area. In addition these hunters spend about $25,000 each year on transportation and other items.

146. Practically all of the lakes and streams throughout the report area are abundantly inhabited with Rainbow, Dolly Varden and Mackinaw trout and Alaska Grayling. Annually, about the first of July, sockeye and king salmon enter the rivers and run up into most of the lakes and small tributaries to spawn. Sport fishing for all of these species, in season, is exceptionally good and is attracting an ever increasing number of anglers each year.

147. The development of air transportation and accommodation facilities is making the various attractions more accessible for the tourists. At present there are five fishing camps, conducted and served by an airline company making flights from Anchorage and King Salmon. These camps, all with first class accommodations, are located at Brooks and Colville Lakes, within Katmai National Monument, and at Nonvianuk, Kulik and Battle Lakes, all on the Alaska Peninsula. During July 1953 a daily average of 22 persons were being flown in to these fishing camps.

148. The lake chain north of Dillingham has not been developed commercially or otherwise, and, as in the major portion of Southwestern Alaska, tourists and sportsmen desiring to enter this area must do so on individually organized charter flights making their own arrangements for provisions and camp facilities.

149. Many opportunities exist throughout the report area for development and expansion of transportation and accommodations to serve the tourist trade. The revenue that may be derived from this source could eventually become one of the principal incomes of the area.

150. Power - The present use of electric power in the area is confined principally to domestic loads at the population centers and to seasonal semi-industrial loads at the fish canneries, there being as yet no users of large blocks of industrial prime power. The principal generation of power is by gasoline or diesel driven portable or semi-portable plants of small capacity which serve single houses or houses in small groups. Larger semi-portable units are used at the canneries which operate only during the short canning season. The largest single purpose power plants are those at the military installations where several units are usually placed in one plant to serve the variable power requirements. At one such plant twelve 100 kilowatt units provide a total capacity of 1200 kilowatts. The Rural Electrification Administration

has recently constructed a 580 kilowatt diesel powered plant at Kodiak which supplies power to the town of Kodiak and the immediate environs and has permitted retirement of most of the smaller portable units in the vicinity. The mining operations of Goodnews Bay at Platinum include a diesel driven power plant with a total installation of 2250 kilowatts in three units of 1,000, 750, and 500 kilowatts.

151. The cost of generation from these plants varies from about 14 cents per kilowatt-hour from the larger units to an average between 25 and 35 cents per kilowatt-hour for power generated by the smaller gasoline driven units.

152. The total capacity of the plants in any one locality is rather indeterminate as new portable units are brought in, or plants taken out, as population shifts occur. An inventory in 1952 showed a total generating capacity of about 6,000 kilowatts in the Nushagak Bay - Dillingham area and approximately the same total capacity in the Kvichak Bay area. The 2250 kilowatt plant at Platinum constitutes practically the entire capacity of the Goodnews area and the capacities at the other centers of Kodiak, Dutch Harbor and Adak are indeterminate as much of it is in variable military plants. The total installation in all of Southwestern Alaska is about 25,000 kilowatts.

153. The future power requirements of Southwestern Alaska depend upon many factors which cannot be accurately forecast at this time. A gradual growth of power load will occur as the population increases. Some additional load may also be expected as new fishery products are exploited, but this would be relatively insignificant. Any large additional demand for power would hinge upon the development of some new industry. Such new industry might be based upon the development of known mineral deposits or upon new discoveries of rich or strategically

important ores. A further demand for large amounts of power might stem from the establishment of new processing industries attracted to this region by the availability of a big block of relatively low cost power.

154. The potential for further growth does exist and it is reasonable to assume that some new industries will develop and that their power needs will be supplied by hydroelectric power plants. The actual amount of electric power load which might develop in the near future cannot now be estimated but could equal or exceed the hydroelectric potential of the region.

155. Public Lands and Reservations - This report covers an area of approximately 71,000 square miles, of which about 58,000 are included in the Alaska Peninsula and the mainland, 7,000 in the various islands of the Aleutians and 6,000 in the Kodiaks. More than 99 percent of this area is in Federal ownership. Katmai National Monument, on the Alaska Peninsula, contains about 4,215 square miles. Afognak Island containing about 733 square miles is included within the Chugach National Forest. Numerous islands have been set aside as wildlife refuges for Alaska brown bear, moose, elk, caribou, mountain goats, and other game animals and wild fowl. In addition, there are various withdrawals for military purposes, land classification and surveys. Only a fraction of one percent of the total land area, such as towns, homesteads, home sites, and mining claims, is in private ownership.

156. The National Forest is under the jurisdiction of the Department of Agriculture and is administered by the Forest Service with headquarters at Juneau. The balance of the public domain is administered by the Department of Interior, through the Bureau of Land Management with headquarters at Anchorage. Unappropriated lands of the public domain are open for entry and filing for homesteads, home sites,

manufacturing sites, and mining claims. The United States holds title in reserve for the future state to all shore lands of navigable streams below the line of ordinary high water. These lands are not held to be public land, and no title or leases can be conferred under the public land laws. Although jurisdiction over these lands lies with the Secretary of the Interior, permits for construction must be obtained from the Secretary of the Army in order to prevent possible interference with navigation.

157. Water Laws - Alaska has not adopted a water code or a system of water laws, nor has any legislative authority been created to date for the formation of water control districts, similar to those in effect in the western United States, to govern the appropriation and use of water and the administration of established water rights. Appropriations are made by diversion and use, but the laws of the Territory do not require the posting or recording of notice of appropriation of water, and formal notice is not essential to the validity of an appropriation.

## SECTION IV - PROBLEMS

158. Navigation - Waters on the Pacific Ocean side of the Alaska Peninsula and around the Kodiak Islands, in general, provide adequate depths and ample steerage way for ocean going vessels serving that region but approaches are exposed to the open sea. Port facilities are considered adequate for the foreseeable volume of commerce, although some of the cannery wharves can be approached only at favorable stages of tide. Kodiak Harbor is the only port used to any extent except during the commercial fishing season.

159. Small boats and fishing craft operating in the Pacific Ocean side of the Alaska Peninsula are subject to many hazards. While natural shelters for small boats are available, they are not always easily accessible. It is often necessary for fishing boats to run long distances to shelter where they can ride out the sudden severe storms natural to this area. There are many passages among the off-shore islands where navigation is made hazardous by fog, high winds, and fast treacherous currents. None of the many communities that have grown up adjacent to the fisheries have adequate moorage for small craft and only at Kodiak has a small boat basin been proposed.

160. The regular approach to Bristol Bay is through Unimak Pass, although small boats may use the narrow passage at the westerly end of the Alaska Peninsula on favorable tides. The waters of the Bay are open to navigation only during the ice free period which usually extends from May through October.

161. Bristol Bay proper has been only partially surveyed. Reconnaissance lines along the regular steamship routes from Unimak Pass to Kvichak and Nushagak Bays disclose no dangers, but extreme caution must be used in approaching the shores. There are few navigation aids;

the shores are low, without distinctive features, and the high mountains and volcanic cones extending along the Peninsula are obscured by fog much of the time.

162. Kvichak Bay is navigable for deep draft vessels as far as the anchorage, which is about due west of the entrance of the Naknek River. The approach to the anchorage is limited by extensive tide flats extending off both the east and west shores. These flats are dangerous and a number of fishermen have been lost when trapped by a falling tide. Numerous shoals exist north of Naknek River and local pilots are needed to proceed beyond that point. High winds opposed to fast currents, and at maximum ebb, the confluence of discharge from the Naknek and Kvichak Rivers causing overfalls, are both dangerous to light draft vessels in the Bay. It is common practice to avoid all movement of vessels north of Naknek River at lower stages of tide or on a falling tide.

163. Nushagak Bay is obstructed by extensive shoals off the shores, and by long bars, partly bare at low water, which generally extend in the direction of the channels. In the absence of aids, navigation is safe only in the daytime. The worst danger of approach is the shoals which extend southeastward from the mainland for a distance of 8 or 9 miles. Bars and channels in the upper bay and river change considerably with the ice run-out each year and are subject to constant gradual change due to action of current and the sea. Vessels drawing 23 feet have ascended the bay on high tide to anchor off the town of Dillingham but this is not common practice because of the constantly shifting channels.

164. The area west of Nushagak Bay is unsurveyed and there are indications that the navigation charts are considerably in error. Thick

weather frequently prevails in the area and safety is assured only by constant sounding.

165. There are no deep water ports in Bristol Bay so that all cargo is lightered ashore. Extreme tides range from 26 feet above mean lower low water to minus 4.5 feet. Cannery wharves and other private wharves can be used only at high tide by shallow draft vessels as many are dry at low water.

166. Fishing boats, cannery tenders and other small craft ply the waters of Bristol Bay but are subject to the many hazards of this region. Sheltered anchorage is available on the northwesterly side of Unimak Island for all types of vessels and refuge is available for small boats at numerous river entrances and in the lee of various islands. However, the use of these harbors of refuge is limited since they are uncharted and navigation aids for the most part do not exist. Nushagak and Kvichak bays offer no shelter from winds from the east and south. Lagoons along the shores of the bays provide some protection but they can be entered only at high tide and are dry at low water. The several rivers which discharge into Nushagak Bay can be entered only by small boats.

167. Navigation on several of the river systems is possible by small boats. The Kvichak River, flowing from Iliamna Lake to Kvichak Bay is navigable during the ice free period to launches of 3 to 4-foot draft, except during low water when the controlling depth is about two feet. The upper portion of the river flows about three miles per hour and is broken by islands and bars into narrow shallow channels. The lower reach is in a single channel and is tidal.

168. The mouth of Naknek River is over a mile wide and is filled with shoals and banks which extend outward three or four miles. With

local knowledge, boats of 4-foot draft can enter the river at half tide. Craft drawing up to 12 feet can proceed up river at flood tide to King Salmon, some 18 miles from the mouth. Aside from the entrance light, there are no buoys or range markers on the entire river. The channel is crooked and contains some boulders which are dangerous to navigation except by pilots with intimate local knowledge. Beyond King Salmon, boats of 3-foot draft can proceed to the gorge at the head of tidewater about seven miles below Naknek Lake. The channel through the gorge is about three miles long, crooked and boulder studded with swift flowing water and can be navigated only by high powered, shallow draft river boats. Above this reach, and into the lake there are no navigation hazards.

169. Nushagak River is navigable for 100 miles by launches with $2\frac{1}{2}$-foot draft and beyond that for another 100 miles by small boats with outboard motors.

170. Wood River is navigable to Aleknagik Lake, a distance of 24 miles, with a controlling depth of $2\frac{1}{2}$ feet at low water. The lake is navigable throughout its entire length.

171. Navigation among the Aleutian Islands is made difficult by lack of surveys, thick weather, strong winds and ocean currents. Fog prevails a great portion of time. Winds have been recorded in excess of 100 miles per hour. Currents are highly complex and unpredictable and whirls and eddies further complicate the problem. In general, the coast lines are bold with many off-lying islets, rocks, and reefs. Water is usually deep, close to shore. Beaches are rocky and narrow and undertows are especially dangerous to small boats attempting a landing. Except for the military installations, there are no settlements of sufficient size to create a demand for deep-draft commerce.

The limited cargo for the native villages is delivered by shallow draft coastal vessels. Many of the islands afford partially sheltered anchorage in natural harbors on lee shores for the limited number of small craft in the island trade.

172. Citizens of Dillingham have requested that the Corps of Engineers construct a small boat basin in their vicinity. Steamship companies and cannery officials have expressed a desire for installation and maintenance of navigational aids. Fishing interests have requested that roadstead regulations be set up which would regulate movement of traffic in Bristol Bay to the end that fishing operations would not be interrupted. Residents of the Kvichak Bay area have requested that the Corps of Engineers improve the channel of upper Kvichak River in the interest of navigation. There has also been some mention of a water way across the Alaska Peninsula.

173. Power - The present electric power loads in the population centers in Southwestern Alaska are small, and generating capacity to meet these loads has been maintained by adding small gasoline driven or diesel driven generators as the loads have grown. As a consequence, many small inefficient plants are providing the power and the costs are very high. A direct result of these high rates is to limit use to essential purposes with no inducement to increase domestic or industrial uses.

174. A major problem confronting these communities is one of developing power at a cost low enough to stimulate industrial expansion and in sufficient quantity to provide reasonable surplus for all other needs. The village of Dillingham is particularly faced with this problem. The present group of small plants furnish electric power in the village at costs between 25 and 35 cents per kilowatt-hour and consideration is

being given to the construction of a larger diesel driven unit which will provide power at about 15 cents per kilowatt-hour, a rate still much too high to stimulate extensive use.

175. The dredging operations at Platinum are limited by the capacity of the installed diesel driven generators. The cost of generation is absorbed in the dredging costs but an adequate supply of cheaper power would permit expansion of the operations.

176. A somewhat similar condition exists at the town of Kodiak where a recently installed diesel driven unit has permitted retirement of some of the more expensive smaller units and reduced the average cost of power materially, but the rates are still too high to encourage industrial expansion. The high cost of motive fuel and Alaskan labor will always reflect in high power rates in this type of generation.

177. Potential hydroelectric projects exist within nominal transmission distances of the centers, 100 miles from Platinum, 55 to 100 miles from Dillingham and from 20 to 100 miles from Kodiak, and these projects would provide power at much reduced rates. Transmission of the power in the mainland area will offer no great difficulty.

178. Recreation - The water resource projects being investigated for this report would have little adverse effect upon recreational resources. Southwestern Alaska in the natural state has much to offer for development of this basic industry and the existence of many large lakes, streams, and rivers eliminates the need for artificial fresh water reservoirs.

179. The potentialities are beginning to be recognized and recreationalists are already taxing the existing facilities. The principal needs of this growing industry are improved transportation to the remote areas, establishment of additional hotel and lodge

accommodations, and enlargement of facilities. The facilities that might be provided in connection with water resource development would be minor compared to the over-all needs of the industry.

180. Fish - Practically all of the lake, stream, and river systems are inhabited with large numbers of resident trout and grayling. These waters also support large runs of anadromous fish composed principally of sockeye and king salmon and are the spawning grounds essential in maintaining the important fisheries of this region. Any plans for development of water use projects warrant special consideration in order that adequate provisions may be made for the passage of fish and perpetuation of the runs. No project recommended for construction in this report would adversely affect fish migrations.

181. Wildlife - Several species of wildlife inhabiting Southwestern Alaska are of local, commercial, and recreational significance as they provide food and furs for the residents and trappers, attract many sportsmen into the area and furnish a source of revenue to guides, outfitters, and transportation interests. Preservation, management, and proper utilization of this resource is of primary importance.

182. Water resource development currently proposed by the Corps of Engineers would not adversely affect the wildlife of the region. However, if in the future construction of reservoirs should become feasible, some feeding and nesting areas might be inundated. Under such circumstances thorough investigations would have to be made by the U. S. Fish and Wildlife Service and the Territorial Department of Game in order to determine the full effect such construction might have on the wildlife and what corrective measures might be required.

183. Water Supply -In the mountainous portions of the area no problem exists with respect to water supply as pure surface water is

available within reasonable distance and in sufficient quantities to meet the present needs of all communities. A somewhat different condition exists, however, in the low lands contiguous to Bristol Bay. In this area potable surface water is sometimes difficult to find and attempts to develop underground sources by wells have not been entirely satisfactory. Extensive water systems involve high costs due to the need for protection from subfreezing temperatures. This situation is not now serious because of the small size of most communities but should any large scale development take place in the future this problem may become acute.

184. Sedimentation - Tidal action in the coastal waters of Kvichak and Nushagak Bays constantly agitates the silt and causes the shifting of bars and channels. These unpredictable changes are obscured by the silty water and constitute a serious navigation problem in this area. The selection of sites for the construction of small boat harbors or other aids to navigation must give consideration to this problem in order to reduce maintenance costs.

185. Heavy sediment loads are carried by many of the streams in Southwestern Alaska, but this does not create a problem under the present degree of development. The construction of power dams or other hydraulic structures on these streams would require extra storage or other special provisions if they are to function properly.

186. Seaplane Operation - Planes provide a significant part of the transportation in Alaska and especially in the area under consideration in this report. Seaplanes are widely used because of their adaptability to the topography. While rough terrain limits the areas suitable for emergency landing of wheel planes, the numerous lakes, rivers, and tidal waters provide many safe landing sites for seaplanes. However,

as in the case of small boats, facilities for loading and unloading passengers and cargo, as well as for protected storage of planes, are inadequate.

187. Flood Control, Irrigation and Drainage - There are no areas for which flood control, irrigation or drainage is now needed or anticipated in the foreseeable future.

188. Stream Pollution and Malaria Control - Pollution of streams is not at present a problem because of the low population density and absence of industry. The malaria-carrying mosquito has not been reported in Alaska.

189. Existing and Authorized Projects - Three projects in the area under consideration in the report have been adopted to facilitate navigation.

a. Kodiak Harbor - Authorized by River and Harbor Act of August 30, 1935 and modified by the River and Harbor Act of October 17, 1940, provides for a channel between Near Island and Kodiak Island 22 feet deep and 200 feet wide. The project is complete except for a portion easterly of Kodiak where the controlling depth is 21 feet over a width of 160 feet. Costs to date have amounted to $12,145 for new work and $3,458 for maintenance.

b. Egegik River - Authorized by Act of August 30, 1935 provides for a channel 100 feet wide, five feet deep and about 2,500 feet long through the rapids at the head of the river by the removal of obstructing boulders. The project was reported as completed in January 1941 to a depth of three feet, which was found to be the controlling depth for the river beyond the limit of the project. Costs to date have been $4,441 for new work.

c. Iliuliuk (Unalaska) Harbor - Authorized by Act of June 20, 1938 provides for removal of a rock in the harbor entrance to provide a channel not less than 350 feet wide and 25 feet deep. The project was completed in December 1940. The total cost to date amounts to $66,036 for new work.

190. No flood control projects have been either constructed or authorized for construction by the Corps of Engineers in the area under consideration in this report.

191. Other Improvements - Projects for improvement of water use, provided by other Federal agencies and by private or community interests include the construction of a wharf and marine ways at King Salmon on the Naknek River by the Fish and Wildlife Service; construction of a pioneer type road as a portage between Iliamna Bay and Pile Bay at the head of Iliamna Lake by the Alaska Road Commission; construction of a portage road from Portage Bay to Becharof Lake by the Alaska Road Commission; the installation and servicing of a limited number of navigation aids in the coastal waters by the U. S. Coast Guard; the provision of terminal facilities to accommodate ocean going vessels at Kodiak by local private interests; and the provision of wharves at various canneries by private interests.

192. Public Hearings - A public hearing relative to the proposed small boat harbor improvements was held in Kodiak on August 5, 1946. Testimony at the hearing described the inadequacy of existing small boat facilities and presented benefits which would be derived from a protected small boat basin. An informal hearing with local interests was subsequently held in Kodiak on March 20, 1951 and numerous contacts with local authorities, indicated a continued need for a protected small boat harbor at Kodiak.

193. A public hearing was held at Naknek on August 7, 1946 relative to the proposed improvement of that portion of Upper Kvichak River known as Kaskanak Flats. The hearing was attended by representatives of several Federal Agencies, the salmon canning industry, local airlines, transportation firms, fishermen, and business men. The proposal would involve dredging and straightening the channel for a distance of about six miles to permit movement of freight during low water periods.

194. A public hearing was held at Dillingham on September 17, 1952 relative to desired improvements in the Bristol Bay Area. The hearing was attended by local business men and fishermen who requested construction of a small boat harbor at Dillingham. No definite plan was presented but two different sites were proposed. The testimony indicated that the need for a protected harbor is based upon the expected increase in the number of privately owned fishing boats. The increase is expected as a result of the change in regulations which permit the use of powered fishing boats.

195. Informal contacts with shipping interests indicate a need for improvement to the Naknek River in the interest of navigation.

## SECTION V - PLAN OF IMPROVEMENT

### POWER

196. Introduction - The hydroelectric power potential of Southwestern Alaska is one of its great natural resources and constitutes an asset available when needed. The terrain of the mainland portion of the area is favorable to power transmission so that power might be generated at many favorable localities and made available to any point within the area. Should large mining or industrial demand develop, power in amounts up to 300,000 kilowatts prime could be produced.

197. The development of a dependable hydroelectric power supply in Alaska will be affected by factors not generally encountered in continental United States. The importance of the fishing industry to the Alaskan Territory at this time endows the migratory fish with primary rights to the spawning areas in the rivers and lakes. Power development is practical only on those streams and lakes which are inaccessible to the migrating fish or on those where ladders or other facilities can be placed so as to positively permit the passage of the fish without serious opposition.

198. In some parts of Alaska, power plants can be placed only at locations where the conditions will permit the water to remain in an unfrozen state while in storage, in the flow line, and in the reaches below tailwater of the power plant. During a protracted cold spell, danger exists that water released through a power plant will freeze in the channel below the plant, causing an ice dam. Continued water release would only aggravate the condition by making the ice dam bigger until the plant would become inoperative. At such localities, successful continuous operation could be effected by

withdrawal of water from deep storage below an ice sheet and the tail-water discharged beneath a protecting ice sheet in a lake or in a channel protected throughout its length to tidewater.

199. Power - Bristol Bay System - The major power potential in the Bristol Bay area is concentrated in two general areas of the basin. One is the lake area extending about 100 miles north of Dillingham in the upper drainages of the Nuyakuk and Wood Rivers, tributaries of the Nushagak River, and the second is in the region around Iliamna Lake in the headwaters of the Kvichak and Naknek Rivers and some of their tributaries.

200. There are eleven lakes in the chain above Dillingham beginning with Aleknagik Lake at elevation 34 and ranging up to Nishlik Lake at about elevation 1035. The lakes lie in glacial cuts, roughly parallel to each other with their major axes in easterly, or southeasterly directions. Soundings indicate that all of the lakes are at least 300 feet deep. This condition makes the lakes very satisfactory for storage as the great depth will delay the initial surface freezing until quite late in the season.

201. The lower lakes in the Wood River chain are important salmon spawning areas. Lakes Nerka and Beverley appear to support the greater part of the runs. Preservation of these fish runs is made a prime consideration in the power system development as listed in the following inventory. Fish facilities are included in all projects where fish runs presently exist or have existed in the past and no developments are proposed on the streams or lakes of the more important spawning areas.

202. Projects are enumerated on only six of the Wood River - Tikchik Lakes chain. Lakes Aleknagik and Chauekuktuli lack adequate heads, Lake Mikchalk is by-passed by the power tunnel between Lakes

Kulik and Beverley and Lakes Nerka and Beverley are omitted from present consideration in favor of the salmon runs so no projects are planned on these lakes. If at some later date adequate methods are found to preserve the major fish runs, the development of a final step in the power system may become feasible. A low dam on the Agulowak River out of Lake Nerka which would raise Lake Nerka to the present elevation of Lake Beverley and a short tunnel diversion of the flow to tailwater in Aleknagik Lake would develop about 24,000 kilowatts of prime power at nominal cost. This project however is not included in present inventories.

203. Developments of the Wood River - Tikchik Lakes chain is planned on a system basis in which the lower plants of the system receive and utilize the flow regulation secured at the upper plants. Nishlik Lake at the head of the chain and Grant Lake on a tributary flow are the only plants that will not be aided by such regulation. This group of projects is ideal for step development which will probably be most advantageous to conform to the growing power requirements in the use areas as the territorial developments increase. Grant Lake would probably be the initial project in the Wood River - Tikchik Lakes system followed by Nishlik Lake, Upnuk Lake, Chikuminuk Lake, Nuyakuk Lake and Lake Kulik in turn. Grant Lake would have an initial prime power output approximately equal to the present power requirements of Dillingham and the adjacent Nushagak Bay area.

