Evaluation of the Streamflow-Gaging Network of Alaska in Providing Regional Streamflow Information

By Timothy P. Brabets

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ABBREVIATIONS USED IN THIS REPORT:

ft, foot
ft^3/s, cubic foot per second
in., inch
mi, mile
mi^2, square mile

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ABSTRACT

In 1906, the U.S. Geological Survey (USGS) began operating a network of streamflow-gaging stations in Alaska. The primary purpose of the streamflow-gaging network has been to provide peak flow, average flow, and low-flow characteristics to a variety of users. In 1993, the USGS began a study to evaluate the current network of 78 stations. The objectives of this study were to determine the adequacy of the existing network in predicting selected regional flow characteristics and to determine if providing additional streamflow-gaging stations could improve the network's ability to predict these characteristics.

Alaska was divided into six distinct hydrologic regions: Arctic, Northwest, Southcentral, Southeast, Southwest, and Yukon. For each region, historical and current streamflow data were compiled. In Arctic, Northwest, and Southwest Alaska, insufficient data were available to develop regional regression equations. In these areas, proposed locations of streamflow-gaging stations were selected by using clustering techniques to define similar areas within a region and by spatial visual analysis using the precipitation, physiographic, and hydrologic unit maps of Alaska.

Sufficient data existed in Southcentral and Southeast Alaska to use generalized least squares (GLS) procedures to develop regional regression equations to estimate the 50-year peak flow, annual average flow, and a low-flow statistic. GLS procedures were also used for Yukon Alaska but the results should be used with caution because the data do not have an adequate spatial distribution.

Network analysis procedures were used for the Southcentral, Southeast, and Yukon regions. Network analysis indicates the reduction in the sampling error of the regional regression equation that can be obtained given different scenarios. For Alaska, a 10-year planning period was used. One scenario showed the results of continuing the current network with no additional gaging stations and another scenario showed the results of adding gaging stations to the network. With the exception of the annual average discharge equation for Southeast Alaska, by adding gaging stations in all three regions, the sampling error was reduced to a greater extent than by not adding gaging stations.

The proposed streamflow-gaging network for Alaska consists of 308 gaging stations, of which 32 are designated as index stations. If the proposed network can not be implemented in its entirety, then a lesser cost alternative would be to establish the index stations and to implement the network for a particular region.

INTRODUCTION

History

A streamflow-gaging station is defined as a particular site on a stream or river where systematic observations of water stage and discharge are collected. In Alaska, the U.S. Geological Survey (USGS) began operation of streamflow-gaging stations in 1906, primarily to determine water supplies for hydraulic placer mining near Nome (fig. 1). During these years, the streamflow records were short, fragmentary, and probably were intended only for site-specific information. In about 1910, interest in hydropower and water supply in Southeast and Southcentral Alaska led to additional streamflow-gaging stations in these areas. However, in 1921, because of a lack of funding, the streamflow network was discontinued, although some private and other Federal agencies continued to operate some stations.

After World War II, offices of the USGS were established in Alaska and the streamflow-gaging program was reactivated. By 1950, there were 47 stations (fig. 2), all funded by the Federal government. Most of these sites were in Southeast and Southcentral Alaska. Later, the U.S. Army Corps of Engineers and the Bureau of Reclamation funded additional gaging stations. The first locally funded streamflow-gaging station was with the City of Seward in 1957. After Alaska became a state in 1959, a cooperative program began with the Alaska Department of Natural Resources. From this time on, the number of streamflow-gaging stations steadily increased to a high of 129 stations in 1972. The decrease in the number of stations from 1972 to 1976 was due primarily to discontinuing gaging stations in the Aleutian Islands and in Southeast Alaska. The number of gaging stations from the mid 1970's to 1986 was fairly constant. Two significant declines occurred in 1987 and 1994. In 1987, the State of Alaska decided to terminate any future work on the proposed hydropower project on the Susitna River (fig. 1) resulting in the loss of many stations. In 1994, the Department of Natural Resources lost all funding of their cooperative program with the USGS and, in addition, Federal funding to the USGS was severely cut. In 1994, the network consisted of 78 streamflow-gaging stations (fig. 3).