204. The feasible potential projects are listed in the following tabulation with a brief description in the paragraphs that follow:

POTENTIAL POWER PROJECTS - MAINLAND

| River System | Project Unit | Prime * Capability KW | Installed Capacity KW | Estimated Generation Cost in Mills Per KW-Hour |
|---|---|---|---|---|
| Wood River | Grant Lake | 2,900 | 5,800 | 18.1 |
| Tikchik Lakes | Nishlik Lake | 2,200 | 4,400 | 19.8 |
| " | Upnuk Lake | 5,850 | 11,700 | 11.1 |
| " | Chikuminuk Lake | 29,400 | 58,800 | 10.5 |
| " | Nuyakuk-Tikchik Lake | 45,500 | 91,000 | 8.2 |
| " | Lake Kulik | 21,400 | 42,800 | 14.9 |
| | Project subtotals | 107,250 | 214,500 | 10.7 (Av.) |
| Kvichak-Naknek | Lake Kontrashibuna | 10,400 | 20,800 | 10.3 |
| " | Tazimina Lakes | 37,900 | 75,800 | 10.1 |
| " | Ingersol Lake | 35,800 | 71,600 | 14.1 |
| " | Kukaklek Lake | 64,300 | 128,600 | 8.9 |
| " | Kulik Lake (Alagnak Riv) | 3,500 | 7,000 | 10.8 |
| " | Grosvenor Lake | 11,300 | 22,600 | 12.5 |
| Grecian | Crescent Lake | 30,000 | 60,000 | 9.6 |
| Subtotal Iliamna-Lake Clark Region | | 193,200 | 386,400 | 10.5 (Av.) |
| Grand Total Bristol Bay Area | | 300,450 | 600,900 | 10.6 (Av.) |

* Prime capability is obtainable 100 percent of the time.

205. Grant Lake - Grant Lake, at the head of the Wood River chain, lies at about elevation 510. Its southern shore is only 2.5 miles from the northern shore of Lake Kulik whose normal surface elevation is about elevation 140. Grant Lake has a surface area of 3.2 square miles and receives the drainage from some 50 square miles of the more barren country on the divide between the Wood River and Nuyakuk River systems. The lake outlet is principally a series of falls and rapids in the approximately four miles of stream course into Lake Kulik. The highest fall is approximately 100 feet high and is an insurmountable barrier to migrating salmon.

206. The project development would consist of an earth and rock fill dam in the miniature gorge above the upper falls to raise the lake about 43 feet which would create a usable storage of about 96,000 acre-feet

on the lake, effecting complete control of the drainage and providing a regulated flow of about 110 second-feet. An eight foot diameter tunnel 2.5 miles long would divert the flow to a powerhouse on the north shore of Lake Kulik. As the initial unit of the project, the average net head developed would be 397 feet and the prime power capability 3120 kilowatts. As a unit in the final system after storage is created on Lake Kulik the prime capability would be reduced to 2900 kilowatts as the effective power head will be reduced to 369 feet.

207. Preliminary estimates indicate that the project cost would be about $10,000,000 and the cost of production of firm power at the plant would be about 18.1 mills per kilowatt-hour.

208. Nishlik Lake - Nishlik Lake, uppermost of the Tikchik Lake chain, lies at about elevation 1035 in the headwaters of the Tikchik River. The lake has a surface area of about five square miles and receives the drainage from 46 square miles of mountainous terrain in the Kilbuck Mountains. Snow fields and small glaciers provide a portion of the estimated 98,000 acre-feet of annual runoff. A very small earth and rock fill dam about 40 feet high and not over 100 feet long in the narrow rock gorge at the outlet will raise the lake about 31 feet and create over 118,000 acre-feet of usable storage. This would effect complete control of the drainage and produce a regulated flow of about 135 second-feet. A complete diversion of the stream from the lake appears feasible as other downstream tributaries entering a short distance below the dam site would maintain flow in the river. No fish facilities would be required at the dam as it is believed that migrating salmon do not appear this far upstream, and only a small emergency side channel spillway in the abutment rock would be required to insure the safety of the dam. If salmon are found to spawn in this lake provisions would have to be made for their passage.

209. With an intake a short distance above the dam, an eight foot diameter tunnel about three miles long would discharge the water through a powerhouse into Upnuk Lake whose normal elevation is about 830 feet. As an initial project the average net head would be 227 feet and the prime power capability about 2200 kilowatts. In the system development, with additional storage on Upnuk Lake, the average net head would be 210 feet and the prime capability about 2000 kilowatts.

210. Preliminary estimates indicate that the project costs would total about $7,971,000. With a 50 percent load factor, the installation would cost about $1,810 per kilowatt and the firm power cost about 19.8 mills per kilowatt-hour at the plant.

211. Upnuk Lake - Upnuk Lake, the second from the top in the Tikchik Lakes chain, lies at an elevation of about 830 feet. It has a surface area of 19 square miles and receives the drainage from some 100 square miles of Kilbuck Mountain area. Melt from snow fields and small glaciers provides a portion of the average annual runoff estimated to be about 213,000 acre-feet. The stream at the outlet runs through a narrow rock walled canyon of sufficient depth to contain a dam adequate to effect complete control of the drainage. Fish facilities probably will not be required as the salmon migrations do not appear to reach this far upstream, and only a small side channel spillway will be required to insure the safety of the dam. An earth and rock fill dam, 33 feet high and not over 100 feet long at the crest will provide for an active storage of about 256,000 acre-feet of water adequate to effect complete control of the drainage and produce a regulated flow of about 294 second-feet. The diversion tunnel into Chikuminuk Lake would be about two miles long with the powerhouse on the extremity of the most northern arm of Chikuminuk Lake. This unit could be considered as the initial unit of

the project development if provision is made to receive the increased flows to be made later by the diversion from Nishlik Lake. Upnuk flows alone (294 cfs) would require a 10-foot diameter and the combined flows (429 cfs) a 12-foot diameter tunnel. Provisions should also be made at the powerhouse for the increased generation. As the initial unit Upnuk Lake would have a prime capability of about 4,550 kilowatts. As the second stage of the system development, it would have an initial prime capability of 6,600 kilowatts which would reduce to 5,850 kilowatts in the ultimate project when storage is placed on Chikuminuk Lake.

212. Preliminary estimates indicate that the costs for the ultimate project would be about $12,120,000 or about $1,037 per installed kilowatt at 50 percent load factor and that the cost of generation would be about 11.1 mills per kilowatt-hour for firm power.

213. Chikuminuk Lake - Chikuminuk Lake, the third from the top in the Tikchik Lake chain, lies at about elevation 630. It has a surface area of 38 square miles and receives the drainage from some 290 square miles of Kilbuck Mountain area. It also receives a portion of its water from melting snow fields and small glaciers in the mountains to make up its annual runoff estimated to be about 619,000 acre-feet. The outlet stream is Allen River which falls more than 200 feet in the ten mile length of the stream into Lake Chauekuktuli. The fall is more or less concentrated in three sets of rapids which apparently block the salmon migrations as the fish do not appear to reach Chikuminuk Lake, although they are reported in the lower reaches of Allen River.

214. An earth and rock fill dam at the lake outlet that would raise the lake surface 36 feet would provide usable storage of about 743,000 acre-feet, sufficient to give complete control of the drainage basin and yield a regulated flow of 853 cfs. The diverted regulated

flows from Nishlik and Upnuk would increase this power flow out of Chikuminuk Lake to 1,292 cfs. The diversion of the flow to tailwater in Lake Chauekuktuli at elevation 324 for the initial project would require an 18-foot diameter tunnel about 7.1 miles long. The initial average power head will be about 324 feet and the prime power capability 29,700 kilowatts. This will reduce to 29,400 kilowatts in the ultimate project when storage is placed on Lake Chauekuktuli reducing the effective net head to 320 feet.

215. Preliminary estimates, using the limited data available, indicate that the cost of this unit in the Tikchik Lake system development would be about $58,400,000. The cost per installed kilowatt at 50 percent load factor would be about $991 and the cost of generation per kilowatt-hour of firm power about 10.5 mills.

216. Nuyakuk - Tikchik Lake - Nuyakuk and Tikchik Lakes are the lower of the lakes in the Tikchik chain. The outlet of Tikchik Lake forms the head of the Nuyakuk River and the lake receives all of the drainage from the tributary area above including Nishlik, Upnuk, Chikuminuk and Chauekuktuli Lakes mentioned above. Nuyakuk Lake and Tikchik Lake are in reality only one lake, the separation being made by a peninsula which juts into the lake from the north making a partial closure at that point. A rock dike crosses the lake at this location but a wide, very deep channel remains open to connect the lakes and provide an adequate waterway to maintain a uniform lake surface without perceptible current at all lake stages. The surface area of Tikchik Lake is about 24 square miles and that of Nuyakuk Lake about 71 square miles. The lakes receive the drainage from about 1486 square miles of area, a large portion of which lies in the Kilbuck Mountains where snow fields and small glaciers contribute to the annual runoff.

217. The average annual runoff from Tikchik Lake is estimated at 3,000,000 acre-feet of which 930,000 acre-feet are controlled on the upper lakes. The maximum raise possible at this site is believed to be only about 30 feet above normal lake surface of Tikchik and Nuyakuk Lakes, which will place a maximum of 18 feet of superimposed storage on Lake Chauekuktuli. The estimated volume of storage in the upper 18 feet over the three lakes is 1,560,000 acre-feet. The lower 12 feet of storage on Nuyakuk Lake and Tikchik Lake will provide about 750,000 acre-feet. The remainder of the 2,500,000 acre-feet required for complete control, about 190,000 acre-feet, will be obtained by a 3-foot drawdown below the normal lake surface of Nuyakuk and Tikchik. The corresponding lake surface elevations would be maximum elevation 342, minimum elevation 309 and weighted average elevation 328, or about four feet over the normal lake surface of Lake Chauekuktuli. A small portion of the water will be required for about four months of the year to supply fish ladders over the small dam as Tikchik, Nuyakuk, and Chauekuktuli Lakes now support small salmon runs. The total flow available for power use will be about 4,116 cfs with 1,282 cfs being supplied by regulation on the upper lakes.

218. The dam, immediately below the lake outlet, would be a small earth and rock fill 35 feet high, approximately 600 feet long and would require spillway section and fish ladders. The power development would be made approximately 23 miles west of the dam where the shortest distance separates Nuyakuk and Kulik Lakes. A 28-foot diameter tunnel, five miles long, would develop the head between the two lakes, amounting to about 188 feet for the initial installation. When the Lake Kulik development is made, the placing of storage on Lake Kulik will reduce the gross head to about 160 feet. With head loss of about 6.6 feet

in the tunnel, the net power heads will be 181 feet initial and 153 feet ultimate. The prime capability of the installation is about 53,200 kilowatts initially, which will reduce to about 45,500 kilowatts in the ultimate system.

219. Preliminary estimates of cost indicate that this step of the development will cost about $79,000,000 or $842 per installed kilowatt at 50 percent load factor. The cost of generation for firm power will be about 8.2 mills per kilowatt-hour.

220. Lake Kulik - Lake Kulik at elevation 140 is the highest of the larger lakes in the Wood River Lake system. Grant Lake located on a tributary stream draining the eastern, less mountainous portion of the Lake Kulik drainage area lies at higher elevation but is a small lake in comparison. Lake Kulik has a surface area of 18 square miles and receives the drainage from some 219 square miles of territory which includes a portion of the Kilbuck Mountains. Snow fields and a few small glaciers provide a portion of the flow in the streams that enter the western end of the lake. The annual runoff from Lake Kulik drainage basin is estimated to be about 432,000 acre-feet, of which 80,000 acre-feet will be controlled at Grant Lake.

221. A dam which would raise the water surface of Lake Kulik 36 feet would create a storage of 422,000 acre-feet and provide a regulated flow of about 486 second-feet of which 456 cfs will be available for power development. The remainder amounting to about 100 cfs for four months during the summer would activate the fish ladders at the dam. The total flow available for power use would be about 4,682 cfs. A 30-foot diameter tunnel, 3.5 miles long, located about 1½ miles west of the dam at a point where the distance between Lake Kulik and Lake Beverley is a minimum, would develop the 68 feet of

head between the lakes. Head loss in the tunnel would be about four feet, making the effective average power head 64 feet. The prime power capacity of the plant would be about 21,400 kilowatts.

222. Preliminary estimates of cost, from the limited data available, indicate that this final unit of the project will cost about $67,400,000. The cost of installation at 50 percent load factor would be about $1,564 per kilowatt and the cost of generation about 14.9 miles per kilowatt-hour of firm power.

223. The total of 107,250 kilowatts of prime power from the six plants outlined above can be obtained only as a system project as the power potentials are predicated upon the storage, regulation, and diversion of water at upstream plants for use and benefit to those plants downstream. Only Grant Lake and Nishlik Lake, the initial units of the system project, stand alone and receive no benefits from upstream storage but they do impart benefits to the later projects downstream, Grant to one plant and Nishlik to four.

224. The locality in which these plants would be located is at this time entirely undeveloped and unoccupied and most of it is unsurveyed. The only access to the region is by air or by boat up the rivers. The construction of the project would require the construction of an access road from Dillingham into the locality of the group of plants. As this road would provide many more benefits than those accruing to the power system, the entire cost of the road should not be charged to the power plants. All but short stub access roads to the intermediate plant locations would be required in order to install the two small initial units of the project. The construction of the road would open up the lake area for all purposes and make the country accessible to vacationers, hunters, miners, and possibly for homesteaders

and others. It would be of very great benefit to Alaska. A total of $2,300,000 toward the construction of access roads has been included in the cost of the plants proportional to the prime power capabilities of the various units but the entire sum would be required plus other funds to provide access to the two initial projects. Some 55 miles of the road, including a major bridge structure crossing Wood River, would be required for the construction of the Grant Lake unit. An additional section of about equal length including a major bridge structure crossing the Nuyakuk River would be required for the Nishlik Lake unit.

225. Adequate data are not available for location purposes or preliminary cost estimates of the access road. From plane flights over the area it appears that the road from Dillingham should cross Wood River below the mouth of Muklung River and follow the Muklung River valley up to the bench lands east of Lake Nerka and then occupy a position on these bench lands to the Nuyakuk. Most of this route will be on tundra covered gravels and should encounter no difficult terrain. Above the Nuyakuk the route would probably follow the western margin of the Tikchik River valley as no topographical features were observed that would prevent the location in this advantageous location.

236. The power project as outlined would develop 107,250 kilowatts of prime power at a total project cost of about $235,000,000. The average cost of installation at 50 percent power factor would be about $1,080 per kilowatt. The annual costs would be about $10,290,000 and the cost of generation about 10.7 mills per kilowatt-hour for firm power.

237. Lake Kontrashibuna - Lake Kontrashibuna lies to the south of Lake Clark, in the Kvichak River drainage. It is about 215 feet above Lake Clark in elevation and its drainage reaches Lake Clark by way of the Tanalian River. Lake Kontrashibuna has a surface area of nine square miles and receives the drainage from some 205 square miles of mountainous

territory most of which is located in the Chigmit Mountain range where glaciers and snow fields contribute to the annual runoff. Falls in the Tanalian River, the highest of which is estimated to be about 60 feet, bar migrating salmon from entering the lake although they do spawn in the lower reaches of the river.

228. The average annual runoff from the lake is estimated to be about 394,000 acre-feet. The storage of 470,000 acre-feet on the lake would effect complete control of the runoff and develop an average flow of 543 cfs. This storage would require a dam which would raise the lake surface 76 feet. An earth and rock fill dam about 87 feet high and about 400 feet long with no fish facilities and only a side channel emergency spillway would impound this storage and provide additional capacity for ice on the lake. A 15-foot diameter tunnel about $2\frac{1}{2}$ miles long would be required to supply a powerhouse on Lake Clark upstream from Tanalian Point. The average net head would be about 268 feet and the prime power capability of the plant would be about 10,400 kilowatts. The cost of the project is estimated to be $20,200,000 and the cost per installed kilowatt at 50 percent load ~~power~~ factor, $970. The annual costs are estimated to be $940,000 and the cost of generation for firm power 10.3 mills per kilowatt-hour.

229. Tazimina Lakes - Tazimina Lakes also lie south of Lake Clark a few miles south and southwest from Lake Kontrashibuna. Tazimina River, the outlet stream, flows westerly into Sixmile Lake, the outlet of Lake Clark, from where the Newhalen River carries the combined discharges into Iliamna Lake. The Tazimina River tumbles rapidly in its course into Sixmile Lake, being a series of rapids and falls throughout most of its length. The highest fall is estimated to be about 100 feet in height and it forms an effective block to migrating fish. The Tazimina Lakes consist of a series of small lakes and two large ones, identified as

Upper and Lower Tazimina Lakes, all lying in a rather wide valley at practically identical elevations, about 400 feet above Lake Clark and 570 feet above Iliamna Lake. The combined surface area of the lakes is about 18 square miles and they receive the drainage from an area of 330 square miles, a portion of which reaches into the Chigmit Mountain area with its glaciers and snow fields. The estimated average annual runoff from the area is 634,000 acre-feet.

230. Storage of 761,000 acre-feet on the lakes would completely control the basin and create a regulated flow of 875 cfs. This would require a dam raising the lake surface about 72 feet. A fair dam site exists below the lower lake and above the upper fall where an earth and rock fill dam 80 feet high and about 600 feet long could be constructed. No fish facilities would be required and a small side channel spillway, probably in the abutment at the left end of the dam, would be adequate to insure the safety of the dam.

231. Two plans of development are available from this storage. The water may be diverted northward by a 17-foot diameter tunnel five miles long into a powerhouse on the south shore of Lake Clark or it may be diverted southward by a 17-foot diameter tunnel, eleven and a half miles long, into a powerhouse on Iliamna Lake. The first would operate under an average head of 443 feet and develop about 27,600 kilowatts of prime power. The alternate will operate under an average head of 606 feet and develop about 37,900 kilowatts of prime power.

232. The cost of the first alternate would be about $40,730,000 or about $735 per kilowatt installed at 50 percent power factor. The annual charges would be about $1,882,000 and the cost of generation about 7.8 mills per kilowatt-hour of firm power.

233. The cost of the second alternate would be about $75,800,000 or about $1,000 per kilowatt installed at 50 percent power factor. The

annual costs would be about $3,350,000 and the cost of generation about 10.1 mills per kilowatt-hour of firm power.

234. The advantage of total cost and cost per unit favor the first alternate but total power and location of the power plant greatly favor the second. In the second alternate the power plant is only about 37 miles from Iliamna Bay at the entrance of Cook Inlet on the southern coast of the Alaska Peninsula and the pass through which the transmission line would cross is only about 800 feet above sea level. Future industrial developments and future power requirements will eventually determine the ultimate utilization of this power resource.

235. Ingersol Lake - Ingersol Lake with a surface area of about 2.6 square miles is located about seven miles north of the upper end of Lake Clark in the southern extension of the Alaska Range. The lake basin was deeply cut by a glacier which has receded until only fragmental glaciers occupy positions at the heads of several of the upper tributaries. The Kijik River flows westerly through the lake and carries the discharge by a rather circuitous route into Lake Clark at the village of Kijik. The lake is at elevation 1280 and the river tumbles rapidly in the canyon below the lake to discharge into Lake Clark at about elevation 220.

236. The drainage area above the outlet of Ingersol Lake contains some 152 square miles from which the average annual runoff is estimated to be 308,000 acre-feet. Storage of 370,000 acre-feet on the lake would completely control the drainage and yield a regulated flow of about 424 second-feet with a fluctuation of the lake surface of about 193 feet.

237. A rock fill dam crossing the canyon just below the lake outlet would be about 200 feet in maximum height and have a crest length

of about 4,200 feet. No fish facilities would be required as the lake is beyond the limits of the fish runs.

238. A 12-foot diameter tunnel 7.2 miles long driven southeasterly from just above the dam site would lead the water to a power site on the north shore of Lake Clark. The net head developed would be about 1183 feet and the prime power about 35,800 kilowatts.

239. From the limited reconnaissance data available it is estimated that the project would cost about $112,000,000 or $1560 per kilowatt of installed capacity at a 50 percent power factor. The annual costs are estimated at $4,434,000 and the cost of generation at about 14.1 mills per kilowatt-hour for firm power.

240. Kukaklek Lake - Kukaklek Lake is located seven miles south and about 750 feet in elevation above Iliamna Lake. It has a surface area of 70 square miles and receives the drainage from an area of about 470 square miles, a portion of which drains a section of the Aleutian Mountain Range with its glaciers and snow fields. The normal elevation of the lake is at about elevation 800. The outlet stream from the western end of the lake falls about 800 feet in its course of 40 miles into the sea but there are no falls or obstructions which stop the fish migrations, and Kukaklek Lake and the waters above are used by spawning fish, consequently facilities to preserve the fish runs must be incorporated in the project.

241. The average annual runoff from the lake is estimated to be 876,000 acre-feet. Storage of 1,051,000 acre-feet on the lake would completely control the drainage and create a regulated flow of 1208 cfs. This would require a fluctuation range of the lake surface of about 23 feet. The outlet of the lake flows in a shallow banked channel for some distance from the lake and no abutments exist even for the low dam required.

The maximum possible raise of the lake surface appears to be about ten feet and this would require a dike about a mile long to close the wide flat gap at the outlet. Fish ladders and emergency spillway section could occupy the present river channel and long low earth dikes would extend to higher ground on either side. With only ten feet of the storage superimposed on the lake, additional storage would be secured by drawing the lake down 13 feet below its normal elevation. The average elevation of the lake surface would be at about elevation 802 or about two feet above normal lake surface. It would be expected that the lake would refill the drawdown during the early spring melt in May and early June and that the surface would be high enough to activate the fish ladders when the fish runs appear.

242. The power development would be made by diversion through a powerhouse on the south shore of Iliamna Lake. The average gross head would be 752 feet and the average net head about 745 feet. An 18-foot diameter tunnel would be required, which would operate under nominal pressures for only the first two miles. The remaining five miles would operate under gradually increasing pressures as the land elevations fade away to the shores of Iliamna Lake. The estimate is made on the basis that the 18-foot diameter tunnel would terminate in a surge tank at the end of two miles and that four 10-foot diameter pressure tunnels or penstocks, five miles long, would carry the flow into the power units. The prime capability of the plant would be about 64,300 kilowatts.

243. Preliminary cost estimates based upon the limited data available indicate that the initial cost of the project would be about $115,560,000 or a cost of about $900 per kilowatt installed at 50 percent load factor. Annual costs are estimated to be about $5,000,000 and the cost of generation about 8.9 mills per kilowatt-hour of firm power.

244. <u>Kulik Lake</u> - This lake is located on the Nonvianuk Fork of the Alagnak River just above Nonvianuk Lake, and should not be confused with the lake of the same name in the Wood River Lakes chain nor with the Kulik Lake in the Kuskokwin drainage and others in the territory. This lake is 12 miles long by nearly a mile wide and has a surface area of ten square miles. It lies about 60 feet above Nonvianuk Lake and is separated from it by a narrow strip of land about one-half mile wide. The possibility of placing a dam on the narrow peninsula to secure head and regulation on Kulik Lake and the use of the larger Nonvianuk Lake for tailwater is limited by the physical conditions along the narrow spit. An abutment of sorts is available at the north end but the land remains flat and low for many miles to the south. Until more adequate surveys are available it is considered that a dam adequate to raise the surface of Kulik Lake about 60 feet would be the maximum possible development of the site.

245. The drainage area above the lake contains about 236 square miles from which the average annual runoff is estimated to be about 377,000 acre-feet or an average flow of 520 second-feet. Raising the lake surface 60 feet will create a storage of about 388,000 acre-feet resulting in a regulated flow of 494 second-feet with an average head of about 100 feet. Prime power under these conditions would be about 3530 kilowatts.

246. A very preliminary estimate indicates that the installation would cost about $5,600,000 or about $800 per installed kilowatt at 50 percent power factor. Annual costs are estimated at $334,000 and the cost of generation at 10.8 mills per kilowatt-hour for firm power.

247. <u>Grosvenor Lake</u> - The possibility of power development around Naknek Lake in the Katmi National Monument area has been considered by other agencies. The investigations have been confined to the

consideration of power development at Brooks Lake, where there is a vertical fall a few feet high in the outlet stream between Brooks Lake and Naknek Lake. The total fall between the lakes is about 30 feet and a project to develop the entire head and entire flow could produce only about 1,100 kilowatts of prime power. The cost of the project would be about $6,300,000 and the cost of installation at 50 percent load factor would be about $2,860 per kilowatt giving a cost of generation of about 32 mills per kilowatt-hour of firm power.

248. Grosvenor Lake and Lake Colville are to all practical purposes one lake which lies about 80 feet above Naknek Lake and is separated from it by a narrow ridge. The outlet of Grosvenor Lake does not offer a good dam site, as the valley at this point is wide and flat. Some rock outcrops show, and low cliffs exist on both sides of the valley but a closure dam would be some two miles long. It would, however, not be high, more in the order of a dike, so that a closure at this point is not impossible.

249. The surface area of the combined lakes is about 43 square miles, and they receive the drainage from about 630 square miles of drainage basin. The average annual runoff is estimated to be about 1,008,000 acre-feet. Storage of about 1,058,000 acre-feet would require raising the lake surface about 38 feet and provide complete regulation of the drainage basin. The resulting regulated flow will be about 1,386 cfs.

250. The development would consist of an earth, or earth and rock fill dike about 45 feet maximum height and about two miles long to close off Grosvenor Lake. Fish ladders and a small spillway section would be required. The power installation would be made about 14 miles above the dam. An intake structure and a 20-foot diameter tunnel

1.3 miles long would direct the flow through a powerhouse on the shores of Bay of Islands arm of Naknek Lake. The average power head would be about 114 feet and the prime capability about 11,300 kilowatts.

251. Estimates of cost based upon the limited data available indicate that the cost of the project would be about $28,500,000 and the cost of installation, at 50 percent power factor, about $1,260 per kilowatt. The annual costs are estimated at $1,240,000 and the cost of generation about 12.5 mills per kilowatt-hour for firm power.

252. Crescent Lake - (Grecian River). - The use of the potential power in the Lake Clark and Iliamna Lake Regions at some point on Cook Inlet or the southeastern coast of the peninsula will be influenced by several factors. Of great importance among these will be the availability of a year round secure port adjacent to an area large enough to accommodate the industrial development and its attendant city. A route for the transmission line through the mountains over low passes and moderate topography is essential to facilitate construction and future maintenance. A power source near the end of the line to maintain the voltage is desirable if the power is to be transmitted without excessive losses.

253. The low passes exist at only two points in the same general area. The pass between Pile Bay on Iliamna Lake and Iliamna Bay at the mouth of Cook Inlet is 900 feet high and a portage road already exists over it. The next pass south, between Kakhonak Bay on Iliamna Lake and Ursus Cove on Cook Inlet rises to about 800 feet, and the topography is such that the construction and maintenance of transmission lines would not be difficult. Both of these passes lead to Kamishak Bay which is not protected from the southeastern storms prevailing during the winters. The only secure harbor anywhere on this section of coast lies about 65 miles farther up Cook Inlet at

Tuxedni Bay where the combination of the protection provided by the Kenai Peninsula on the eastern side of Cook Inlet and Chisik Island at the entrance of Tuxedni Bay makes a safe harbor at all times. Deep water exists in the lower bay between Chisik Island and the western mainland which with a moderate amount of dredging, could be extended to the northern portion of the bay adjacent to the flat and rolling country on either side of the mouth of the Grecian River. About 20 square miles of presently undeveloped country would be available for industrial sites and future municipal development.

254. Crescent Lake is on the western fork of the Grecian River about 15 river miles from tide water. The general axis of the lake is somewhat parallel to the upper reaches of Tuxedni Bay and at the closest point they are only about three miles apart. Both lie in old glacier cuts with the surface of Crescent Lake about 550 feet above the tide water in Tuxedni Bay. Reconnaissance data indicate that about 30,000 kilowatts could be developed at this location and this would serve very well for the purpose of stabilizing the voltage in the transmission system.

255. An earth and rock fill dam about 115 feet high and 2000 feet long would span the Grecian River Valley immediately below the forks of the river, about five miles below the outlet of Crescent Lake, and would create a lake on the eastern fork almost equal in size to Crescent Lake on the western fork and at the same elevation. A tunnel about 3.2 miles long, driven through the mountain ridge south of Crescent Lake, would conduct the water to a power house site on the northern shore of Tuxedni Bay.

256. A superimposed storage of about 600,000 acre-feet upon the common surface of the two lakes would completely regulate the drainage area of 224 square miles and would yield a regulated flow of about 690

second-feet with a draw down of 84 feet. The maximum lake surface would be at about elevation 635 and the average at elevation 608, giving a net power head of about 605 feet.

257. The tunnel intake would be placed on the southern shore of Crescent Lake about $1\frac{1}{2}$ miles above the present lake outlet and about $7\frac{1}{2}$ miles above the dam site. The tunnel would have a 15-foot diameter and be about three miles long terminating in a surge tank at the head of the penstocks above the powerhouse on the shore of Tuxedni Bay.

258. The powerhouse design should provide for a maximum tidal range of about 29 feet, between high elevation of about 22 feet and low elevation of minus 7 feet. The installation would be 60,000 kilowatts at 50 percent load factor.

259. Preliminary estimates based on the limited data available indicate that the project costs would total about $53,100,000. With a 50 percent load factor the installation would cost about $883 per kilowatt and the cost of generation would be about 9.6 mills per kilowatt-hour at the plant.

260. Although the project is desirable from an engineering standpoint it would create a serious local fish problem. Grecian River now supports a large run of salmon which could not be fully maintained if the dam were built. Even if the fish were passed over the dam, fluctuating water elevation would destroy the effectiveness of the major part of the spawning beds. Consideration might be given to transplanting the run to other waters or the installation of a small hatchery on the river below the dam.

261. The planning for the definite development of an ultimate transmission system for Bristol Bay area is impossible at this time, as the load for any important block of the power has not as yet developed. The

pattern of the power markets as they develop will determine the transmission system required. Market expectations for the amount of power and the locations of the markets will determine the size and capacity of the transmission system at the time of construction. With transmission distances less than 100 miles, the Wood River-Tikchik Lake project could feed into areas on the lower Kuskokwim and lower Yukon Rivers to the north, to Bethel, Platinum and Goodnews Bay areas to the west as well as the Nushagak and Kvichak Bay areas to the south if the requirement for power develops in these areas. The entire group of generating plants of the Wood River-Tikchik Lake system, if fed into the Nushagak Bay area, would require a transmission system capacity of 216,000 kilowatts which would indicate that the main transmission should probably be made at 230 kilovolts. The entire output of the plants could be transmitted to local areas on the southeast coast of the peninsula where open ports are available. The strategic location appears to be the mouth of Cook Inlet somewhere northeast of Iliamna Bay. The coast could be reached by a 37-mile transmission line from the Tazimina plant on Iliamna Lake over a pass only 800 feet high. Iniskin Bay could be reached with only a few miles longer line and Tuxedni Bay and the Crescent Lake tie with a 65-mile extension. The entire eastern group of generating plants could feed to this outlet if the power demand existed. There would be about 386,000 kilowatts of firm power available from the eastern group and an intertie following the Kvichak River to connect with lines from the Wood River-Tikchik Lake group between Dillingham and Naknek would increase the amount available to about 600,000 kilowatts of firm power, to the mouth of Grecian River on Cook Inlet, less the amount used in the Bristol Bay area. Such a transmission system would consist roughly of about 151 miles of 33 kilovolt line, 22 miles of 115 kilovolt, 9 miles of 138 kilovolt (all feeder lines) and about 310 miles of 230 kilovolt line in the main transmissions. The cost of delivery over the line, as an ultimate development is estimated at about three mills per kilowatt-hour.

262. Kodiak Island System - Conditions detrimental to power development on Kodiak Island are much less severe than in the interior regions of mainland Alaska. The fishing industry remains the principal industry and the maintenance of the fish runs is still of paramount importance but the severe icing conditions will not be encountered. Winters are quite mild with freezing periods of short duration. Under such conditions only nominal provisions need be made to insure continuous operations. Also Kodiak Island is in a heavy rainfall area and the rains are not confined to a "rainy" season. Winter rains will probably produce the greater precipitation but the summer seasons also will provide an important amount. Under such conditions the storage capacity of a reservoir will be much more effective.

263. Kodiak Island is a mountainous area about 100 miles long and 55 miles wide in its over-all dimensions, but its shore lines are cut into many peninsulas by long arms of the sea which extend many miles into the land mass. The main ridge of the mountains, which determines the principal axis of the island, extends in a northeast-southwest direction and crowds the southern shore. The mountains reach up to about 5,000 feet in elevation and are snow and glacier capped. Deep bays from the Gulf of Alaska extend into the southern shore of the island to within a very few miles of the crest of the range. These bays receive all of the streams originating in the mountains so that all streams on this side of the island are short and steep with small drainage areas. Power development on any of these streams would be confined to very small plants consisting of diversion for head development and the use of the unregulated

flow in the stream. The amount of power from such developments would be small and unreliable and such installations are not considered for inclusion in this report.

264. The northern slope of the island is much wider and some of the streams attain considerable length and a significant flow before they enter tide water. There are also several lakes which might act as storage reservoirs. Arms and bays from Shelikof Strait penetrate this shore deeply. Uyak Bay, the deepest, penetrates the island about 35 miles and lacks only about eight miles of cross cutting the island completely. Zachar Bay, Spiridon Bay, Uganik Bay, Terror Bay, and Kizhuyak Bay all cut deeply into the north shore and make this portion generally a series of peninsulas. The bays also intercept all of the important drainage from the higher portion of the islands so that power development on the larger lakes which are located nearer the coast is limited by the water supply furnished by rainfall on rather restricted areas on the peninsulas. Generally Kodiak Island storms are carried by southeast winds so that the eastern and southeastern portions of the island receive the major portion of the rainfall and the northern and western sections of the island receive a materially lesser amount.

265. The United States Fish and Wildlife Service uses several of the lakes on Kodiak Island for fish propagation purposes. Among these are Afognak Lake on Afognak Island and Karluk and Red River Lakes on a peninsula of the main island. Although each of the lakes has a power potential, the prime importance of them to the program for the maintenance of the fish runs precludes their present use for power development. The four projects in the following list appear to be the only feasible projects which offer a significant block of power and which, with the exception of Uganik Lake, will not be in conflict with the fish propagation program.

Three of these are at locations inaccessible to the fish but the fourth, at Uganik Lake, would require alternate spawning areas if the power supply becomes vitally necessary.

POTENTIAL POWER - KODIAK ISLAND

| Project | Prime Capability | Installed Capacity | Estimated Generation Cost Mills per kw-hr | Transmission Distance Miles to Kodiak |
|---|---|---|---|---|
| Terror River | 9,220 | 18,440 | 13.3 | 20 |
| Spiridon Lake | 2,640 | 5,280 | 10.5 | 60 |
| Frazier Lake | 5,360 | 10,720 | 14.5 | 100 |
| Uganik Lake | 10,200 | 20,400 | 25.4 | 45 |

266. Terror River - Of the larger streams draining the north slope of Kodiak Island, Terror River is closest to the city of Kodiak. It heads in the glaciers and snow fields in the northeastern end of the mountains and flows over a series of waterfalls into the head of Terror Bay. The stream channel above the lake is a gorge cut by glacial action. Two small glaciers and a smaller glacial lake still occupy positions in the upper end of the canyon. The canyon walls are steep and are cut by many hanging valleys in which glacial remnants still are active. Much of the summer flow is contributed by the melting of these glacial remnants. Terror Lake is a "glint" lake scoured out by glacial action. The evidence indicates that the lower end of the lake now marks the greatest advance of the glacier. The rock ledges which now form a partial block of the canyon at the lake outlet and offer a very satisfactory dam site show some scour and rounded surfaces but are not cut through as would have been the case if the glacier had extended to lower elevations. The valley below the lake is wider, and the stream flows in a narrow inner canyon over a series of high falls in its drop to tide water.

267. Terror Lake lies at an elevation of about 1,250 feet above sea level, and has a surface area of approximately one square mile. The drainage area above the lake contains about 17 square miles and the average annual runoff is estimated to be about 72,500 acre-feet. A dam about 80 feet high which would have a crest length of about 400 feet would effect complete control and create a regulated flow of about 100 cfs. A 7-foot diameter tunnel seven miles long driven through the mountain in a northeasterly direction would deliver the flow to a powerhouse at the head of Kizhuyak Bay under an average operating head of 1,291 feet. The prime power capability would be 9,220 kilowatts. This plant would be only about 20 miles from the town of Kodiak.

268. Preliminary estimates indicate that the project would cost about $25,000,000. The cost of installation at 50 percent power factor would be about $1,355 per kilowatt. The annual costs are estimated at $1,075,000 and the cost of generation about 13.3 mills per kilowatt-hour of firm power.

269. Spiridon Lake - Spiridon Lake at elevation 440 lies on the peninsula formed between Uganik Bay on the east and Uyak and Spiridon Bays on the west. Its local drainage area consists of about 22 square miles of the peninsula area which is quite mountainous but is cut off from the higher portions of the island. The highest point on the drainage rim is at about elevation 3,900 and there are no glaciers or snow fields contributing to the water supply. The lake is about five miles long and has a surface area of about four square miles. The average annual runoff is estimated to be about 58,700 acre-feet, the complete control of which would yield about 81 cfs in regulated flow.

270. It is estimated that an earth fill dam 36 feet high and about 300 feet long for which a fairly good site exists at the lake outlet would be required to effect the regulation. No fish facilities would be required and a small side channel emergency spillway would insure the safety of the dam. The power development would be made at the southern end of the lake where a six-foot diameter tunnel one mile long would conduct the water to a powerhouse on Spiridon Bay at an average operating head of 457 feet. The prime power capability would be about 2,640 kilowatts.

271. Estimates based upon the limited data available indicate that the cost of the project would be about $4,400,000 and the cost of installation at 50 percent power factor about $835 per installed kilowatt. The annual costs are estimated at $242,000 and the cost of generation about 10.5 mills per kilowatt-hour of firm power.

272. <u>Frazier Lake</u> - Frazier Lake, along with Karluk, Red River, and Akalura Lakes, is located on the peninsula that forms the extreme western portion of Kodiak Island. The land mass of the peninsula containing about 750 square miles is almost cut away from the rest of the island by Uyak Bay penetrating from the north and the combination of Olga Bay and Deadman Bay from the south. Uyak and Deadman Bays intercept all drainage from the main part of the island so that the lakes and streams on the peninsula are fed only by local rains. No glaciers or permanent snow fields exist in this section of the island. The highest point in the area is the summit of Grayback Mountain at the base of the peninsula which rises to an elevation of 3,317 feet. The highlands around Frazier and Karluk lakes range up to about 3,000 feet but most of the area lies below elevations of 1,000 feet. Karluk Lake has a surface elevation of about 380 feet, Frazier Lake about 370, Red River Lake about 230, and Akalura Lake about 70 feet.

273. Akalura Lake lies at such a low elevation and has such a small runoff that power development at that location is not feasible. Red River Lake and Karluk Lake are fish propogating areas and sites for spawn taking and control stations by the United States Fish and Wildlife Service, making them unavailable for power development. Frazier Lake has no fish runs or prior use commitment that would remove it from power consideration.

274. Frazier Lake has a surface area of about six square miles and a tributary drainage area of about 40 square miles. The average annaul runoff is estimated to be about 138,700 acre-feet. An earth fill dam 50 feet maximum height and crest length about 600 feet will impound about 166,000 acre-feet and effect complete regulation. No fishways will be required and a side channel emergency spillway will insure the safety of the dam. The regulated flow will be about 191 cfs.

275. The power installation would be made at the southern end of the lake from where a 9-foot diameter tunnel, 4½ miles long will divert the flow to a powerhouse on Olga Bay at an average head of 395 feet. The prime capability of the plant would be 5,360 kilowatts.

276. Estimates based upon the limited data available indicate that the project would cost about $14,000,000 and the cost of installation be about $1,304 per kilowatt installed at 50 percent power factor. The annual costs are estimated at $684,000 and the cost of generation at 14.5 mills per kilowatt-hour for firm power.

277. Uganik Lake - The Uganik River heads in the glaciers and snow fields of the highest areas on Kodiak Island. Two forks of the river known as the East and West Forks contribute to the flow and join in the vicinity of Uganik Lake. Uganik Lake is about four miles long and its lower end is only about three miles from tide water at the head of Uganik

Bay. Above the lake the East Fork is eight miles long and the West Fork 15 miles long. Both drain glacial areas 3,000 to 4,000 feet in elevation but the West Fork has the dominant flow. Uganik Lake, at about elevation 70, has a surface area of about two square miles and receives the drainage from an area of 97 square miles. The average annual runoff from the lake is estimated to be 388,000 acre-feet.

278. The regulation of this stream would require the storage of about 400,000 acre-feet which would raise the lake surface 310 feet. An adequate site for a concrete dam 315 feet high exists at the lower end of the lake where rock foundations and abutments are available but the site is quite wide at higher elevations.

279. The power development would be made by tunnel and penstock diversion through the right abutment ridge three miles to a powerhouse located at the head of Uganik Bay. Regulation of the stream would yield a regulated flow of about 534 cfs at an average effective power head of 268 feet. The prime capability of the plant would be about 10,200 kilowatts.

280. Estimates based upon the limited data available indicate that the project will cost about $58,700,000 and the cost of installation at 50 percent load factor about $2,880 per kilowatt. The annual cost is estimated at $2,268,000 and the cost of generation about 25.4 mills per kilowatt-hour for firm power.

281. The development of Uganik Lake project is outlined in this report because it has the largest prime capability of any of the feasible projects on Kodiak Island. The project as outlined would completely block the fish from the lake and the two tributaries above. Two minor tributaries entering below the dam would keep the lower stream alive but it is doubtful if they could accommodate the total fish run. Until such time

as power becomes of paramount importance the development of the Uganik Lake should not be considered. The power would not be cheap as the dam required would be an expensive structure.

282. Transmission System - The transmission of power into the town of Kodiak from the Terror River project offers no difficulties. The course of the line would be almost directly eastward into Kodiak, passing the military installations enroute. The line would be about 20 miles long and there is already a highway over the eastern seven miles. The route would follow low passes westward to the head of Kizhuyak Bay, and the summit elevations are less than 1,000 feet.

283. Transmission of the power from the other units would encounter topographical difficulties if the town of Kodiak develops to be the principal load center for the larger quantity of power. A line laterally around either side of the island would require long detours to avoid the bays or long suspension spans or submarine cables to cross them. The ridges projecting into the peninsulas would require long detours to evade or steep high climbs to cross. Should future development be located in the vicinity of the plants, making short transmissions feasible, satisfactory routes would be available but plans to continue the major load center at Kodiak for power generated at Uganik Bay, Spiridon Bay, and Olga Bay would require transmission lines over difficult routes, 45, 60, and 100 miles long, respectively.

284. From the limited data available it is estimated that the cost of transmission of power from the Terror River plant on Kizhuyak Bay to Kodiak would be about two mills per kilowatt-hour for firm power. Transmission costs from the other plants to Kodiak would be much greater.

285. Aleutian Islands - The physical features of the island chain do not provide the conditions that are necessary for the development of economically feasible hydroelectric projects. All of the islands are

mountainous. The smaller islands may consist of a lone peak with or without flat bench lands along some portion of the shore line while the larger ones may have several peaks forming the backbone of the island with or without flat areas. The effect upon the drainage systems is the same in either case as the water from any point on the island flows only a short course to reach tide water. On the smaller islands only a few streams attain lengths of from three to five miles and on the larger islands the streams are seldom more than 20 miles long and the greater portion of these longer rivers are on flat bench lands along the shore where power development would be impractical. Lakes, which could serve for storage reservoirs at elevations that would provide a power head, are invariably near the headwaters of the stream and lack drainage area adequate to provide a usable flow, even in that heavy rainfall area. The normal precipitation at Dutch Harbor on Unalaska Island is about 57 inches and at Attu, on the end of the chain, it is about 74 inches. Studies were made of several of the streams on some of the larger islands with the same negative results. Two adverse basic features prevail at all locations. The drainage areas are always too small to provide an adequate flow and the reservoir areas are such that high dams would be required to secure any appreciable degree of regulation. For example, the five streams studied on Attu Island had drainage areas above the possible damsites of 12, 11, 11, 3, and 5 square miles. The maximum heads obtainable were 200, 200, 200, 900, and 200 feet and all but one had this head created by dams 200 feet or more high. Under the assumption that complete control could be secured, the resulting regulated flows would be 65, 60, 60, 16, and 27 cfs, respectively, and the prime power 930, 860, 860, 1000, and 386 kilowatts, respectively. Such small plants could not justify the expensive dams necessary to create them. Flenner Lake on Semisopachnoi Island is located in the caldera of an old volcano. It has a drainage area of about 16 square miles and a questionable dam site. The maximum power obtainable, assuming that full control and regulation could be secured, would be about 1620 kilowatts. The structure is not feasible because of high costs.

286. Other potentials were investigated on Atka, Unalaska and Umnak Islands with similar results. Many of the streams observed have seasonal flows which could be developed as run-of-river plants at nominal cost to provide small amounts of seasonal power which might be useful at some locations, but such power would be highly undependable.

## IMPROVEMENT FOR NAVIGATION

287. Dillingham Small Boat Basin - The village of Dillingham, with a population of about 600 is located at the head of Nushagak Bay on the right bank of Nushagak River just below its confluence with Wood River. It is the principal trading center on the north shore of Bristol Bay. There are three general merchandise stores, one hardware store, two hotels, two restaurants, and a distributing plant for one of the major oil companies. Two major air lines maintain offices in the village and several companies offering charter service are based there. The Territory of Alaska built an airstrip two miles northwest of the town that is suitable for planes of DC3 or C47 type and a landing strip at the east edge of town will accommodate small planes.

288. The tributary area with a total population of about 1500 includes the drainage basins of Nushagak and Wood Rivers, about 100 miles of the Bering Sea coast, and the fishing grounds in the estuary of Nushagak River. Salmon fishing and canning is the only industry that has been developed. There are two canneries adjacent to Dillingham and three others within a radius of 15 miles. Undeveloped resources in the tributary area include bottom fish, minerals, recreation and a wealth of hydroelectric power.

289. There are no bridges over any of the navigable waters, no prior reports have been made, there are no existing Corps of Engineers projects, nor have there been any improvements in the interest of navigation by any Federal agency.

290. The cannery companies have provided wharves equipped with transfer facilities and marine ways adequate for their own cargo and floating plant but there are no such facilities available to the general public. General cargo destined for Dillingham is discharged from lighterage barges on to the beach adjacent to the village.

291. A public hearing was held at Dillingham on September 17, 1952 at which local interests requested that the Corps of Engineers construct a small boat basin to accommodate 100 boats. They requested that it be located on a site adjacent to town known as Scandinavian Flats, that it be 300 by 700 feet in size, with depths that would permit craft with 3-foot draft to enter or leave on each high tide. The following claims were presented in support of their request. A boat basin would make it possible to construct facilities where vessels could be repaired more efficiently and with greater safety than is now the case on the open beach; it would result in the life of boats being doubled; it would minimize damage that occurs during the infrequent maximum storm tides; it would cut in half the time and money expended in the process of lightering over the open beach by permitting more economic handling of freight over a public dock; it would make possible the building of a bonded warehouse, thus reducing loss from neglect and theft; it would eliminate the loss of cargo and damage to boats loaded for reshipment which now lie on the beach while waiting for a favorable stage of tide; it would result in overall reduction of freight rates; floating plant could be floated off earlier in the spring; it would result in increased fishing time; and revenue from taxes on a newly created fishery product would repay the expenditure.

292. There are no records of commerce or vessel traffic on Nushagak Bay. Ocean going vessels, operating out of west coast ports of the United States, transport all items of commerce except emergency and perishable items transported by air. The Alaska Steamship Company usually schedules three sailings annually to Bristol Bay ports carrying an estimated average of 3000 tons consigned to Dillingham. Outgoing shipments consist principally of furs and ore samples.

Outgoing shipments from the canneries are principally fish products. Receipts are cannery supplies, material, and fishing gear.

293. The mean range of tide in Nuskagak Bay is 15.3 feet with extremes ranging from 23 feet above mean lower low water to minus 4.6 feet. The head of navigation for ocean going vessels is normally opposite Clarks Point 15 miles south of Dillingham although vessels drawing not more than 22 feet may, under favorable conditions, navigate up the bay to anchor about one-half mile off the town. Storms often interfere with lighterage operations causing delay and damage to or loss of cargo. Further delay is due to the fact that barges beached for transfer of cargo will usually not refloat for 24 hours.

294. It was brought out at the hearing that there is no sheltered anchorage accessible to small boats at all stages of tide in the estuary of Nushagak River. Boatmen in case of a storm must seek such protection as is afforded in the narrow unmarked tidal sloughs or run for a lee shore.

295. Subsequent to the removal of restrictions on the use of power, practically the entire fishing fleet has been converted to gasoline power. A further effect of the change is the increasing number of privately owned fishing boats. There were 20 private boats based at Dillingham in 1952, 50 in 1953, and it is expected the number will increase to 100 in the near future.

296. There are about 100 boats, not suitable for fishing, which each year bring families from their homes along the various rivers to work in the canneries or on the fishing grounds. These same boats are used after the fishing season to transport winter supplies and families back to their homes. These boats under present conditions are beached where they are subjected to storm damage while their owners are at work. Each year several of these boats with their

cargo have been swamped and damaged or totally lost while waiting for favorable conditions to proceed back up river. Existing conditions relative to small boats indicate a need for a small boat harbor at Dillingham.

297. The proposed plan of improvement as shown on plate 12 would be located on the left bank of Scandinavian Creek and would consist of an excavated basin, an entrance channel, embankment, moorage facilities, a public wharf, an access road, and two navigational aids.

298. The basin would be excavated to a depth of two feet above mean lower low water over an area of approximately 230,000 square feet. It would be about 700 feet long with the west edge coinciding with the center of Scandinavian Creek. The south end would be about 300 feet from the right bank of Nushagak River. Entrance to the basin would be through the creek which would be improved, over a reach of about 1,100 feet, to provide a bottom width of 40 feet. The bottom of the entrance channel would coincide with the bottom of the existing channel. A sill of sheet piling across the basin outlet would have a top elevation of seven feet above mean lower low water.

299. Excavated material amounting to some 200,000 cubic yards would be used as fill material for the access road and for an embankment, for storm protection, on three sides of the basin. Cut slopes would be excavated to 1 on 5 and the embankment on the basin side would be finished to the same slope. Excess material would be spread over the nearby flat land or disposed of in Nushagak Bay, whichever would be less expensive. A protective gravel blanket 6 inches thick, obtained either from selected excavated material or borrowed from nearby gravel pits, would be placed on the face of the embankment as shown on plate 12.

300. Representatives of the United States Coast Guard have furnished a cost estimate and have indicated the type and locations of navigational aids which would be installed by their organization.

301. Examination of tidal curves indicate that the entrance, with a controlled elevation of seven feet above mean lower low water, would permit entrance or egress about 50 percent of the time during the ice-free period. The basin with a bottom elevation two feet above mean lower low water would provide a minimum depth of 5 feet at all times. Natural protection is afforded from westerly winds and the embankment would protect the other three sides except at the entrance opening.

302. Several sites for a small boat harbor were examined. Two sites were surveyed, the Scandinavian Creek site located adjacent to the village of Dillingham and an alternate site at the mouth of Squaw Creek located about two miles west of the village. The principal objection to the Squaw Creek site is its distance from the village. However, excavation would be about 10 percent greater than at the proposed site, the entrance channel across the open beach would be about twice as long, and about one-half mile of new access road would be required.

303. Consideration was given to a plan which would permit entrance and egress at all stages of tide. Such a plan would require excavating to a depth of 5 feet below mean lower low water with a maximum cut of some 35 feet resulting in quantities which would make the cost prohibitive, and maintenance impractical.

304. Consideration was also given to provisions for sea-planes, but such provisions would include space for runways and involve costs which would not be commensurate with the benefits that might be derived. Small seaplanes could use the proposed basin for moorage, for

loading and discharging cargo and passengers, but it would not provide adequate runway. Nushagak River would have to be used for runway but could be used only during calm weather, so the improvement would be of little value to seaplane operations. Natural lakes in the vicinity appear to provide adequate facilities for the present and foreseeable future.

305. Following is a tabulation of estimated costs and annual charges for the proposed improvement based on prices prevailing January 1, 1954:

| | |
|---|---|
| **First Cost** | |
| Federal | |
| Basin excavation 200,000 cy at $1.15 | $230,000 |
| Embankment and access road | 14,000 |
| Timber s~~t~~ill in place | 2,000 |
| Gravel blanket, 800 cy at $10.00 | 8,000 |
| Contingencies and overhead | 84,000 |
| Cost (Corps of Engineers) | 338,000 |
| Navigation Aids (U. S. Coast Guard) | 5,000 |
| Total Federal Cost | $343,000 |
| Non-Federal | |
| Public wharf | 14,000 |
| Moorage facilities | 15,000 |
| Road surface | 1,000 |
| Contingencies | 10,000 |
| Total Non-Federal Cost | $ 40,000 |
| Total Project Cost | $383,000 |
| **Annual Charges** | |
| Federal | |
| Interest and amortization (50 yr. life) | $ 12,100 |
| Maintenance | 9,000 |
| Total Federal | $ 21,100 |
| Non-Federal | |
| Interest and amortization (30 yr. life) | 1,900 |
| Operation and maintenance | 1,100 |
| Total Non-Federal | 3,000 |
| Total Annual Charges | $ 24,100 |

306. The excavation cost in the above estimate is based upon use of a suction dredge. Included in the estimate are charges for transporting personnel and equipment from Seattle and return. The cost of the gravel blanket is based upon use of material borrowed from local gravel pits but if sufficient selected material of satisfactory quality can be obtained from the basin excavation, a reduction of cost for this item will result. Cost for right-of-way is not included since the only cost involved would be a negligible amount for transfer of title as the land has no sale value. Present owners of the land upon which the project would be built have agreed to donate the right-of-way when the project is authorized for construction.

307. Life of the project for amortization purposes is assumed to be 50 years for the excavated basin and 30 years for the facilities provided by local interests. Interest is computed at the rate of $2\frac{1}{2}$ percent per annum.

308. Annual charges would consist of interest, amortization, removing silt and debris from the basin and entrance channel, removing moorage floats for the winter and replacing them in the spring, repairs to wharf, operation of the completed project, and policing. The Federal government would maintain the excavated basin and entrance channel and local interests would maintain wharf and moorage facilities.

309. The principal item of maintenance would result from silting in the basin. The silt is extremely fine and is stirred up by tidal currents acting along the sides and bottom of the Nushagak River estuary. Rising tides would force this turbid water about 1000 feet up Scandinavian Creek and into the basin where some disposition would occur. However, outgoing tides, the natural flow of Scandinavian Creek which normally runs clear, and agitation by craft within the basin

would probably flush most of it out again. The fineness of the silt makes it very slow to settle and easily returned to suspension by currents or any disturbance in the water. Scandinavian Creek is currently stable as regards siltation and this natural state will be disturbed as little as possible by this project in order to minimize silt depositions in the basin. On the basis of siltation at the rate of one foot per year, maintenance is estimated to cost $9,000 annually.

310. The Dillingham Public Utility District No. 1 has agreed to:

a. Provide without cost to the United States all necessary lands, easements, and rights-of-way for construction and maintenance where and as required.

b. Hold and save the United States free from property damages that may result from the construction and maintenance of the project.

c. Provide and maintain without cost to the United States necessary mooring facilities and utilities including a public landing with suitable supply facilities open to all on equal terms.

311. At present about 120 fishing boats from 28 to 32 feet in length with attendant craft consisting of 14 power scows, 3 ordinary scows, 4 power tugs, and 9 general work boats, all based at Dillingham, operate in the vicinity during the salmon fishing season. Of these about 50 fishing boats, 3 power scows, 3 ordinary scows, and 2 power tugs are now individually owned and the balance of the craft are owned and operated by the two canneries located in the vicinity. In addition, about 100 privately owned river boats, used by the owners principally in transporting their families and supplies between the summer fishing area and their winter homes, are in the vicinity from spring to early fall. These river boats are secured along the shores and on the beaches when not in use.

312. Due to the fact that there is no harbor at Dillingham, ocean-going vessels must anchor offshore. Ships up to 22-foot draft can anchor one half mile from Dillingham and ships of greater draft must anchor at Clarks Point, 15 miles distant. All cargo destined for Dillingham and reshipment upriver is lightered ashore in scows and landed on the beach. Landings are made during high tides, and the beached scow, after transferring cargo, usually has to remain 24 hours or for the next higher tide to float clear. Only on rare occasions is it possible to move out on the next flood tide 12 hours after landing. The present method of unloading cargo from the scows directly onto the beach often results in damage to general merchandise.

313. Direct benefits which would be derived from the proposed improvement would consist principally of reduction of loss or damage of boats and cargo, reduction in cost of storage and mooring of boats and scows, and saving due to reduction of stand-by-time of ships while unloading cargo. Based upon information obtained from the Public Hearing and upon field investigation carried on during 1953 the benefits that can be evaluated have been estimated as accurately as possible.

314. The Nushagak Bay region is subject to sudden and violent storms during which, under existing condition at Dillingham, severe damage to fishing boats and equipment is sustained. When such a storm strikes, the boat operator must either weather the storm or run for a lee shore or to a tidal slough for whatever protection may be obtained. Storms of long duration inflict serious damage to boats and gear and have caused the yearly loss of one or more fishing boats valued at $1500 to $8000.

315. The small boat basin at Dillingham will greatly reduce the loss of boats and storm damages sustained. Although boats will be able to enter the basin freely at half-tide stages and above, the maximum delay would be only six hours under the most unfavorable tide condition. With a safe harbor for refuge and a six-hour maximum period of weathering the storm for the few boats which might be caught by unfavorable tide stage, it is expected that at least 80 percent of the damage and loss of boats due to storms would be eliminated by the proposed improvement. The number of boats operating out of Dillingham is steadily increasing and the total damages and losses will increase in proportion each year, but for the purpose of this report it is conservatively assumed that the small boat basin will eliminate the loss of one fishing boat per year having an average value of $4750.

316. Little information is available locally as to the cost of repairing storm damages to fishing boats sustained annually, but careful analysis at other harbors in Alaska indicates that damages amounting to $100.00 per boat may be considered very low. Since costs of materials and supplies necessary for repairs are particularly high at Dillingham, the use of this figure is conservative and, on the basis of 80 percent reduction in damage, the total saving creditable to the small boat basin is 100 x $80.00 = $8,000.

317. Each year there are about 100 boats, not suitable for fishing, which bring families from their homes along the various rivers to work on the fishing grounds. These same boats are used after the fishing season to transport winter supplies and families back to their homes. Under present conditions these boats are beached during the summer months where they are subject to storms and general damage. The proposed improvement would provide safe moorage and would

be so used. While the damage incurred from this cause is seldom of major proportion it occurs to all boats in varying amounts and is conservatively estimated to average \$20.00 per boat, which for 100 boats equal a benefit to the basin of \$2000.

318. The best data available indicates that 5 or 6 of these boats, together with their cargo, have been swamped and damaged or totally lost annually. The boats are valued at approximately \$1500 and winter supplies at about \$1000 to \$1500 per boat. Investigation indicates that not all of this loss would be eliminated by the proposed improvement but that elimination of about two-thirds of the loss, or an average of 3 boats and 4 cargoes, would represent a fair estimate of the benefits to the boat basin. This would thus total 3 x 1500 = \$4500 plus 4 x 1000 = \$8500.

319. Storm damage is sustained by the two privately owned tugs as well as to the fishing boats and transportation boats. It is estimated that the proposed improvement will eliminate damage to these tugs in the amount of at least \$100 per boat or a total of \$200. Under existing conditions boat owners must assemble equipment and individually place their boats on skids for winter storage wherever a safe place may be found. The proposed small boat basin will not eliminate the need for storing boats and scows on skids during the winter but it will provide an easily accessible area for safe storage and will permit efficient use of gear for handling the boats out of the water. It is estimated that the savings resulting from the proposed improvement will amount to \$10.00 per fishing boat for 100 boats and \$100 for each of the three privately owned power scows, or a total of \$1300.

320. All cargo destined for Dillingham and its large tributary area is lightered to shore and landed on the open beach at high tide,

where it is subject to damage by the elements and loss by pilferage. Lack of proper handling facilities and general difficulties of unloading along the muddy shore line cause additional direct losses to cargoes every year. Local interests have estimated that the loss from these courses amounts to at least $3000 annually and investigation indicates that a figure of $2000 would be a reasonable amount. By providing the opportunity for floating scows to unload at a fixed dock by use of adequate equipment, this loss would be eliminated.

321. The nature of the beach on which all cargo must be discharged, in conjunction with the large tidal variations place a severe handicap on present methods of handling cargo. Scows may be launched during only the higher high tide and thus may be withdrawn only during a following higher high tide. This requires a minimum of 24 hours, but more commonly 48 hours to complete one round trip, during all of which time the freight ship must stand by. The proposed basin would permit access to efficient unloading facilities, and egress from the basin on each high tide. This would permit completion of a round trip for the scow in 12 or 24 hours and would reduce by at least half the time required to unload the freighter. Data obtained from the Alaska Steamship Company shows that operation of the type of freighter serving Dillingham costs an average of $1800 per day. Conservatively assuming that only one day would be saved to each of the three ships normally serving the area each year, the benefit to the project will amount to $5400.

322. The foregoing benefits are based upon use of the basin only by privately owned boats and no credit is taken for use by cannery-owned vessels. However, it is probable that many of these boats will find it advantageous to utilize the facilities. Additional substantial benefits will stem from the provision of an area suitable

for boat repair and thus facilitate and reduce the cost of all maintenance and repair. The proposed project would not improve the landing conditions for float or sea planes but would benefit them by furnishing safe storage and a location for easy fueling and servicing.

323. The evaluated benefits totalling $32,150 exceed the annual costs of $24,100 by $8,050, indicating a benefit cost ratio of 1.33.

324. Upper Kvichak River. - The Kvichak River, which drains the watersheds of Iliamna Lake and Lake Clark provides a water route into an area of Southwestern Alaska containing about 7,000 square miles. These two lakes are the distinctive feature in the tributary area. Iliamna Lake, about 80 miles long and 8 to 20 miles wide, is the second largest fresh water lake lying wholly within continental United States, being exceeded only by Lake Michigan. Lake Clark in the northern part of the tributary area is 52 miles long and from 1 to 4 miles wide.

325. The inhabitants, mostly of native descent, are widely scattered around the shores of the lakes and along the banks of the rivers. There are no incorporated towns in the tributary area and the total population according to the 1950 census was 368.

326. Commercial enterprises above tidewater consist of a combination trading post and roadhouse at Iliamna, a trading post at Nondalton on Lake Clark, charter plane service at Nondalton and at Tanalion Point, and a transportation company at Pile Bay. The latter company moves freight over the portage road from Iliamna Bay to Pile Bay and delivers it by barge to various points on Iliamna Lake. Transportation companies based at Levelock on lower Kvichak River also serve the tributary area.

327. The Kvichak River tributaries are the most important salmon spawning grounds of all the streams entering Bristol Bay. The forests are predominately white spruce with intermingled birch. The timber is not classified as commercial but could well supply lumber for the needs on Bristol Bay. Mineral resources consist of gold, copper, silver, and petroleum but there has been little production other than placer gold and some copper ore shipped out for smelter tests. Certain lands on the shore of Lake Clark are suitable for gardening with capability to supply fresh produce to markets on Bristol Bay. The tourist industry has a great potential but the present deterrent to tourist travel are high cost of access and lack of adequate resort facilities for guests.

328. Two roads totaling 28 miles in length exist in the area but both are of pioneer type. The road from Iliamna to Lake Clark is used as a portage since the Newhalen River is not navigable. The other road connects Iliamna Lake with Iliamna Bay on the Cook Inlet side of the Alaska Peninsula.

329. There are no bridges across the Kvichak River. There have been no prior reports and no project for improvement has been undertaken by the Corps of Engineers or any other government agency.

330. Barge landings are located at Iliamna, Pile Bay, and Iliamna Bay. Otherwise there are few docking facilities and no freight handling equipment on Iliamna Lake since shipments to any one point have not been large.

331. A public hearing, held at Naknek on August 7, 1946 by the Seattle District Engineer, was attended by representatives of salmon canning companies, U. S. Marshal's Office, U. S. Fish and Wildlife Service, local and regional airlines and local businessmen. Subsequent

interviews included discussion with local businessmen, transportation firms, and fishermen who make their homes in the tributary area.

332. A preponderance of the local representatives desire improvement of the Kvichak River channel which would permit freight barges and boats of moderate draft to navigate throughout the entire ice free period of each year. Improvement would be necessary in that portion of the river known as Kaskanak Flats extending from 4 to 11 miles downstream from Iliamna Lake. It was the unanimous opinion that the channel should be 100 feet wide but suggested depths ranged from 8 to 18 feet. Later conferences with responsible individuals revealed that a minimum depth of 5 to 6 feet below the average low water gradient would be satisfactory.

333. The reasons advanced in justification of the proposed improvement were: reduced freight rates would result if lighterage barges could navigate Kvichak River so that cargo would not have to be rehandled at Bristol Bay docks; further reduced rates would follow due to increased competition, a longer navigation season, and elimination of hazards; the advent of power boats on Bristol Bay and the newly explored fish resources for off-season activities will increase the number of settlers in the tributary area and thus the amount of freight required; greater development would be accelerated by lowered freight rates and easier accessibility.

334. Statistics on commerce or vessel traffic are not published but examination of records of the various transportation companies indicate that the traffic to ports on Iliamna Lake in 1952 amounted to 992 tons via Kvichak River and 350 tons via Pile Bay. The 1953 traffic via Kvichak River increased to 1450 tons while the traffic via Pile Bay remained about the same so that the total cargo moved into the tributary area amounted to 1800 tons.

335. Two airfields recently constructed and operated by the Civil Aeronautics Administration at Iliamna and Igiugig are stimulating activity within the tributary area. Mining activities are increasing and annual requirements of petroleum products are rising steadily. The needs of the Civil Aeronautics Administration alone has now grown to about 300 tons annually. These increased activities indicate that a 50 percent increase in freight movement may be expected within the next 10 years and an annual average of at least 2700 tons will be required.

336. The river channel above and below Kaskanak Flats is adequate for foreseeable navigation needs. That portion of the river below the Flats is tidal with a controlling depth of about 10 feet. There are no shoals in Iliamna Lake except along the shores.

337. The river through the Kaskanak Flats is divided into a series of channels where controlling depths of about 2 feet exist during periods of low water. Velocities in this portion of the river average 3 feet per second, with the water surface profile maintaining a nearly uniform slope of 1.75 feet per mile. The river is usually free of ice from May 1 to mid October but ice does not ordinarily leave the lake until late in May. Minimum flows prevail throughout the winter months but low water conditions continue during May and June, with gradually increasing flow until high water occurs during August and September. Commercial navigation with cargo barges under these conditions is thus limited to the high water period of about two and one-half months. From the standpoint of economy of operation and capability of navigation on a large lake such as Iliamna Lake, it is necessary that barges of fairly large size and capacity be utilized. Loaded barges currently in use draw four feet.

338. A portion of the freight arriving at the Naknek ship anchorage is lightered to Levelock and stored until navigation is possible on the upper river. Due to the many channels and bars in the problem area it is difficult to follow the main channel with the result that craft are often grounded causing costly delays. Due to the short navigation period of $2\frac{1}{2}$ months it is necessary for merchants and residents of the area to stock supplies to carry over for $9\frac{1}{2}$ months.

339. The alternate route via Cook Inlet, requires rehandling of the cargo at Seldovia and at Iliamna Bay, and a 15 mile portage by truck before it is transferred to lake barges.

340. The plan of improvement, shown on plate 10, includes excavating a channel 100 feet wide to a depth of 5.5 feet in eight separate reaches where such a channel is not available during periods of ordinary low water, and construction of four timber bulkheads where soundings indicate that flows from side channels are causing aggradation in the main channel. The locations of these bulkheads as shown would be subject to revision at the time of construction. Shifts of minor high water channels might even eliminate the need for any one or all of them. Removal of approximately 100,000 cubic yards of loose material, including one foot of overdepth, would be required.

341. The 5.5 foot project depth would provide the minimum bott om clearance feasible for operation of barges drawing 4 feet. The channel alignment avoids any portion of the river where probings indicated a soft aggrading material. The construction should be done in late summer to avoid interference with salmon runs which usually occur during the early summer months.

342. First cost and annual charges for the improvement, based on average prices during the last quarter of 1953, are shown in the following tabulation:

First cost

Federal

| | |
|---|---|
| Channel excavation 100,000 cu. yds. at $2.00 | $200,000 |
| Bulkhead timber 41 MFBM at $400.00 | 16,400 |
| Bulkhead piling 150 ea. at $45.00 | 6,800 |
| Bulkhead hardware | 200 |
| Contingencies and overhead | 74,600 |
| Total project cost | $298,000 |

Annual charges

| | |
|---|---|
| Interest and amortization | 10,500 |
| Maintenance | 4,000 |
| Total | $14,500 |

343. The above costs are based upon transporting equipment, material, and personnel from Seattle. The entire cost of the project would be borne by the Federal Government since there are no local organizations capable of assuming any financial obligation. No provision is made for rights of way as there are no privately owned lands along the river and the entire project would be within the confines of the river banks.

344. Annual charges are based upon an expected life of 50 years with interest at the rate of two and one-half percent per annuam ~~except that the bulkheads would have a 20-year life~~. Maintenance would consist primarily of occasional dredging in the lower portion of the project where the tide from Kvichak Bay meets the river current.

345. The only direct benefit to the project which can be evaluated would result from the saving of time due to the elimination of navigational hazards. Under present conditions the time required for a round trip from Bristol Bay to Iliamna averages seven days. In

navigating the Kaskanak Flats reach of the river, frequent grounding occurs which causes delays and often requires the unloading of freight in order to lighten the barges before proceeding upstream through the shoals. Thus considerable rehandling and delay in doubling back is necessary, which the local transportation agent states averages a loss of at least one day per round trip. Elimination of this delay would result in a saving which could be reflected in lower freight rates and would be a general benefit to the community.

346. The evaluation of this savings is as follows. About 200 tons are transported per trip at an average cost of about $25 per ton. Six trips now require 42 days to transport 1200 tons of freight at a total cost of $30,000. With the channel improved, seven trips totaling 1400 tons could be made in the same interval of time for the same cost, since the labor costs and overhead would be the same and amount of fuel now consumed in doubling back during six trips would more than offset the fuel costs for the extra trip. The saving would then amount to $25 less (30,000 ÷ 1,400) or $3.57 per ton. Assuming that the 350 tons now being shipped annually via Pile Bay continues to be transported by that route and that only 2350 tons are benefited by the project, the benefit amounts to 2350 x $3.57 = $8,390. This compared to the estimated annual cost of $14,500 indicating a benefit to cost ratio of 0.58.

347. In addition to the elimination of lost time, the project would extend the safe navigation season by about two months. This amounts to an 80 percent increase in the time during which freight could be moved and would permit more efficient use of all equipment and the movement of the total freight with less equipment. Also, by permitting the earlier movement of freight up river, part of the costs of storage, which are currently incurred while awaiting high

water, would be eliminated. The monetary value of these items, which might be reflected in lower freight costs, are difficult t o determine exactly and although they are real and direct benefits, they are not evaluated. The elimination of navigation hazards and increased commerce might encourage competition in freight transportation and bring about lower rates. However, the present and foreseeable tonnage is scarcely sufficient to support additional operations.

348. Naknek River. - The Naknek River has its source at the outlet of Naknek Lake and flows westerly about 35 miles to Kvichak Bay. The stream varies in width from about 500 feet in the upper reaches to more than a mile at its mouth and its controlling depth over the bars above Naknek is about three feet at mean lower low water. The diurnal range of tide at the mouth is 22.8 feet, and high tides affect the stream up to the rapids seven miles below Naknek Lake. Low water occurs during winter when the stream is frozen, and high water occurs during the month of August.

349. The drainage basin, which covers about 3,730 square miles, includes about 50 percent of the Katmai National Monument area and contains several large lakes having recreational attraction. The development within the basin is concentrated in the area around King Salmon, situated on the right bank at river mile 18, and in the vicinity of the village of Naknek near the mouth of the river. A few isolated trapper cabins and Indian camps are scattered along the shores of the lakes and two sport fishing camps operate within the National Monument during summer months.

350. The airfield at King Salmon, built during World War II, is operated by the Civil Aeronautics Administration. Two scheduled airlines operating between Anchorage and Dillingham make regular

stops, and planes are available for charter. Aside from the nearby military establishment there are located at King Salmon a post office, a combination trading post and road house, Alaska Communication Service facilities, and a U. S. Fish and Wildlife Service sub-base. A transit camp is maintained during summer months for the convenience of an estimated 4,000 men who move via the airfield enroute to and from the various Bristol Bay fisheries.

351. Naknek, a village of about 175 population, has a number of business houses, a territorial school, a post office, a U. S. Commissioner's office, and United States Deputy Marshall's office, and is the largest trading center in the Kvichak Bay area. A telephone line and about 14 miles of dirt road connect the village with King Salmon. South Naknek, a village of less than 100 population, has a post office, school, cannery, and general store and is situated on the south bank of the river directly across from Naknek. Several large canneries are located near the mouth of the Naknek River, some of which have not operated in recent years.

352. No bridges cross the Naknek River and there are no Corps of Engineers' projects in the basin.

353. Navigation facilities at King Salmon consist of a small bulkhead type dock, a marine ways, and a float plane landing constructed by the U. S. Fish and Wildlife Service.

354. The facilities along the lower river are confined to the cannery wharves, which are equipped with cranes for transfer of cargo and limited facilities for the repair of their own equipment. These wharves are usable during high tide periods only, as the river bed is exposed at these locations during low tide.

355. No public hearing was held, but interviews with local interests revealed that numerous unmarked rocks and sand bars lie

in the normal navigation channel. Operators of tugs and power scows desire improvement of the river below King Salmon by removal of the rocks which are navigation hazards. It was pointed out that little damage occurs to craft when grounded on a sand bar, but when a vessel grounds on a boulder, considerable damage results.

356. Complete records are not available of vessel traffic or freight movements on the river. All of the heavy equipment and building material in connection with the construction of the airbase, and the major portion of the supplies for the residents of the region, including aviation gasoline, motor fuel, and heating fuel, have been and are continuing to be transported on the river.

357. The ship anchorage about six miles off the mouth of Naknek River is considered the head of deep water navigation. All cargo destined for ports on Kvichak Bay is lightered ashore from this point. Shoals and banks, many of which uncover at low tide, fill the lower course of the river and extend three or four miles off the mouth. Boats with four-foot draft can enter the river at mean lower low water and proceed about two miles up river, providing the pilots possess knowledge of local conditions. Craft drawing ten feet may anchor alongside the cannery wharves at high tide, but cannot remain during low water periods without grounding. Boats of ten-foot draft can proceed up river to King Salmon by leaving the mouth one hour before high tide. A light on the north bank at the mouth is the only navigational aid on the river.

358. The plan of improvement consists of removing boulders at 23 separate locations as shown on plate 11. All of the work would be in the reach between mile 8 and 17. The boulders would be removed by shattering with powder so that excavation would not be necessary. This work should be performed at such time as to avoid damage to the fish run.

359. The following tabulation shows the estimated first cost and annual charges based on average cost for similar work during the last quarter of 1953.

| | |
|---|---|
| First cost | |
| Explosives | |
| 2500# at $64/100 | $1,600 |
| Floating plant | |
| 1 power scow for 30 days at $100 | 3,000 |
| 2 skiffs with motors, 30 days at $20 | 1,200 |
| Salaries and wages | |
| 6 men for 30 days at $30/man day | 5,400 |
| Miscellaneous supplies and equipment | 1,800 |
| Contingencies and engineering | 4,000 |
| | $17,000 |
| Annual charges | |
| Interest and amortization | $ 600 |

360. The estimate of cost is based upon the assumption that floating plant and personnel can be obtained locally, and explosives will be shipped from Seattle, Washington. No provisions are made for rights-of-way as the entire project is within the confines of the river banks and no privately owned lands would be involved. Interest is computed at the rate of $2\frac{1}{2}$ percent per annum and, for amortization purposes, it is considered the life of the project will be 50 years. It is not contemplated that any maintenance will be necessary. The Federal G overnment would assume the entire cost of the project since there are no local organizations in a position to assume any financial obligation.

361. Investigations indicate that removal of the boulders from the channel would not be necessary if they were properly marked. However, use of buoys, or other markers as navigational aids, would not be practicle since the ice would destroy them each winter. Annual replacement would cost about $1,500, which amounts to consideraly more

than the estimated annual charges for the proposed project. The Commandant of the Seventeenth Coast Guard District has advised that navigational aids will not be needed with the contemplated improvement.

362. All equipment and supplies destined for the airbase, the U. S. Fish and Wildlife Service plant, and the village of King Salmon are transported up the Naknek River from ocean-going vessels anchored off shore about six miles from the mouth of the river. Power scows, tugs and barges are utilized in the movement of the cargoes upstream. From 800 to 1,000 tons of petroleum products and 100 or more tons of general merchandise is presently being moved in each year by common carrier. A large but unknown quantity of military equipment and supplies has been and is presently being transported by the same method. Government barges also handle a large portion of this tonnage; however, privately owned lighterage firms move some by contract.

363. The boulders which encroach upon the river channel constitute a considerable hazard to navigation. Pilots who are familiar with the location of these boulders experience difficulty and often sustain damage and delay. Inexperienced pilots must proceed with extreme care and lose much time seeking a safe channel. Many barges transporting military cargo have sustained severe damage and loss to cargo. The exact amount of monetary loss is not available as the movement of military equipment constitutes classified information. However, the amount has undoubtedly risen into thousands of dollars, and it is reasonable to assume that elimination of this item, together with time lost would be in excess of $1,000 annually.

364. This annual benefit to the project would exceed the estimated annual charges of $600 by $400 and would indicate a B/C ratio in excess of 1.67.

365. -<u>Water Route Across Alaska Peninsula</u>. - Preliminary studies were made with the view of providing an all water route across the Alaska Peninsula, connecting Cook Inlet with Bristol Bay, to eliminate the 1,000 mile route by way of Unimak Pass.

366. One possible site for a waterway is located about 50 miles south of Pile Bay. A navigable channel connecting Iliamna Lake with Kamishak Bay would be about 17 miles long. Construction would involve excavating millions of cubic yards of material through a pass some 400 feet above sea level. Practically all of the excavated material would be solid rock. A lock system would also be required to prevent lowering of the lake level. Some protection to the easterly terminus of the channel would be afforded in a small cove off Kamishak Bay. However, shoal water in the cove and in the bay would prevent boats from entering or leaving the channel except at high stages of tide. Use of the route would be limited to small boats since deep draft vessels cannot approach the shores of Kamishak Bay, and Kvichak River is shoal. This plan would shorten the route of travel by some 900 miles.

367. Another plan would provide for a waterway between Puale Bay and Becharof Lake. The channel at this site would be about 14 miles long through a pass 200 feet above sea level, where rock excavation would not be expected. There is no evidence that rock foundations could be found for the lock structures that would be required. Little protection would be afforded at the east end of the channel. Here again, because of shoal water, entrance or exit could only be made at high tide and use would be limited to small boats. Becharof Lake is deep and navigable for its entire length and Egegik River at the outlet of the lake has been improved to allow passage of boats with 3 feet draft. A waterway at this site would eliminate about 800 miles from the existing route.

368. A proposal was also studied which would provide a waterway between Port Heiden and Aniakchak Bay by connecting Aniakchak River on the east of the Alaska Peninsula with Meshik River on the west. The route would be about 55 miles long. The ground between the two rivers is less than 200 feet above sea level, and no rock would be encountered in construction of a channel. The waters involved are important salmon spawning areas. This route would eliminate about 700 miles of travel from the existing route.

369. Still another plan would connect Chignik Bay with Bristol Bay by way of Black Lake. The waters involved here are also important spawning areas. This route would be about 50 miles long and would eliminate some 600 miles from the existing route. A fair harbor exists in Chignik Bay on the easterly side of the Peninsula but the westerly end would terminate directly in Bristol Bay where the water is shoal. Probably no rock would be encountered in construction of a channel.

370. Information published in U. S. Geological Bulletin No. 796 (1926) indicates that a navigable channel, either via Black Lake or Meshik River would involve almost insurmountable maintenance problems. A peculiar type of creep is described, where large tracts of the surface moves down the slopes several inches a year involving soil to a depth of 1 to 2 feet. Weathering proceeds rapidly owing to the abundance of moisture and repeated freezings and thawings with the result that soil and broken rock are brought down in greater quantity than streams can transport. Deposition exceeds erosion so that the valley floors are aggrading. It is doubtful if effective sites could be found for support of locks or control structures, because of the highly porous character of the volcanic rock.

## SECTION VI - DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

371. Discussion - Southwestern Alaska includes a total area of 71,000 square miles of which 58,000 are on the mainland and 13,000 are in the Kodiak, Aleutian, and Pribilof Islands. The climate of the mainland portion is generally cold with severe winters, but that of the islands is generally mild due to maritime influence. The entire area is subject to frequent and severe storms, has relatively few days of clear weather, and is often fog shrouded. The islands are generally mountainous with steep-to shores and have very little flat land. The mainland is mountainous with wide tundra-covered valleys and coastal plains.

372. The economic growth of Southwestern Alaska prior to World War II has been based almost entirely upon its fishery resources. However, the fishing industry, although furnishing an important item in the nation's food supply and earning tens of millions of dollars annually, has contributed little toward the development of this portion of Alaska. The majority of the canneries are owned by outside interests and under current operating methods at least two-thirds of the labor needed for catching and processing the fish is imported.

373. The condition is aggravated by the highly seasonable nature of the salmon fishing since the year's activities are usually crowded into a period of about six weeks. With no other employment available and little opportunity to earn other income, there has been small inducement for people to settle and develop the country. This has been reflected by census figures which showed a slow population growth to a total of only 6,976 people in the area by 1939.

374. During the war the importance of Alaska to the defense of North America was recognized, and an extensive construction program was undertaken, which has equaled or exceeded the fishing industry in benefiting the area. This program has brought in many new people, has helped to open the country, and has furnished employment opportunities throughout the entire year. Under the impact of this program the population gained about 130 percent from 1939 to 1951 as indicated by the latest census figure of 16,055.

375. Apart from these two factors, other industries have contributed very little to the growth of Southwestern Alaska. The major mining operation is located at Platinum, where about 70 men are employed in the placer mines. Only limited development of other natural resources has occurred.

376. The future growth of this area is difficult to forecast, as it is dependent upon various factors which are unpredictable. The salmon fishing is presently producing to capacity under a sustained yield program, but some expansion might be realized if new spawning areas were made available by removing natural barriers or providing fish ladders at strategic points. Greater promise of growth exists in the development of other fisheries to utilize halibut, bottom fish, crabs and clams.

377. A serious question is presented by the indefinite future of the defense construction program. The current program is scheduled for completion about 1954, and it is expected that use and occupancy of the new facilities will maintain the present population and offset any loss due to termination of construction. Should a further program be initiated, continued rapid growth could be expected.

378. Recreation holds promise of becoming a major factor in the local economy. Established sportsmen camps are well patronized in season, and expansion to many times the present facilities may be expected as the scenic and recreational possibilities become better advertised and access to additional areas is provided.

379. Major expansion in the development of other natural resources or industrial activities is not foreseeable at this time. Many valuable minerals are known to exist in Southwestern Alaska, but present production costs exceed the costs in competing areas. Exploration of potentially large deposits of copper and cinnabar is currently under way and these may develop into large operations. Rising demand for coal may bring about the working of the coal fields in this area. Possibly greater gain may result from explorations for oil now being conducted on the east shore of the Alaska Peninsula. Should oil in commercial quantities be discovered, a tremendous gain to the economy would result.

380. Studies of possible water resource development in Southwestern Alaska in the interest of broadening the economic base of the area show that, while many facilities are needed and would be beneficial to the country, the scant population and present low use factor preclude development in all but a few localities. Developments in the interest of navigation can be justified at three locations at this time.

381. Specifically, local interests have requested the construction of small boat basins at Kodiak and Dillingham and improvements in upper Kvichak River and lower Naknek Rivers in the interest of navigation.

382. Partial Interim Report No. 5, Kodiak Harbor, Alaska, submitted by the District Engineer October 1, 1951, and concurred in by the Board November 20, 1950 recommended the construction of a small boat harbor at Kodiak at an estimated cost to the

1,685,000
Corps of Engineers of ~~$1,504,730~~ and an average annual maintenance cost to the Corps of Engineers of $2,000. The need for this small boat harbor continues, and its early construction would benefit not only the City of Kodiak but also a large tributary area.

383. The small boat basin at Dillingham would involve dredging of some 200,000 cubic yards of silt to provide a basin 230,000 square feet in extent located on the left bank of Scandinavian Creek. The basin would be excavated to an elevation of 2 feet above mean lower low water, but a sill across the outlet at elevation +7 would maintain a minimum depth of water of 5 feet in the basin. Boats with draft of 3 feet could enter at 10 foot stage of tide, which would permit entry and egress about 50 percent of the time during the 6 months of the ice free season. The improvement would provide protection for the increasing number of fishing boats and for the numerous boats used by residents of the tributary area who travel to the Nushagak Bay fisheries each year and return with their winter supplies. The Federal first cost is estimated to be $343,000 with subsequent annual cost of $9,000 for maintenance dredging. The evaluated annual benefits c ompared to the estimated annual charges result in a benefit to cost ratio of 1.33.

384. The considered plan of improvement in the upper Kvichak River would consist of the excavation of approximately 100,000 cubic yards of loose material in eight reaches of the river and the construction of four pile and timber bulkheads, to provide a channel 100 feet wide and 5.5 feet deep. Federal first cost of this project is estimated to be $298,000 with subsequent annual cost of $4,000 for maintenance. The improvement would lengthen the navigation season on Kvichak River about 80 percent; it would eliminate some rehandling and storage of freight at Bristol Bay docks, and eliminate most delays due

to hazards in Kaskanak Flats. However, the evaluated benefits, based upon existing commerce, compared to the estimated annual charges, results in a benefit to cost ratio of only 0.58. While the project is not economically justified at the present time, future population growth or economic development within the tributary area could cause a large increase in the amount of freight required to be transported up the Kvichak River. A review of the project at that time would be warranted.

385. The plan of improvement in the lower Naknek River would consist of removing boulders at 23 separate locations to eliminate shipping hazards and prevent loss of cargo. The estimated cost to the the Federal Government amounts to $17,000 for new work. No maintenance would be required. Comparison of annual benefits with estimated annual charges indicates a benifit to cost ratio of 1.67.

386. The desirability of a water route across Alaska Peninsula has long been recognized. Investigation of several possible routes indicates that millions of cubic yards of excavation would be required, a large part of which would be rock, and the cost would amount to millions of dollars. Extensive locks systems would be necessary, and entry or egress could be made only at high tide. The amount of cargo which would benefit from such an improvement is very small at the present time.

387. One of the greatest untouched resources of Southwestern Alaska is the large hydroelectric power potential, and one of the important phases of this report has been its investigation and evaluation. Field reconnaissance, investigations of power sites, and many studies have been made and the results are presented as an inventory of possible hydroelectric developments available when needed.

388. The river systems of the Bristol Bay Region with their numerous large lakes providing favorable storage sites are c apable of development to provide 300,000 kilowatts of prime power. In addition, many sites scattered throughout the area are capable of development from an engineering standpoint but have not been evaluated because of small size, interference with major fish runs or for other pertinent reasons.

389. The terrain of the mainland area is favorable to power transmission so that it would be entirely feasible to concentrate the output of the several plants at any one of a number of locations either on the east coast of the Peninsula or on Bristol Bay.

390. Due to isolation and lack of transportation facilities the cost of generation of hydro power is not as low as in some other parts of the Territory. It is estimated to vary from 8.2 mills to 19.8 mills with an average of 10.6 mills per kilowatt-hour under current conditions at the plants listed in the report. The cost of transmission, if the power from the ultimate development were brought to one area, is estimated to be about three mills per kilowatt-hour.

391. The present power load in the vicinity of Dillingham is sufficiently large to utilize the 6,200 kilowatts of installed initial capacity proposed for the project at Grant Lake. Replacement of the power now generated by diesel and gasoline powered generating plants at costs of from ~~14~~ 15 cents to 35 cents per kilowatt hour, by hydroelectric power which may be sold at from 3 cents to 4 cents per kilowatt hour, would appear to be an economically sound investment.

392. Conclusion. - As a result of these studies the District Engineer concludes that the economic development of Southwestern Alaska will derive from its strategic position in the defense of North America and from its principal basic natural resources of fish, minerals,

hydroelectric power and recreation. Any improvement of rivers and harbors which may be constructed to aid in the development of these resources will contribute to the welfare of all of Alaska and to the United States.

393. A review of the immediate needs of this large area shows that under present conditions three projects fall in this category. These projects are:

a. The small boat harbor at Kodiak recommended in separate Partial Interim Report No. 5, dated October 1, 1951.

b. Construction of a small boat basin at Dillingham which is urgently needed at this time and is economically justified.

c. Improvement of lower Naknek River by removal of boulders from the navigation channel which is justified by benefits derived from eliminating loss or damage to cargo.

394. The District Engineer further concludes that:

a. Improvements of Upper Kvichak River cannot be justified at this time.

b. Construction of a waterway across Alaska peninsula would be impractical, it would have little use, and the cost would be prohibitive.

c. There is no present need for flood control within the report area.

395. The development of the large potential of hydroelectric power would be of great benefit to the economy of Southwestern Alaska, but further extensive growth of load demand must occur to justify construction. However, replacement of the present loads at Dillingham and Platinum by low cost power generated at the Grant Lake site is feasible at this time and should offer attractive possibilities for private development.

396. Recommendations. - The District Engineer recommends as follows:

a. The construction of a small boat basin at Dillingham dredged to a depth of 2 feet above mean lower low water, with a sheet piling sill across the basin outlet with top elevation 7 feet above mean lower low water as shown on plate 12, at a total first cost to the Corps of Engineers of $338,000 and $9,000 annually for maintenance, not including cost of navigation aids; provided that local interests furnish necessary lands, easements, and rights-of-way including spoil disposal areas, agree to hold and save the United States free from damages that may result from the construction and maintenance of the project, agree to furnish and maintain without cost to the United States necessary mooring facilities and utilities including public landing with suitable supply facilities open to all on equal terms in accordance with plans approved by the Chief of Engineers.

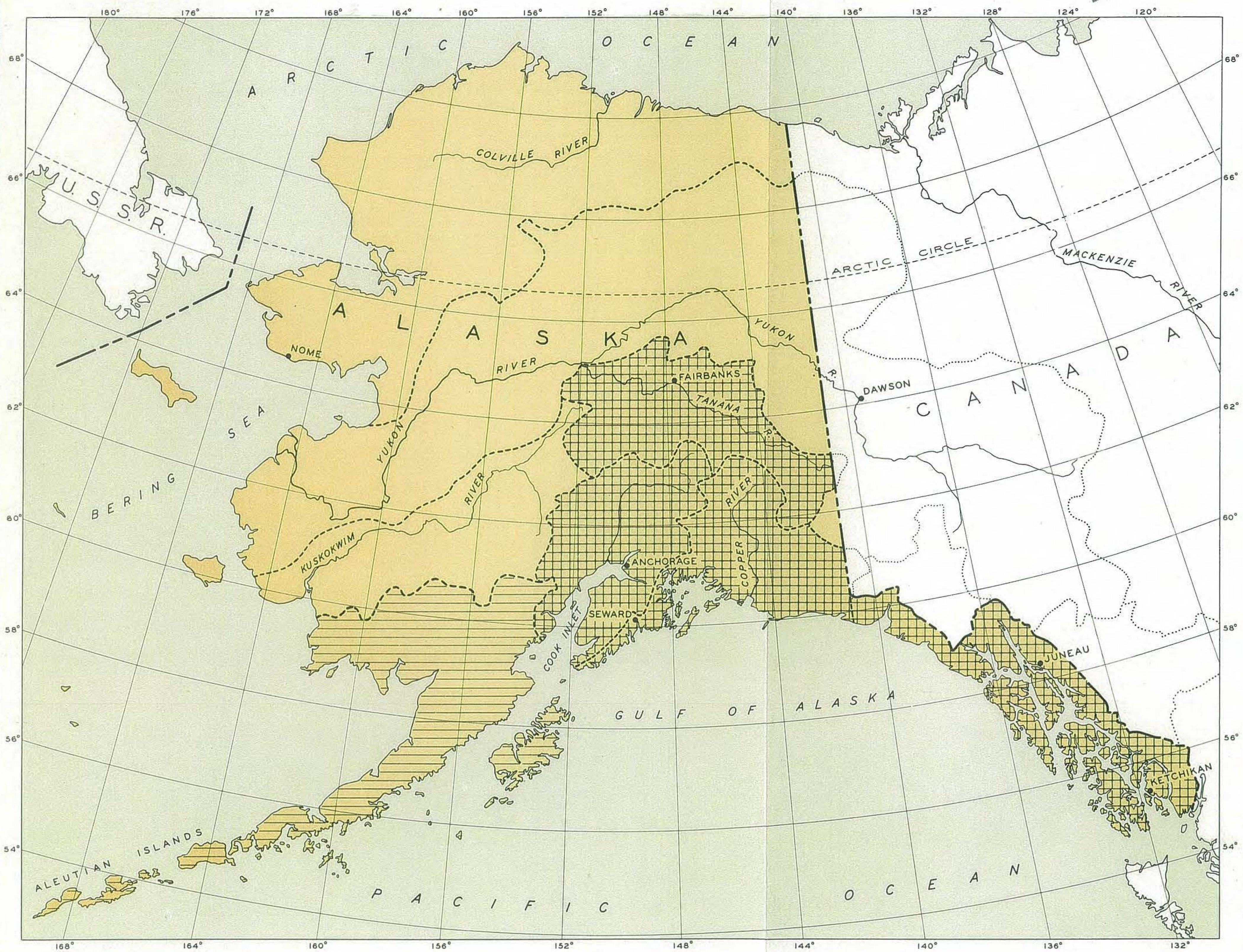
b. Improvement of the channel in the Naknek River by removal of boulders at 23 locations as shown on plate 11 at a total first cost to the Corps of Engineers of $17,000 and no maintenance.

L. H. Foote

L. H. FOOTE
Colonel, Corps of Engineers
District Engineer

CORPS OF ENGINEERS U.S. ARMY






LEGEND

COMPLETED REPORT

CURRENT REPORT

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

STATUS OF INTERIM REPORTS

SCALE IN MILES
50 0 50 100 150 200

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. MacDuffee
ENGINEER

APPROVED: [signature]
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

RECOMMENDED: A. L. Kenny
CHIEF, SPECIAL SURVEY BRANCH

DRAWN BY: R.J.M.
TRACED BY: W.J.M.
CHECKED BY: R.J.M.

TRANSMITTED WITH REPORT
DATED JAN. 20, 1954

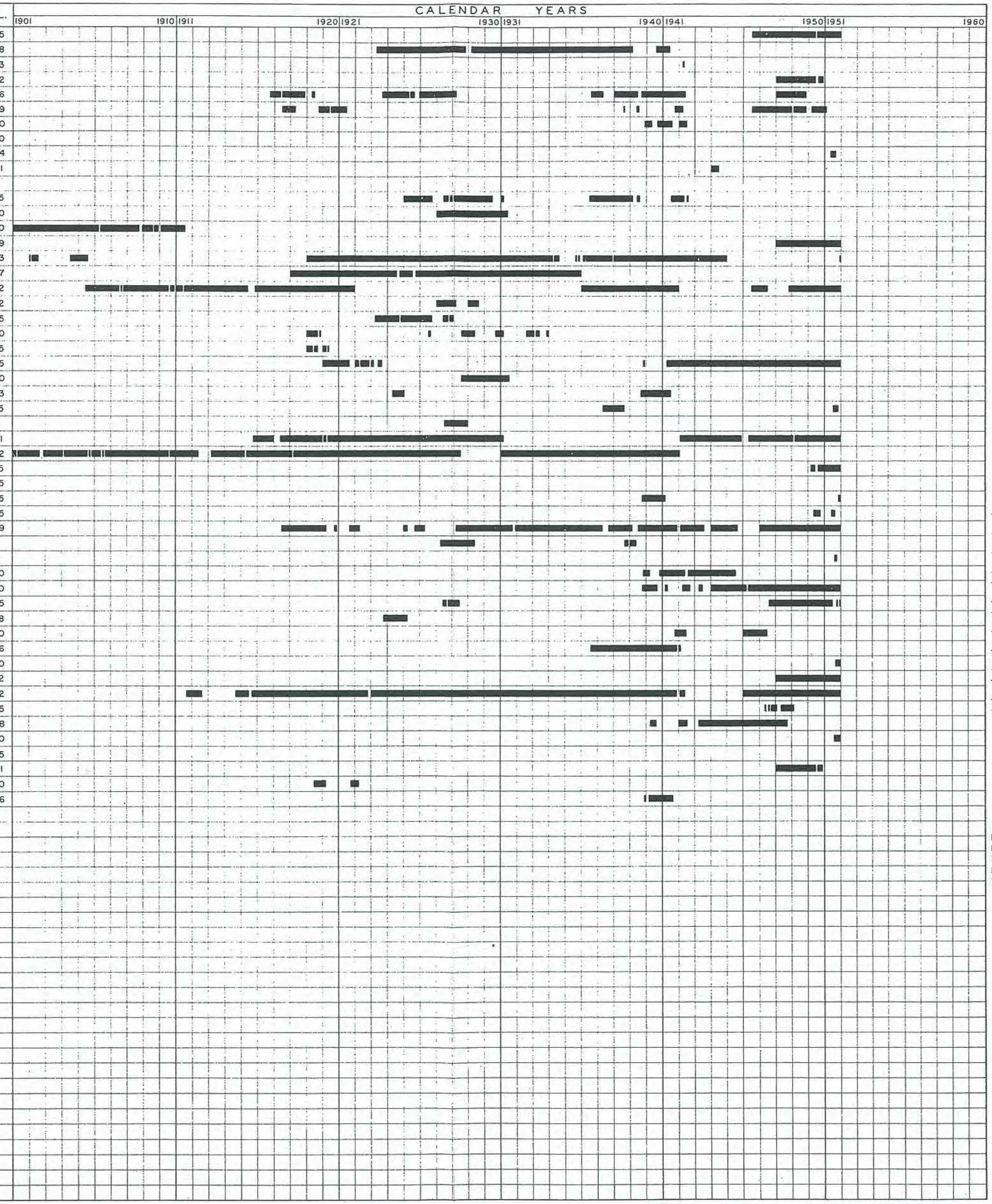
Q-19-5-1

PLATE I

CORPS OF ENGINEERS

U. S. ARMY

| STATION | MAP NO. | LOCATION | DRAINAGE | EL. |
|---|---|---|---|---|
| Adak | 37 | Aleutian Islands | Kuluk Bay | 15 |
| Afognak a | 1 | Whale Island | Marmot Bay | 8 |
| Alitak | 2 | Kodiak Island | Alitak Bay | 23 |
| Amchitka | 38 | Aleutian Islands | Bering Sea | 202 |
| Atka b | 39 | Aleutian Islands | Pacific Ocean | 36 |
| Attu c | 40 | Aleutian Islands | Pacific Ocean | 59 |
| Belkofski | 3 | Alaska Peninsula | Pacific Ocean | 50 |
| Bering Islands d | 41 | Aleutian Islands Vicinity | Bering Sea | 20 |
| Brooks Lake | 4 | Alaska Peninsula | Naknek River | 44 |
| Bruin Bay | 5 | Alaska Peninsula | Kamishak Bay | 51 |
| Cape Sarichef L.S. e | 42 | Aleutian Islands | Bering Sea | — |
| Chernofski Harbor | 43 | Aleutian Islands | Bering Sea | 25 |
| Chignik | 6 | Alaska Peninsula | Chignik Bay | 10 |
| Coal Harbor f | 7 | Shumagin Islands | Zachary Bay | 30 |
| Cold Bay g | 8 | Alaska Peninsula | Pacific Ocean | 99 |
| Dillingham h | 9 | Mainland | Nushagak Bay | 83 |
| Dutch Harbor (A) | 44 | Aleutian Islands | Bering Sea | 47 |
| Dutch Harbor (B) i | 45 | Aleutian Islands | Bering Sea | 22 |
| False Pass | 46 | Aleutian Islands | Bechevin Bay | 12 |
| Geese Islands | 10 | Geese Islands | Gulf of Alaska | 15 |
| Goodnews Bay | 11 | Mainland | Goodnews Bay | 20 |
| Herendeen Bay | 12 | Alaska Peninsula | Port Moller | 15 |
| Iliamna C.A.A. | 13 | Mainland | Iliamna Lake | 145 |
| Kalsin Bay | 14 | Kodiak Island | Kalsin Bay | 20 |
| Kanatak | 15 | Alaska Peninsula | Portage Bay | 23 |
| Karluk Lake | 16 | Kodiak Island | Karluk River | 365 |
| Kiukpalik Island | 17 | Kiukpalik Island | Shelikof Strait | — |
| Kodiak (A) | 18 | Kodiak Island | Woman's Bay | 21 |
| Kodiak (B) j | 19 | Kodiak Island | Chiniak Bay | 152 |
| Lake Aleknagik | 20 | Mainland | Wood River | 55 |
| Lake Nerka k | 21 | Mainland | Wood River | 65 |
| Larsen Bay | 22 | Kodiak Island | Uyak Bay | 15 |
| Mosquito Point | 23 | Mainland | Wood River | 55 |
| Naknek | 24 | Alaska Peninsula | Naknek River | 49 |
| Nikolski | 47 | Aleutian Islands | Bering Sea | — |
| Olga | 25 | Kodiak Island | Akalura Lake | — |
| Pilot Point | 26 | Alaska Peninsula | Bristol Bay | 60 |
| Platinum | 27 | Mainland | Bering Sea | 20 |
| Port Heiden | 28 | Alaska Peninsula | Bristol Bay | 95 |
| Port Moller | 29 | Alaska Peninsula | Port Moller | 18 |
| Sand Point | 30 | Shumagin Islands | Popof Strait | 50 |
| Scotch Cap | 48 | Aleutian Islands | Pacific Ocean | 56 |
| Shearwater | 31 | Kodiak Island | Kiliuda Bay | 0 |
| Shemya | 49 | Aleutian Islands | Bering Sea | 92 |
| St. Paul Island W.B. A.P. l | 50 | Pribilof Islands | Bering Sea | 22 |
| Tanaga | 51 | Aleutian Islands | Tanaga Bay | 145 |
| Tanalian Point | 32 | Mainland | Lake Clark | 308 |
| Uganik Bay | 33 | Kodiak Island | Uganik Bay | 50 |
| Ugashik m | 34 | Alaska Peninsula | Ugashik Bay | 25 |
| Umnak n | 52 | Aleutian Islands | Pacific Ocean | 131 |
| Unga | 35 | Shumagin Islands | Pacific Ocean | 60 |
| Wosnesinski | 36 | Shumagin Islands | Pacific Ocean | 36 |




Reference Notes:

a Referred to as Whale Island from Sept. 1, 1923 to Feb. 28, 1939.
b Also discontinuous temperature and precipitation records for 1879 and from 1881 to 1887.
c Also discontinuous temperature and precipitation records for 1880 and 1881.
d No temperature record. Precipitation record only from May 1882 to May 1886.
e No records prior to 1952.
f Also discontinuous temperature and precipitation records from 1889 to 1901.
g Referred to as Thornbrough from Jan. 1, 1948 to Jan. 1, 1950.
h Also discontinuous temperature and precipitation records from 1881 to 1887.
i Referred to as Unalaska from Nov. 1, 1948 to Jan. 1, 1951. Also discontinuous temperature record from 1872 to 1901.
j Also discontinuous temperature and precipitation records from 1869 to 1901.
k No records prior to 1952.
l Also discontinuous temperature and precipitation records from 1869 to 1901.
m Precipitation record only from Aug. 1883 to Jan. 1886.
n Referred to as Cape from Jan. 1, 1948 to March 1, 1950.

Notes:

Map No. refers to station location number on map of Climatological Stations, Plates 3 and 4.

Horizontal bars indicate duration of climatological records for which values of either precipitation or temperature are published.

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

## CLIMATOLOGICAL STATIONS PERIOD OF RECORD

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. MacDaffee
ENGINEER

RECOMMENDED: A. C. Henry
CHIEF, SPECIAL SURVEY BRANCH

APPROVED: [signature]
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

DRAWN BY: E.V.W.
TRACED BY: A.Y.
CHECKED BY: K.M.M.

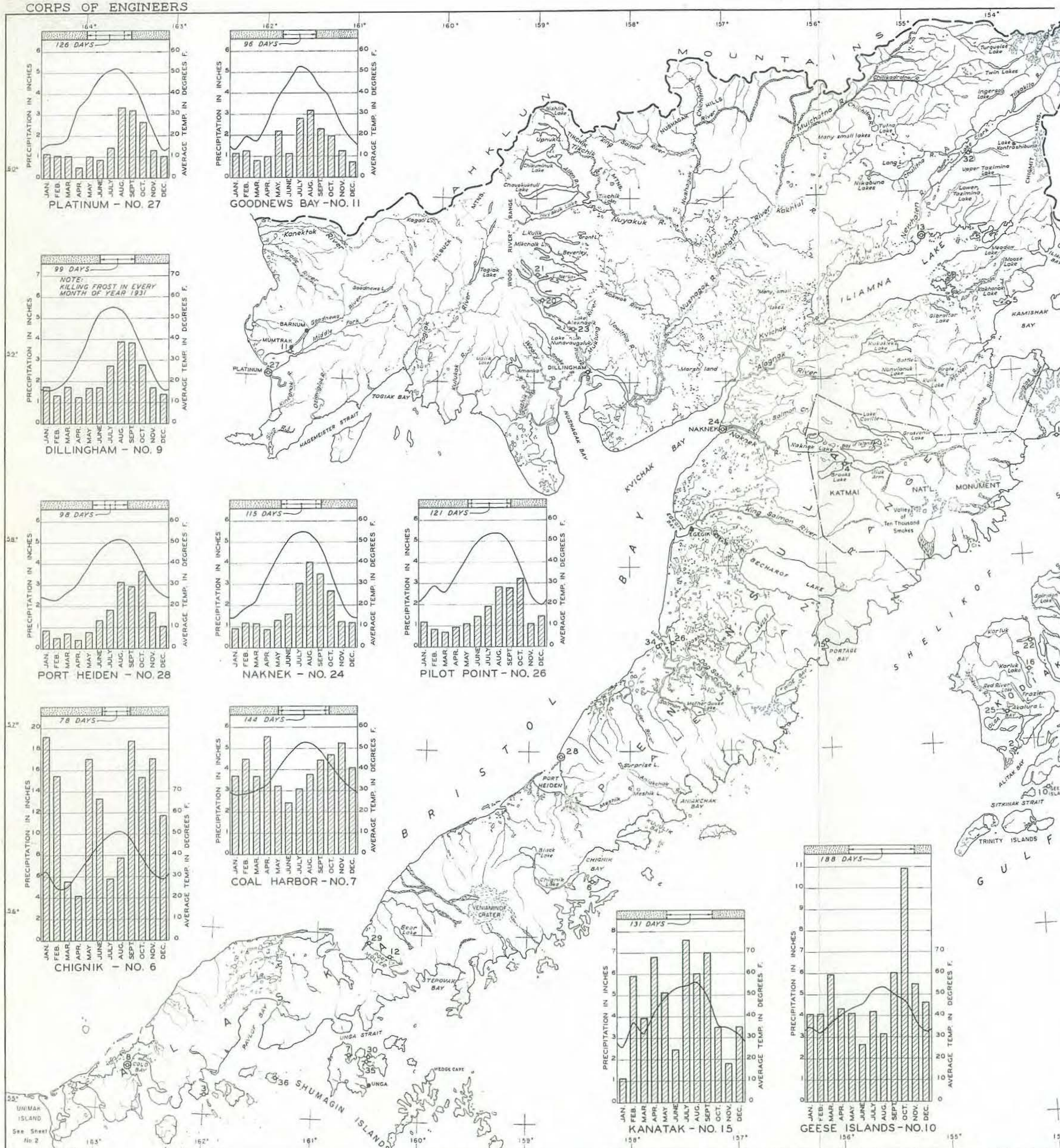
TRANSMITTED WITH REPORT
DATED JAN. 20, 1954

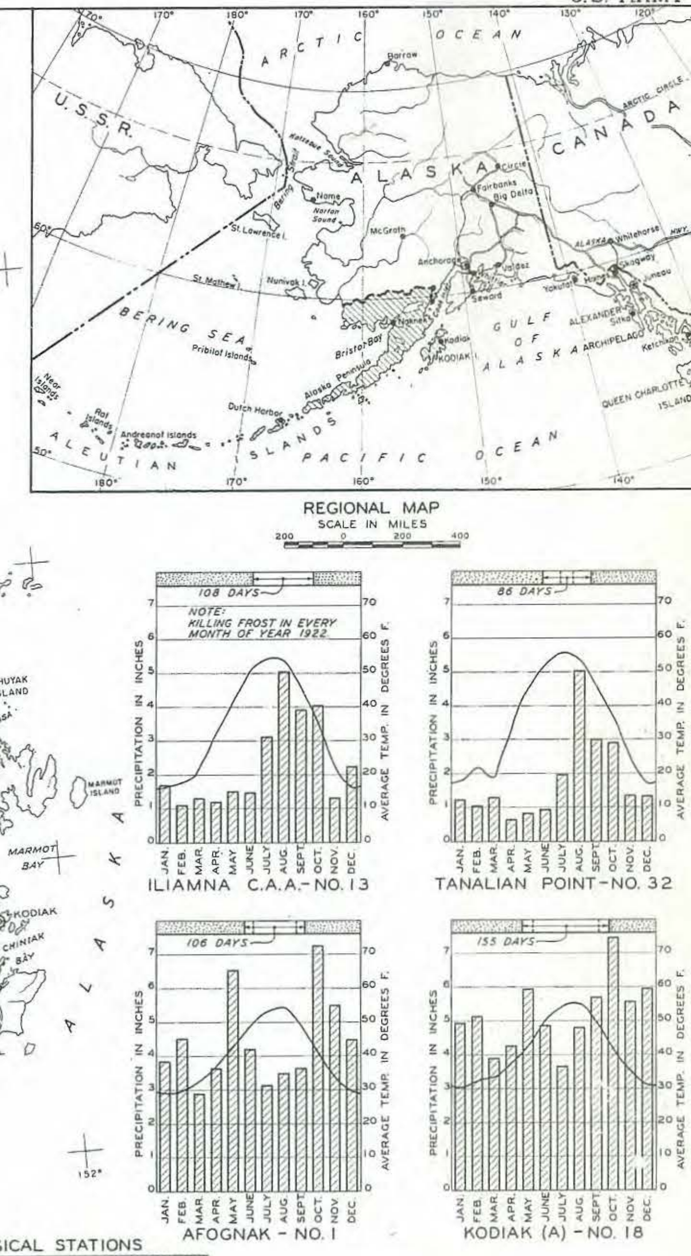
Q-19-5-2

PLATE 2

CORPS OF ENGINEERS

U.S. ARMY




## CLIMATOLOGICAL STATIONS

| STA. NO. | STATION | EL. | YEARS OF RECORD | | AVERAGE ANNUAL | |
|---|---|---|---|---|---|---|
| | | | TEMP. | PRECIP. | TEMP. | PRECIP. |
| 1 | AFOGNAK | 8 | 19 | 19 | 40.1 | 53.29 |
| 2 | ALITAK | 23 | 1 | 1 | — | — |
| 3 | BELKOFSKI | 50 | 4 | 4 | 40.7 | — |
| 4 | BROOKS LAKE | 44 | 1 | 1 | — | — |
| 5 | BRUIN BAY | 51 | 1 | 1 | — | — |
| 6 | CHIGNIK | 10 | 5 | 5 | 37.1 | 151.44 |
| 7 | COAL HARBOR | 30 | 23 | 16 | 39.1 | 48.51 |
| 8 | COLD BAY | 99 | 4 | 4 | 37.5 | 32.48 |
| 9 | DILLINGHAM | 83 | 36 | 35 | 34.3 | 25.86 |
| 10 | GEESE ISLANDS | 15 | 4 | 6 | 42.0 | 59.75 |
| 11 | GOODNEWS BAY | 20 | 7 | 8 | 32.1 | 19.77 |
| 12 | HERENDEEN BAY | 15 | 2 | 2 | 38.0 | — |
| 13 | ILIAMNA C.A.A. | 145 | 16 | 16 | 33.8 | 27.88 |
| 14 | KALSIN BAY | 20 | 4 | 4 | 39.9 | 99.82 |
| 15 | KANATAK | 23 | 5 | 5 | 41.6 | 54.79 |
| 16 | KARLUK LAKE | 365 | 3 | 3 | 40.4 | 33.56 |
| 17 | KIUKPALIK ISLAND | — | 2 | 2 | 38.9 | 75.71 |
| 18 | KODIAK (A) | 21 | 27 | 27 | 41.0 | 62.14 |
| 19 | KODIAK (B) | 152 | 47 | 55 | 40.8 | 61.95 |
| 20 | LAKE ALEKNAGIK | 55 | 2 | 2 | 33.1 | 59.99 |
| 21 | LAKE NERKA | 65 | 1/ | 1/ | — | — |
| 22 | LARSEN BAY | 15 | 4 | 4 | — | — |
| 23 | MOSQUITO POINT | 55 | 2 | 2 | — | — |
| 24 | NAKNEK | 49 | 31 | 27 | 34.4 | 22.89 |
| 25 | OLGA | — | 1 | 1 | — | — |
| 26 | PILOT POINT | 60 | 7 | 7 | 37.1 | 19.64 |
| 27 | PLATINUM | 20 | 13 | 13 | 32.6 | 18.62 |
| 28 | PORT HEIDEN | 95 | 7 | 7 | 36.2 | 18.92 |
| 29 | PORT MOLLER | 18 | 3 | 3 | 38.0 | 19.63 |
| 30 | SAND POINT | 50 | 4 | 4 | 39.3 | 62.35 |
| 31 | SHEARWATER | 0 | 1 | 1 | — | — |
| 32 | TANALIAN POINT | 308 | 8 | 8 | 35.2 | 21.65 |
| 33 | UGANIK BAY | 50 | 1 | 1 | — | — |
| 34 | UGASHIK | 25 | 0 | 3 | — | 24.62 |
| 35 | UNGA | 60 | 4 | 1 | 40.5 | — |
| 36 | WOSNESINSKI | 36 | 2 | 3 | 42.2 | 37.30 |

1/ No record prior to 1952

Note: Dash indicates insufficient continuous record for average.

### LEGEND

CLIMATOLOGICAL STATIONS

- ○ PRECIPITATION ONLY
- -○- PRECIPITATION AND TEMPERATURE
- ◎ COMPLETE METEOROLOGICAL STATION

NOTES:

1. BAR DIAGRAMS SHOW AVERAGE PRECIPITATION BY MONTHS BASED ON UNADJUSTED ARITHMETIC MEANS.
2. CURVES ON BAR CHARTS INDICATE AVERAGE MONTHLY TEMPERATURES BASED ON U. S. WEATHER BUREAU CLIMATOLOGICAL SUMMARIES.
3. AT TOP OF BAR CHARTS, OPEN PORTION BETWEEN VERTICAL SOLID LINES INDICATES AVERAGE FROST-FREE PERIOD. OPEN PORTION BETWEEN VERTICAL BROKEN LINES INDICATES MINIMUM FROST-FREE PERIOD.

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

# CLIMATOLOGICAL STATIONS AND CLIMATIC CHARACTERISTICS

IN 2 SHEETS — SCALE IN MILES — SHEET NO. 1

10 0 10 20 30 40 50

ALASKA DISTRICT, ANCHORAGE, ALASKA — JAN. 20, 1954

SUBMITTED: K. M. Macduffee
ENGINEER

APPROVED:
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

RECOMMENDED: A. L. Kenny
CHIEF, SPECIAL SURVEY BRANCH

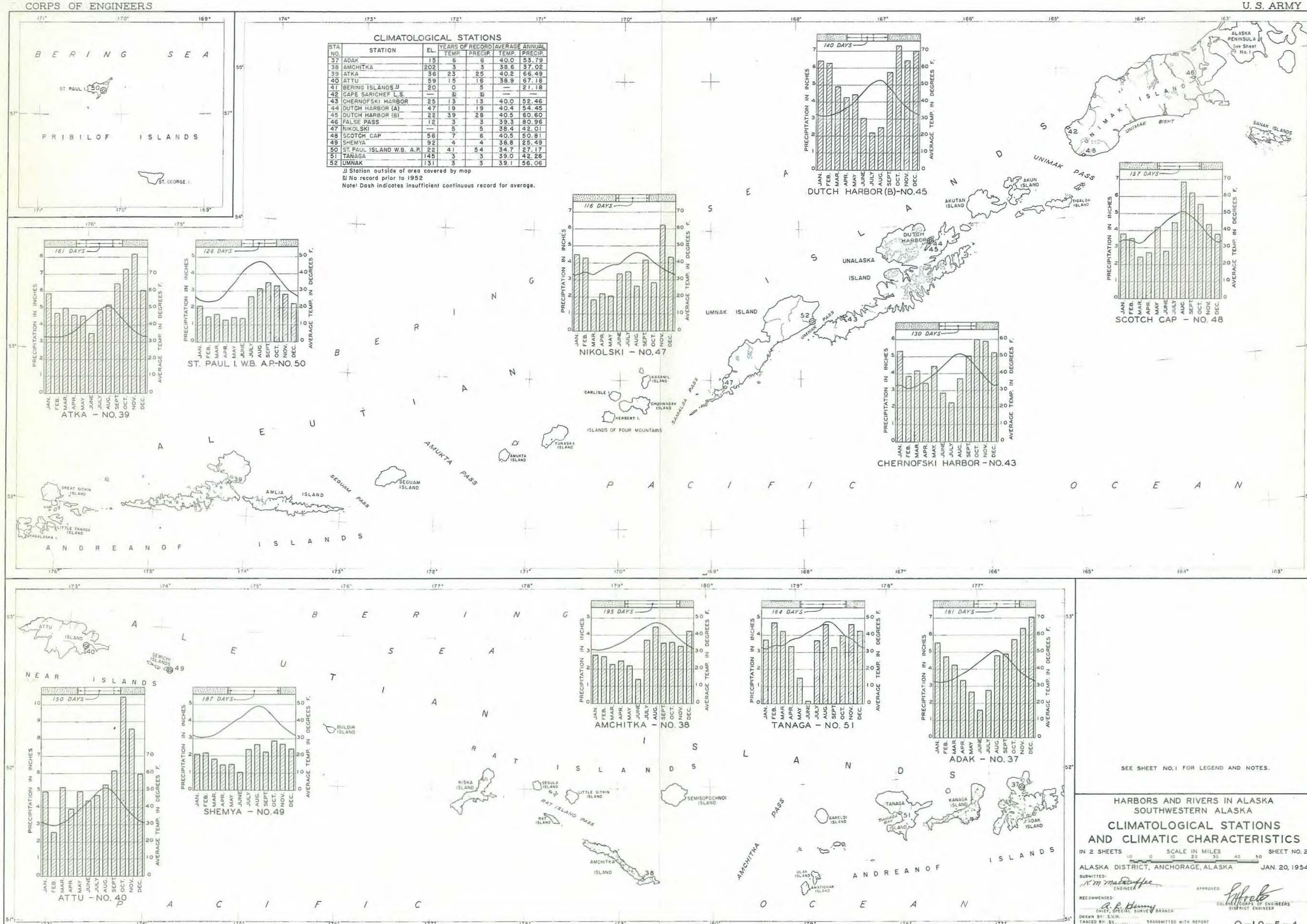
DRAWN BY: E.N.W.
TRACED BY: SV.
CHECKED BY: K.M.M.

TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-3

PLATE 3

CORPS OF ENGINEERS | U. S. ARMY




## CLIMATOLOGICAL STATIONS

| STA. NO. | STATION | EL. | YEARS OF RECORD TEMP. | YEARS OF RECORD PRECIP. | AVERAGE ANNUAL TEMP. | AVERAGE ANNUAL PRECIP. |
|---|---|---|---|---|---|---|
| 37 | ADAK | 15 | 6 | 6 | 40.0 | 53.79 |
| 38 | AMCHITKA | 202 | 3 | 3 | 38.6 | 37.02 |
| 39 | ATKA | 36 | 23 | 25 | 40.2 | 66.49 |
| 40 | ATTU | 59 | 15 | 16 | 38.9 | 67.18 |
| 41 | BERING ISLANDS [1] | 20 | 0 | 5 | — | 21.18 |
| 42 | CAPE SARICHEF L.S. | — | [2] | [2] | — | — |
| 43 | CHERNOFSKI HARBOR | 25 | 13 | 13 | 40.0 | 52.46 |
| 44 | DUTCH HARBOR (A) | 47 | 19 | 19 | 40.4 | 54.45 |
| 45 | DUTCH HARBOR (B) | 22 | 39 | 28 | 40.5 | 60.60 |
| 46 | FALSE PASS | 12 | 3 | 3 | 39.3 | 80.96 |
| 47 | NIKOLSKI | — | 5 | 5 | 38.4 | 42.01 |
| 48 | SCOTCH CAP | 56 | 7 | 6 | 40.5 | 50.81 |
| 49 | SHEMYA | 92 | 4 | 4 | 38.8 | 25.49 |
| 50 | ST. PAUL ISLAND W.B. A.P. | 22 | 41 | 54 | 34.7 | 27.17 |
| 51 | TANAGA | 145 | 3 | 3 | 39.0 | 42.26 |
| 52 | UMNAK | 131 | 3 | 3 | 39.1 | 56.06 |

[1] Station outside of area covered by map
[2] No record prior to 1952
Note: Dash indicates insufficient continuous record for average.

SEE SHEET NO. 1 FOR LEGEND AND NOTES.

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

# CLIMATOLOGICAL STATIONS AND CLIMATIC CHARACTERISTICS

IN 2 SHEETS | SCALE IN MILES 10 0 10 20 30 40 50 | SHEET NO. 2

ALASKA DISTRICT, ANCHORAGE, ALASKA | JAN. 20, 1954

SUBMITTED: K. M. MacDuffee, ENGINEER

RECOMMENDED: A. L. Henry, CHIEF, SPECIAL SURVEY BRANCH

APPROVED: [signature] COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: E.V.W.
TRACED BY: S.V.
CHECKED BY: K.S.L.M.

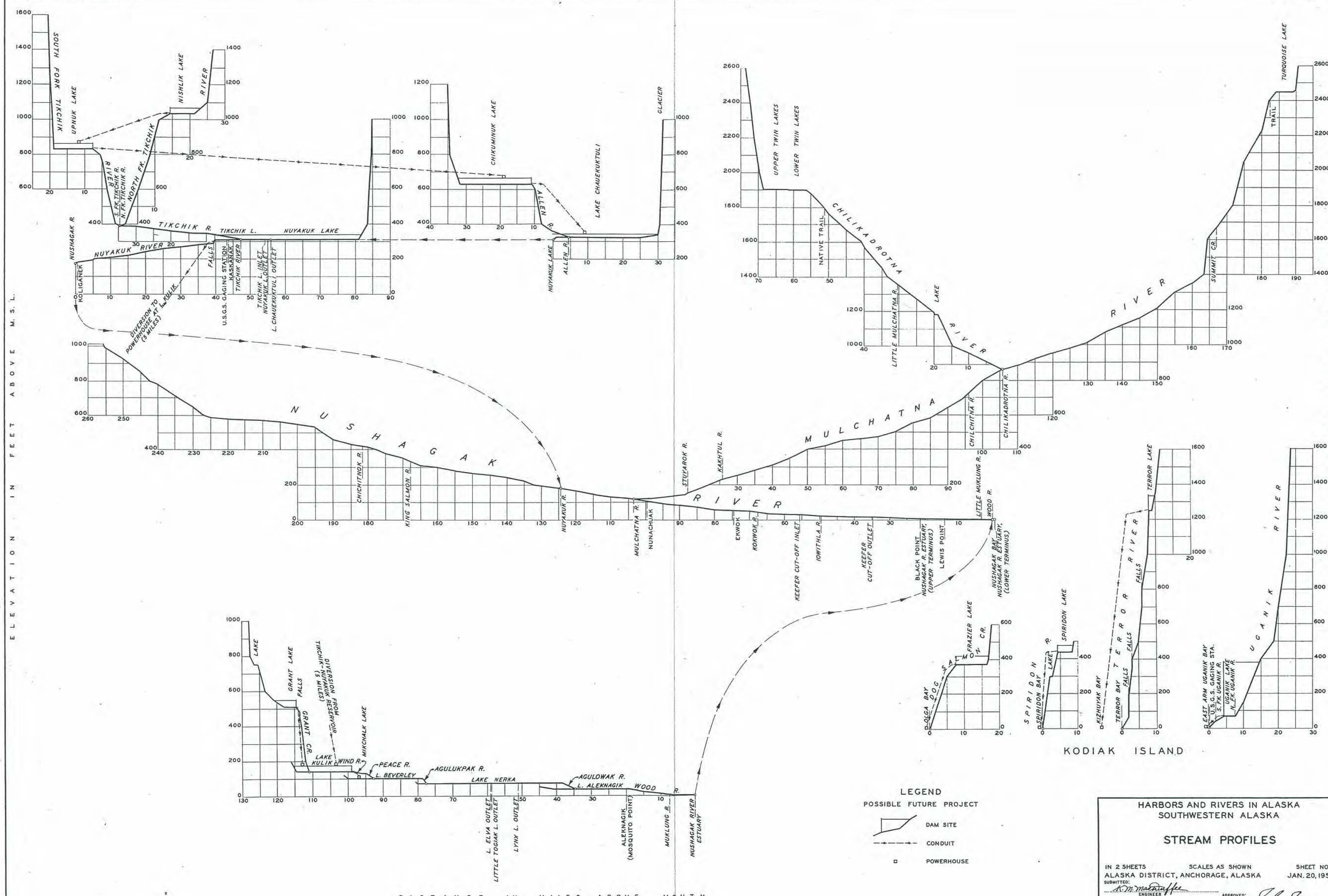
TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-4

PLATE 4

CORPS OF ENGINEERS

U. S. ARMY




HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

STREAM PROFILES

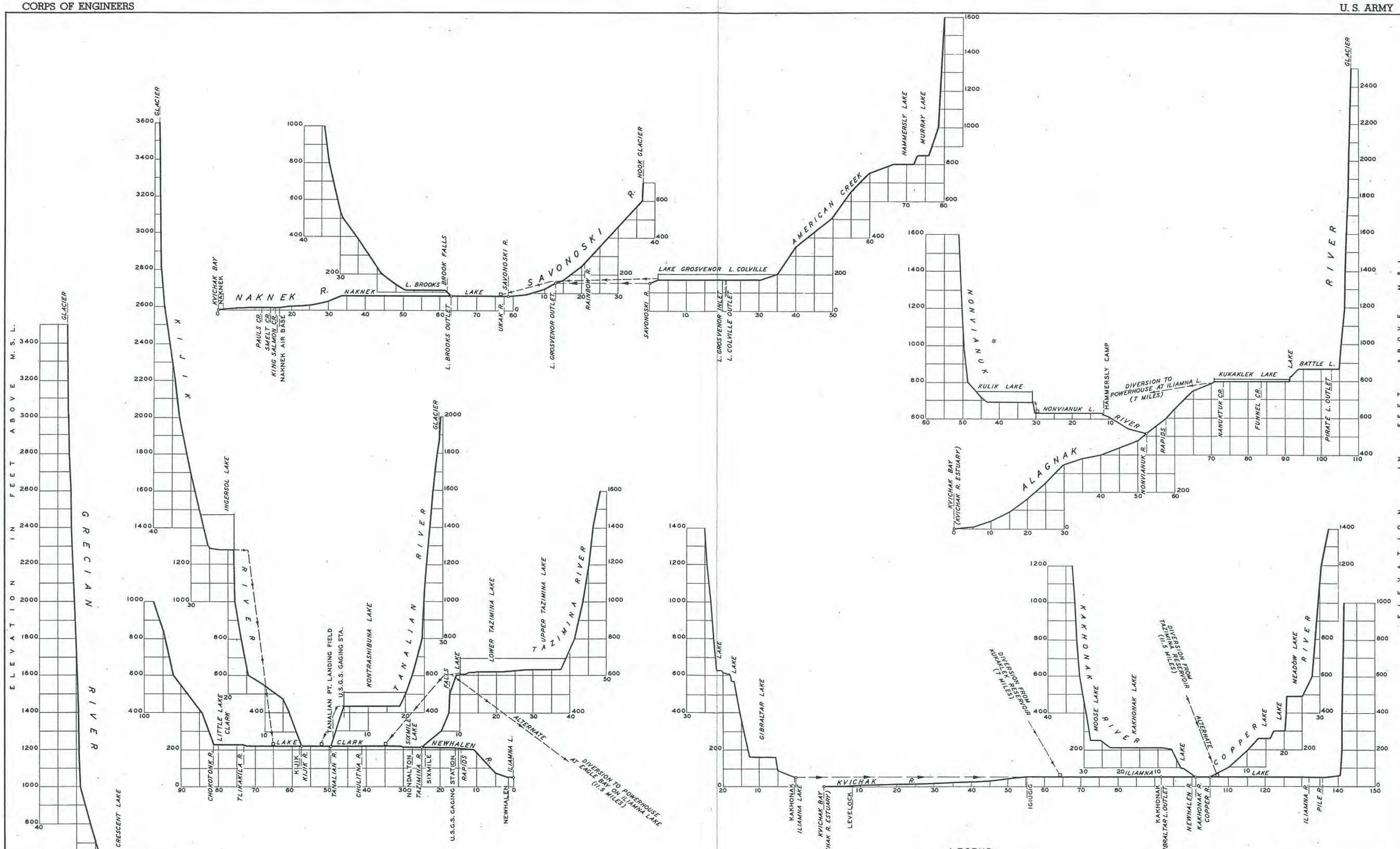
IN 2 SHEETS | SCALES AS SHOWN | SHEET NO. 1
ALASKA DISTRICT, ANCHORAGE, ALASKA | JAN. 20, 1954

SUBMITTED: ENGINEER
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
RECOMMENDED: CHIEF, SPECIAL SURVEY BRANCH
DRAWN BY: E.V.W.
TRACED BY: H.E.B.
CHECKED BY: K.L.M.
TRANSMITTED WITH REPORT DATED: JAN. 20, 1954

Q-19-5-5
PLATE 5

CORPS OF ENGINEERS

U. S. ARMY




HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

## STREAM PROFILES

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 2
ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. Macduffee ENGINEER

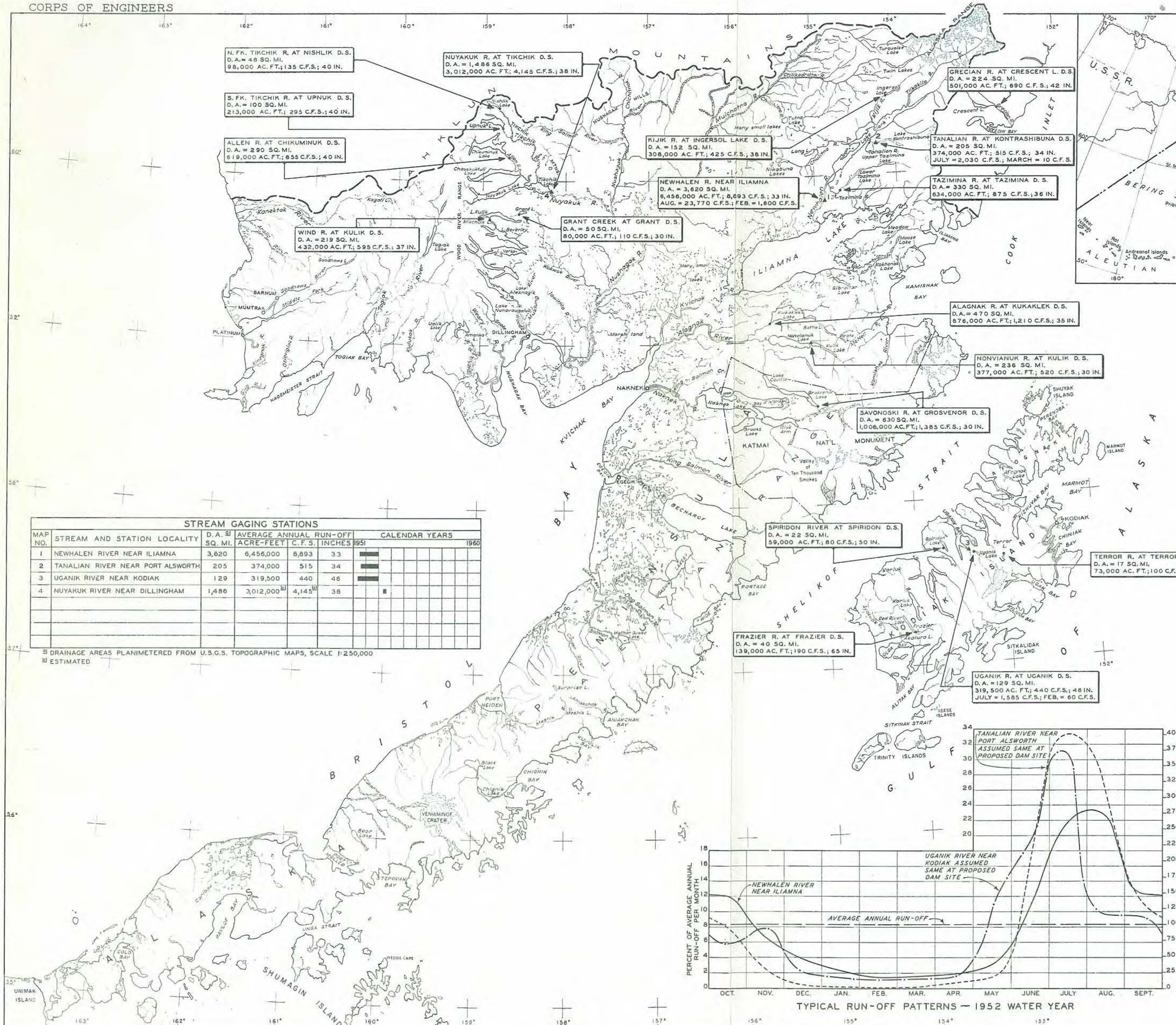
RECOMMENDED: A. B. Henry CHIEF, SPECIAL SURVEY BRANCH

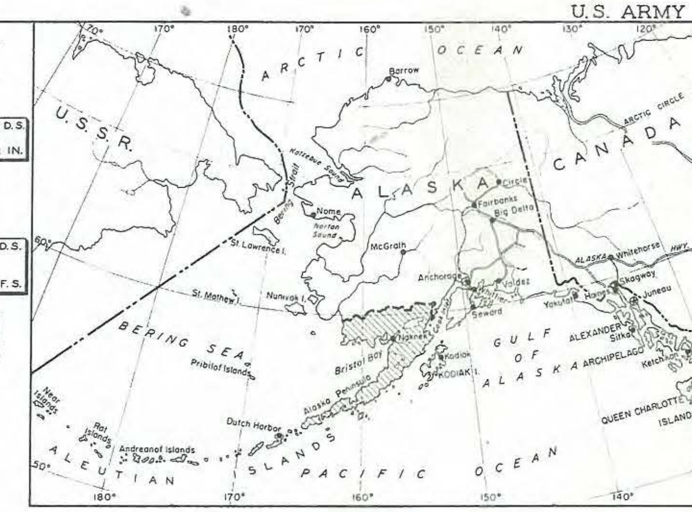
APPROVED: COLONEL, CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN BY: S.F.M.
TRACED BY: H.S.G.
CHECKED BY: K.M.M.

TRANSMITTED WITH REPORT DATED: JAN. 20, 1954

Q-19-5-6
PLATE 6




REGIONAL MAP
SCALE IN MILES

| STREAM GAGING STATIONS | | | | | | |
|---|---|---|---|---|---|---|
| MAP NO. | STREAM AND STATION LOCALITY | D.A. [a] SQ. MI. | AVERAGE ANNUAL RUN-OFF ACRE-FEET | C.F.S. | INCHES | CALENDAR YEARS 1951–1960 |
| 1 | NEWHALEN RIVER NEAR ILIAMNA | 3,620 | 6,456,000 | 8,893 | 33 | |
| 2 | TANALIAN RIVER NEAR PORT ALSWORTH | 205 | 374,000 | 515 | 34 | |
| 3 | UGANIK RIVER NEAR KODIAK | 129 | 319,500 | 440 | 46 | |
| 4 | NUYAKUK RIVER NEAR DILLINGHAM | 1,486 | 3,012,000 [b] | 4,145 [b] | 38 | |

[a] DRAINAGE AREAS PLANIMETERED FROM U.S.G.S. TOPOGRAPHIC MAPS, SCALE 1:250,000
[b] ESTIMATED

TYPICAL RUN-OFF PATTERNS — 1952 WATER YEAR

NOTES:

1. ON THE BASIN MAP AT THE LEFT IS INDICATED THE AVERAGE ANNUAL RUN-OFF OF STREAMS AT WHICH GAGING STATIONS HAVE BEEN ESTABLISHED AND DISCHARGE DATA IS AVAILABLE, AND ALSO THE ESTIMATED ANNUAL RUN-OFF OF OTHER STREAMS WHICH HAVE PPOJECTS CONSIDERED IN THIS REPORT.
   THE FOLLOWING BLOCK ILLUSTRATES THE METHOD OF INDICATING RUN-OFF DATA:

   NAME OF STREAM AND LOCATION
   DRAINAGE AREA IN SQUARE MILES
   AVERAGE ANNUAL RUN-OFF IN AC.FT., C.F.S., & INCHES
   AVERAGE MAXIMUM AND AVERAGE MINIMUM MONTHLY DISCHARGES IF AVAILABLE

2. THE GRAPHS SHOW AVERAGE ANNUAL STREAM-FLOW PATTERNS WHICH WERE ESTIMATED FROM SHORT-TERM STREAM-FLOW RECORDS OF STREAMS AT WHICH GAGING STATIONS HAVE BEEN ESTABLISHED.

LEGEND

▲ STREAM-FLOW GAGING STATION, RECORDING TYPE

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

# STREAM GAGING STATIONS AND STREAM RUN-OFF CHARACTERISTICS

SCALE IN MILES

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. Macdurffee, ENGINEER

RECOMMENDED: A. R. Henry, CHIEF, SPECIAL SURVEY BRANCH

APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

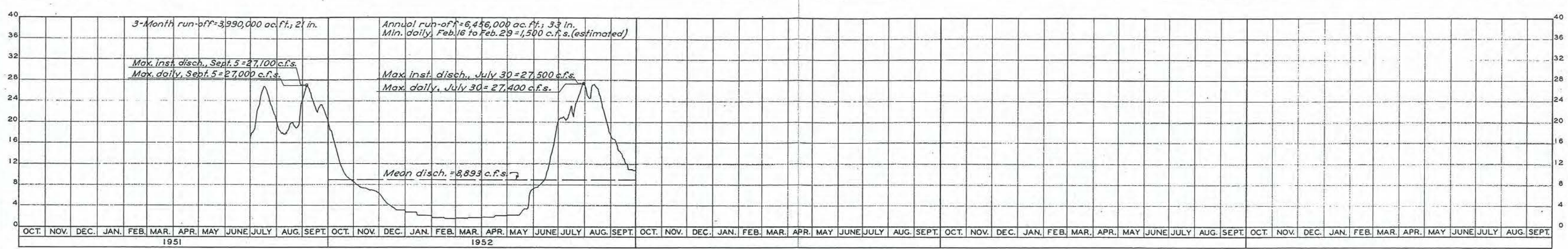
DRAWN BY: E.W.W.
TRACED BY: ...
CHECKED BY: K.M.M.

TRANSMITTED WITH REPORT DATED JAN. 20, 1954

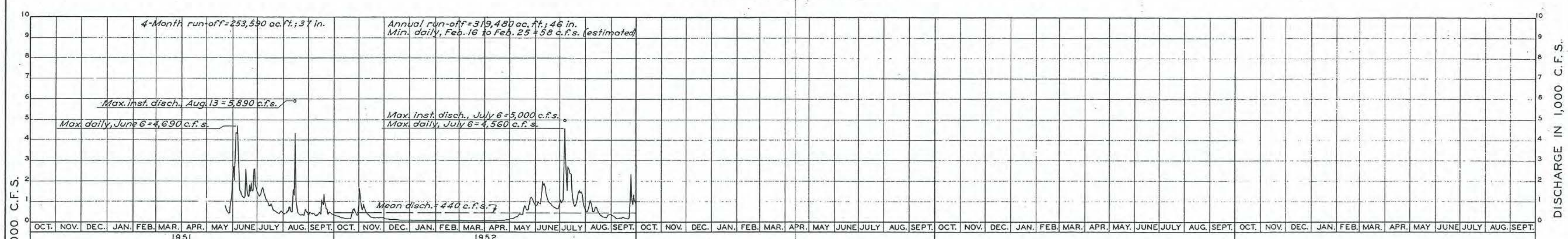
Q-19-5-7

PLATE 7

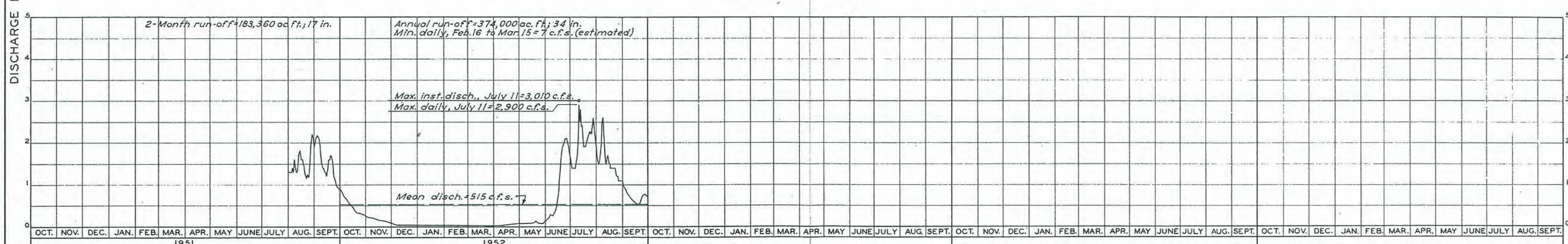
CORPS OF ENGINEERS — U. S. ARMY



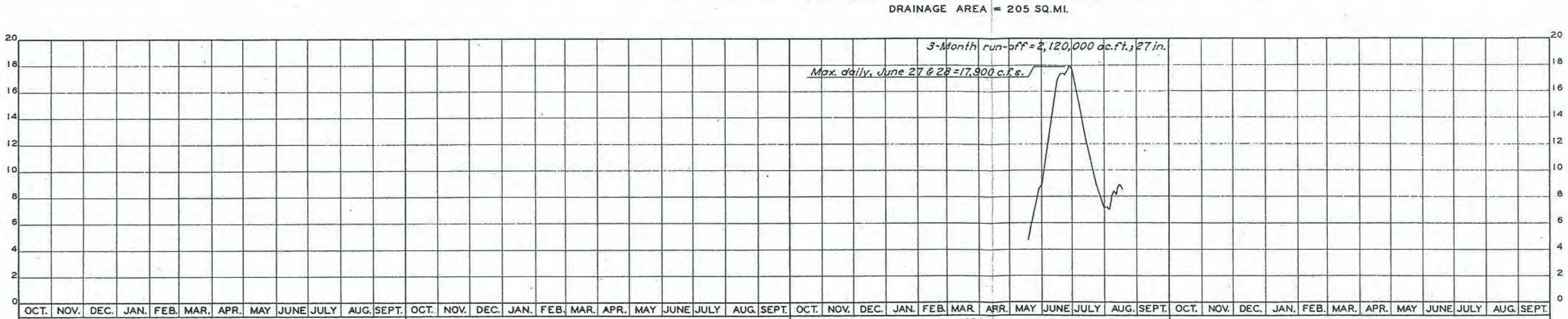

NEWHALEN RIVER NEAR ILIAMNA
DRAINAGE AREA = 3,620 SQ.MI.




UGANIK RIVER NEAR KODIAK
DRAINAGE AREA = 129 SQ.MI.




TANALIAN RIVER NEAR PORT ALSWORTH
DRAINAGE AREA = 205 SQ.MI.




NUYAKUK RIVER NEAR DILLINGHAM
DRAINAGE AREA = 1,486 SQ.MI.

*Note:*
*Data from which hydrographs were plotted and information contained thereon are from unpublished and provisional U.S.G.S. records which are subject to revision.*

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

## DAILY DISCHARGE HYDROGRAPHS

SCALES AS SHOWN

ALASKA DISTRICT, ANCHORAGE, ALASKA — JAN. 20, 1954

SUBMITTED: K. M. MacDuffee, ENGINEER

RECOMMENDED: CHIEF, SPECIAL SURVEY BRANCH

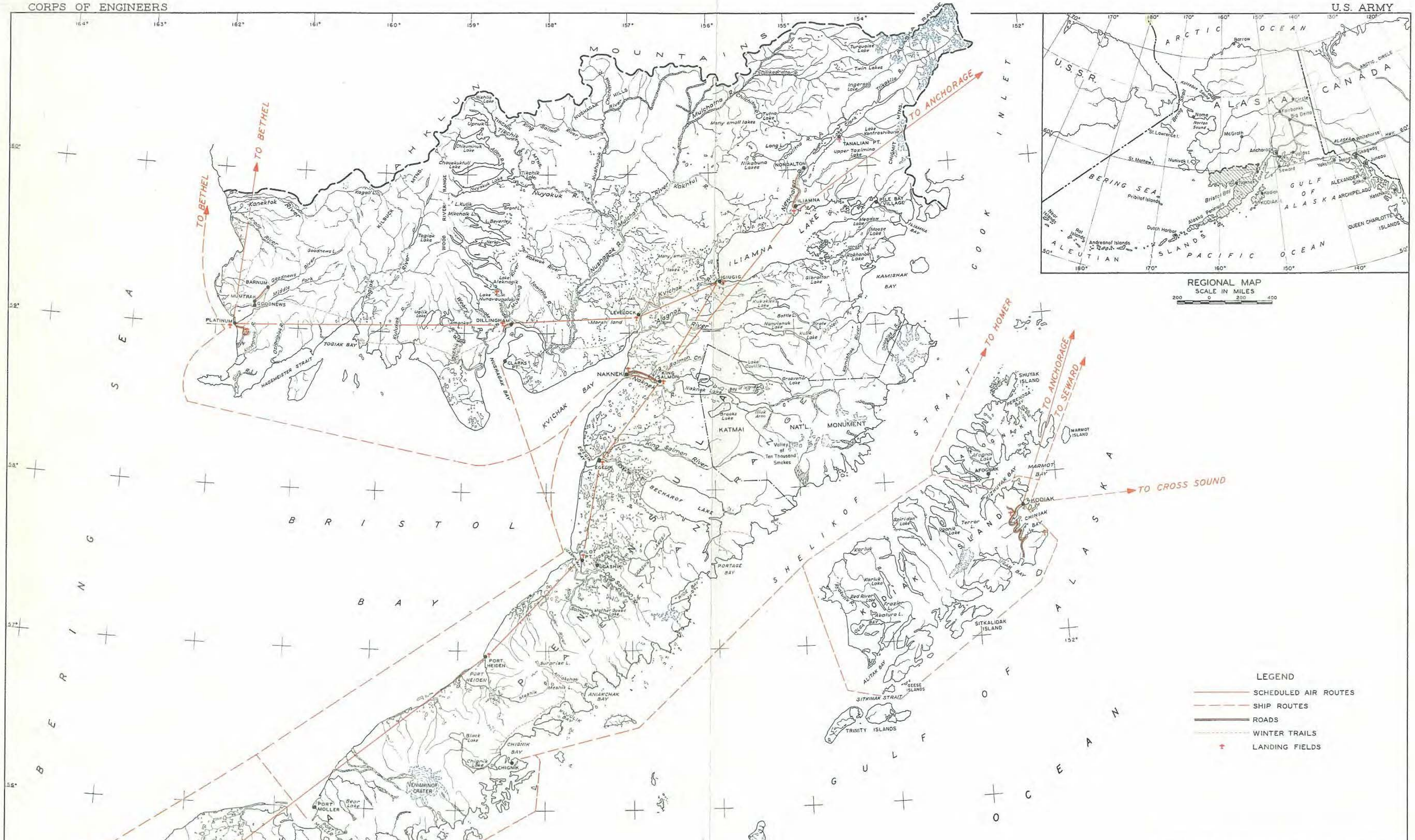
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: E.L.W.
TRACED BY: B.V.
CHECKED BY: K.M.M.

TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-8

PLATE 8




HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

## TRANSPORTATION ROUTES

SCALE IN MILES
10 0 10 20 30 40 50

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: G. N. Shoemaker
ENGINEER

RECOMMENDED: A. L. Hurney
CHIEF, SPECIAL SURVEY BRANCH

APPROVED: [signature]
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

DRAWN BY: R.J.M.
TRACED BY: B.V.
CHECKED BY: G.W.S.

TRANSMITTED WITH REPORT
DATED JAN. 20, 1954

Q-19-5-9

PLATE 9

CORPS OF ENGINEERS U. S. ARMY

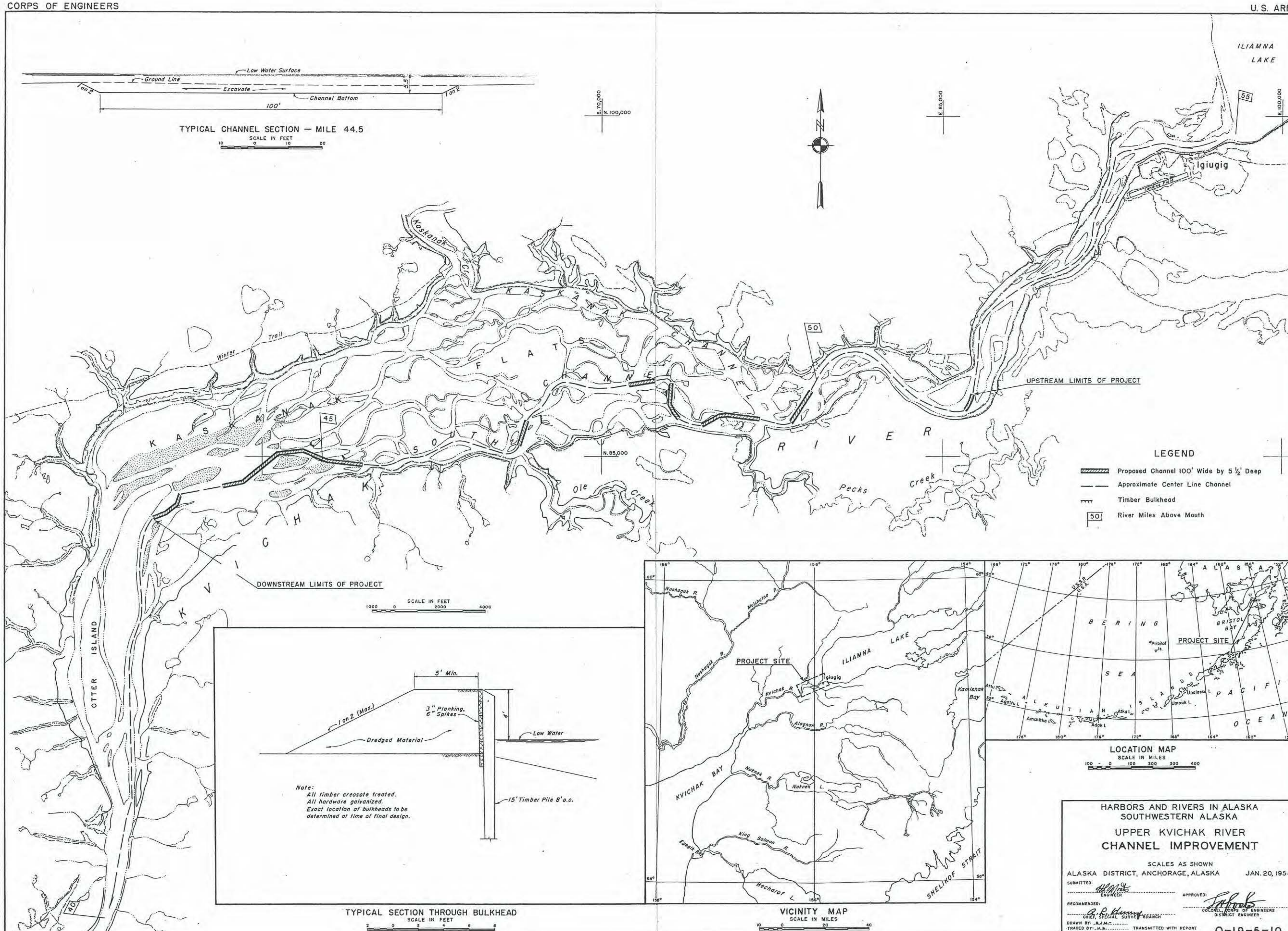



PLATE 10

CORPS OF ENGINEERS U.S. ARMY

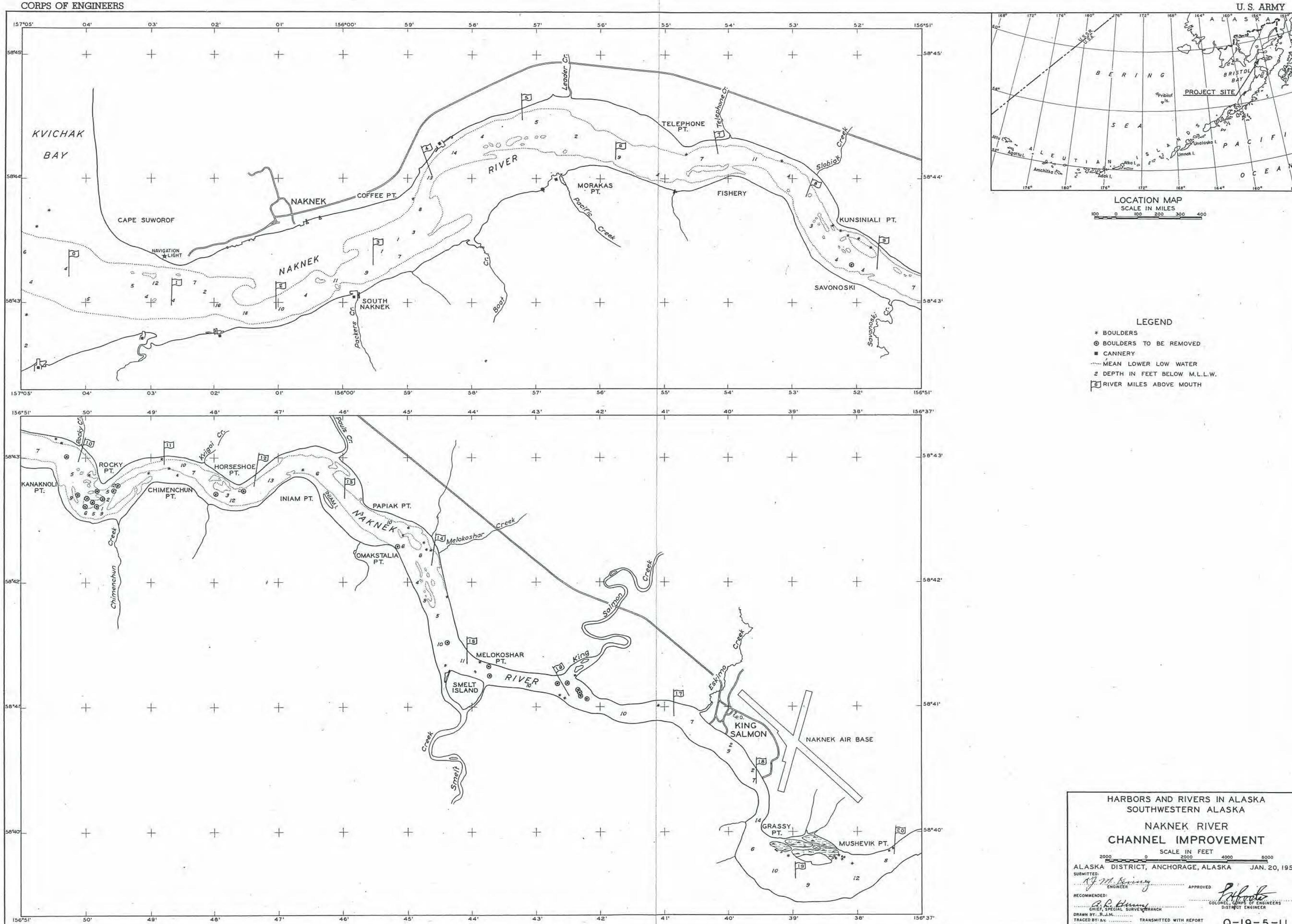
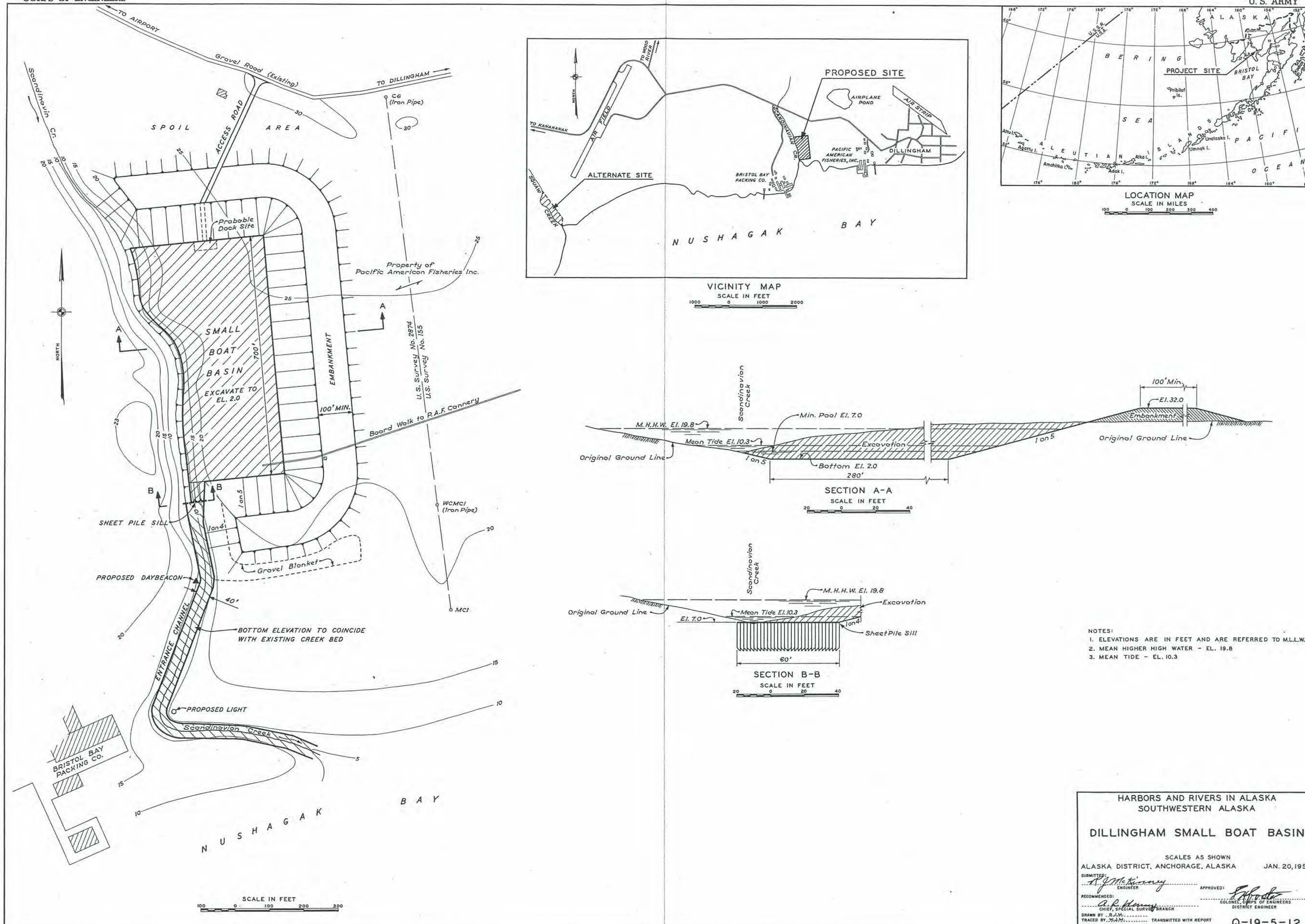



PLATE II

CORPS OF ENGINEERS U.S. ARMY




NOTES:
1. ELEVATIONS ARE IN FEET AND ARE REFERRED TO M.L.L.W.
2. MEAN HIGHER HIGH WATER - EL. 19.8
3. MEAN TIDE - EL. 10.3

HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

DILLINGHAM SMALL BOAT BASIN

SCALES AS SHOWN
ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: R. J. McKinney, ENGINEER
APPROVED: [signature] COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
RECOMMENDED: A. L. Kenny, CHIEF, SPECIAL SURVEYS BRANCH
DRAWN BY R.J.M. TRACED BY W.J.M. CHECKED BY R.J.M.
TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-12

PLATE 12

CORPS OF ENGINEERS

U.S. ARMY

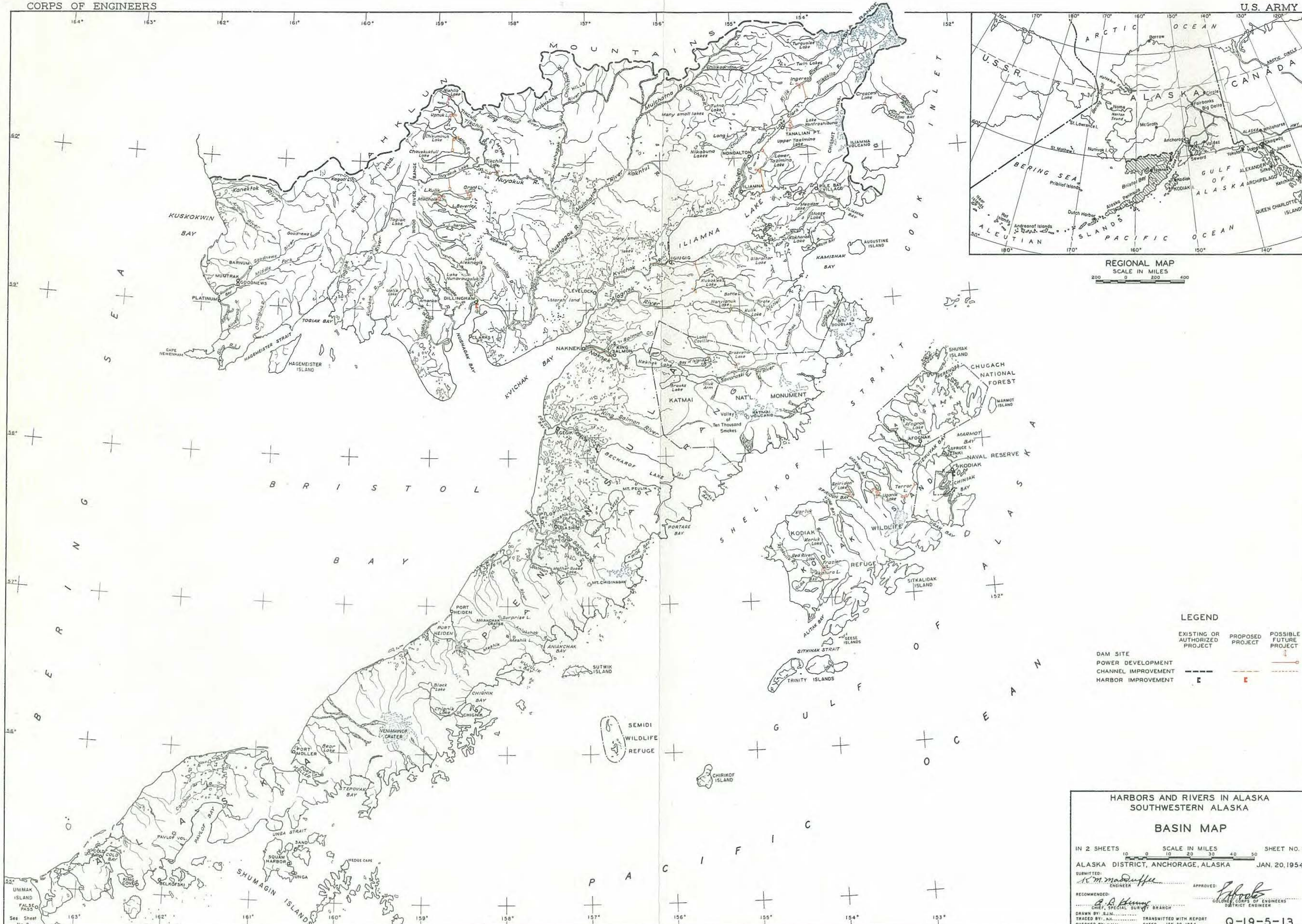
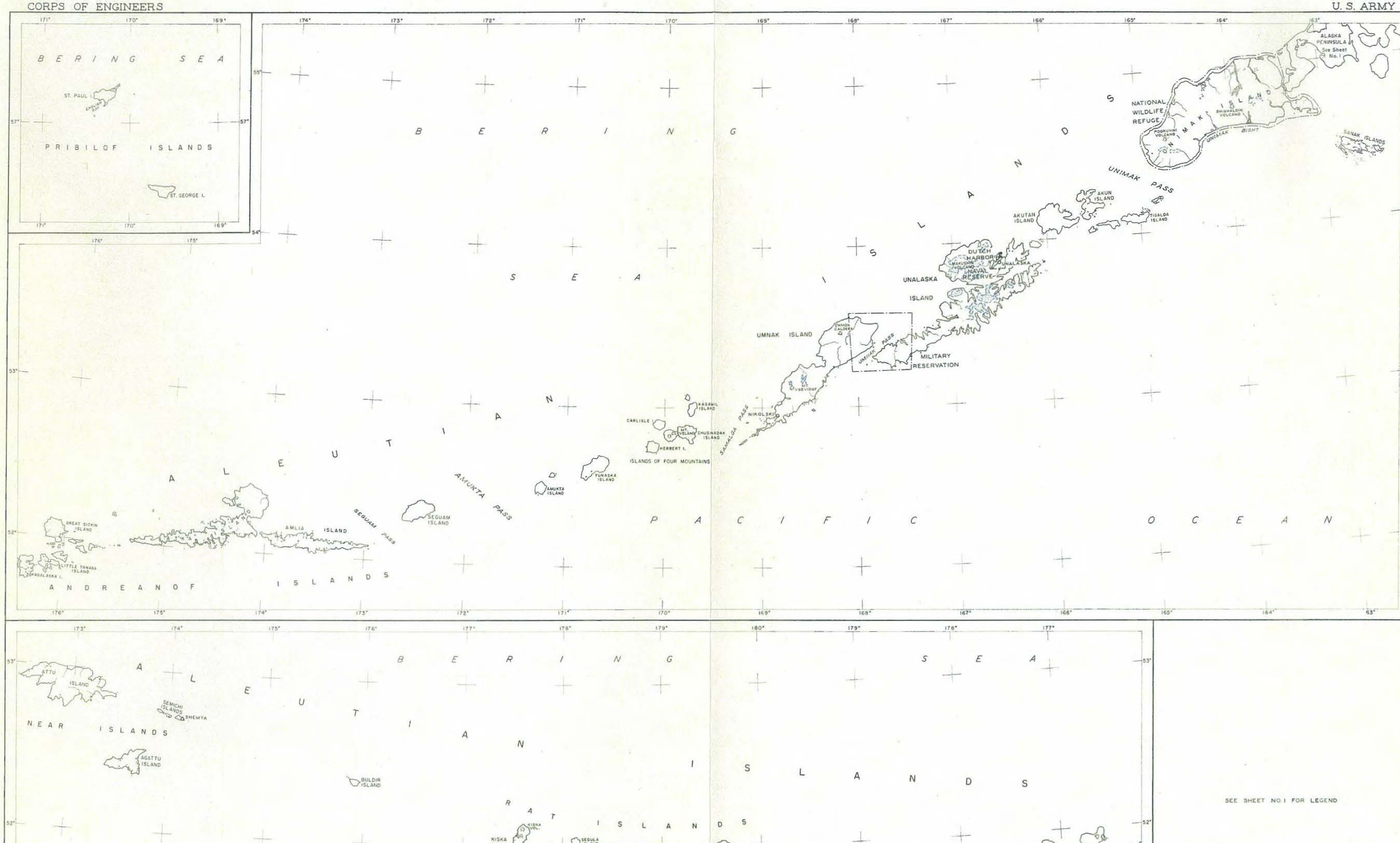



PLATE 13

CORPS OF ENGINEERS U. S. ARMY




HARBORS AND RIVERS IN ALASKA
SOUTHWESTERN ALASKA

BASIN MAP

IN 2 SHEETS SCALE IN MILES SHEET NO. 2
10 0 10 20 30 40 50

ALASKA DISTRICT, ANCHORAGE, ALASKA JAN. 20, 1954

SUBMITTED: K. M. MacDuffee
ENGINEER

RECOMMENDED: A. L. Henry
CHIEF, SPECIAL SURVEY BRANCH

APPROVED: [signature]
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

DRAWN BY: R.J.M.
TRACED BY: ...
CHECKED BY: K.M.M.

TRANSMITTED WITH REPORT DATED JAN. 20, 1954

Q-19-5-14

PLATE 14

NPDGP (20 Jan 54 - NPA to NPD) 1st Ind
NPD 800.16 (Alaska)
SUBJECT: Interim Report No. 5 on Survey of Harbors and Rivers in Southwestern Alaska

Office, Division Engineer, North Pacific Division, Corps of Engineers, 210 Custom House, Portland 9, Oregon, 20 September 1954

TO: Chief of Engineers, Corps of Engineers, Department of the Army, Washington 25, D. C.

I concur in the views and recommendations of the District Engineer.

L. H. Foote

L. H. FOOTE
Colonel, Corps of Engineers
Division Engineer