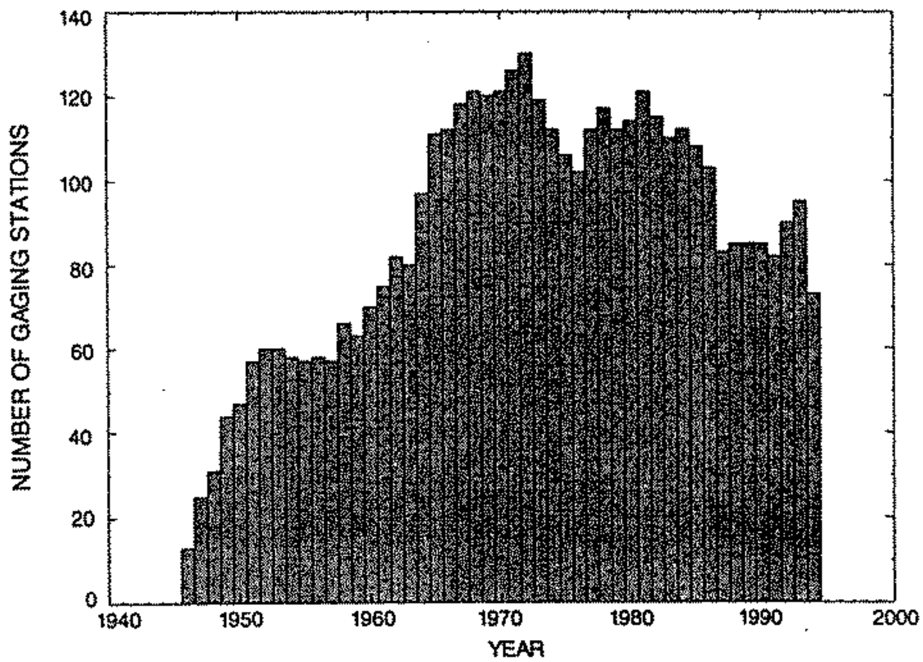
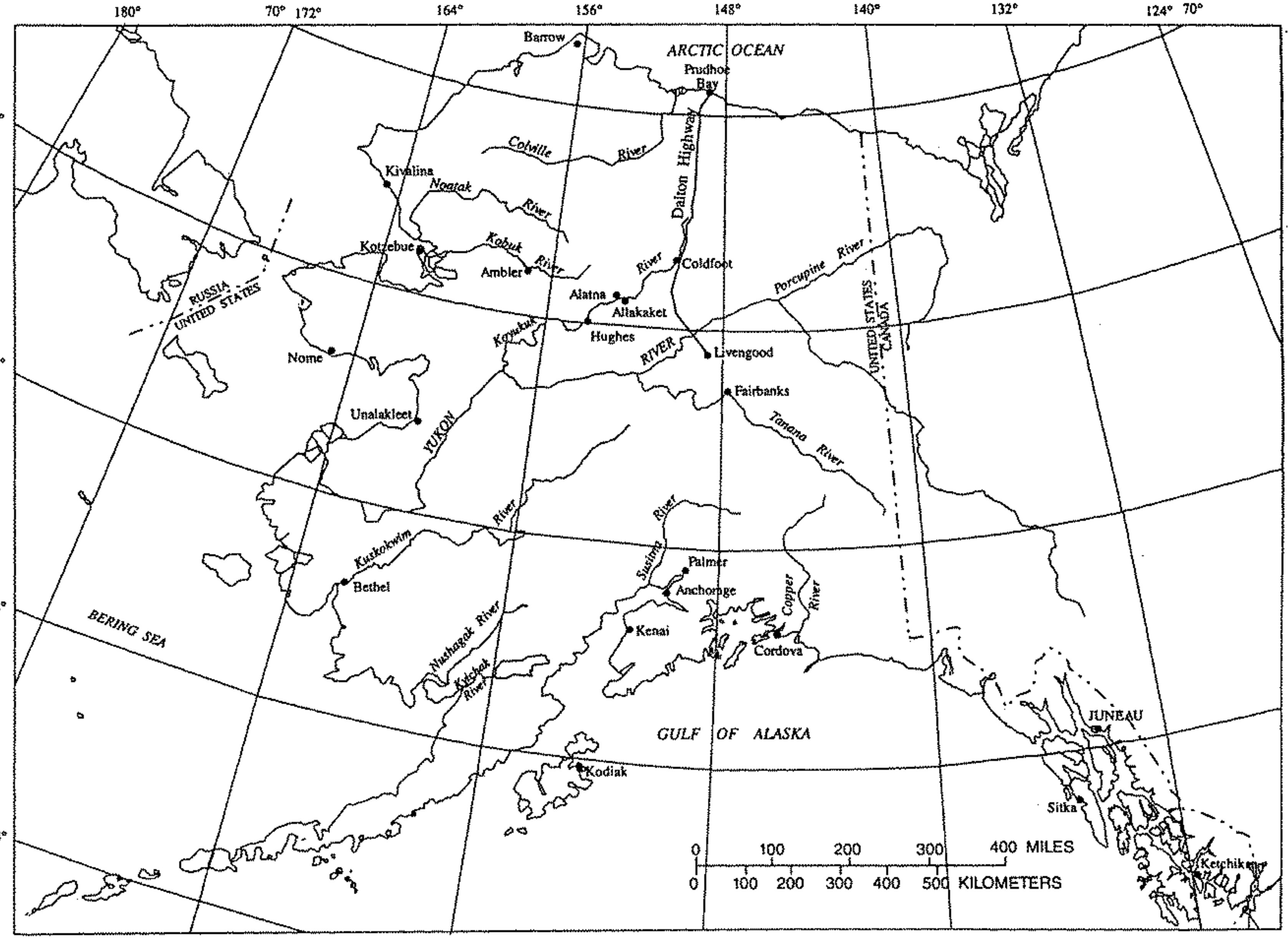


Figure 2. Number of streamflow-gaging stations in Alaska - 1946-94



Base adapted from U.S. Geological Survey Map C

Figure 1. Location of major rivers and selected cities and highways of Alaska.

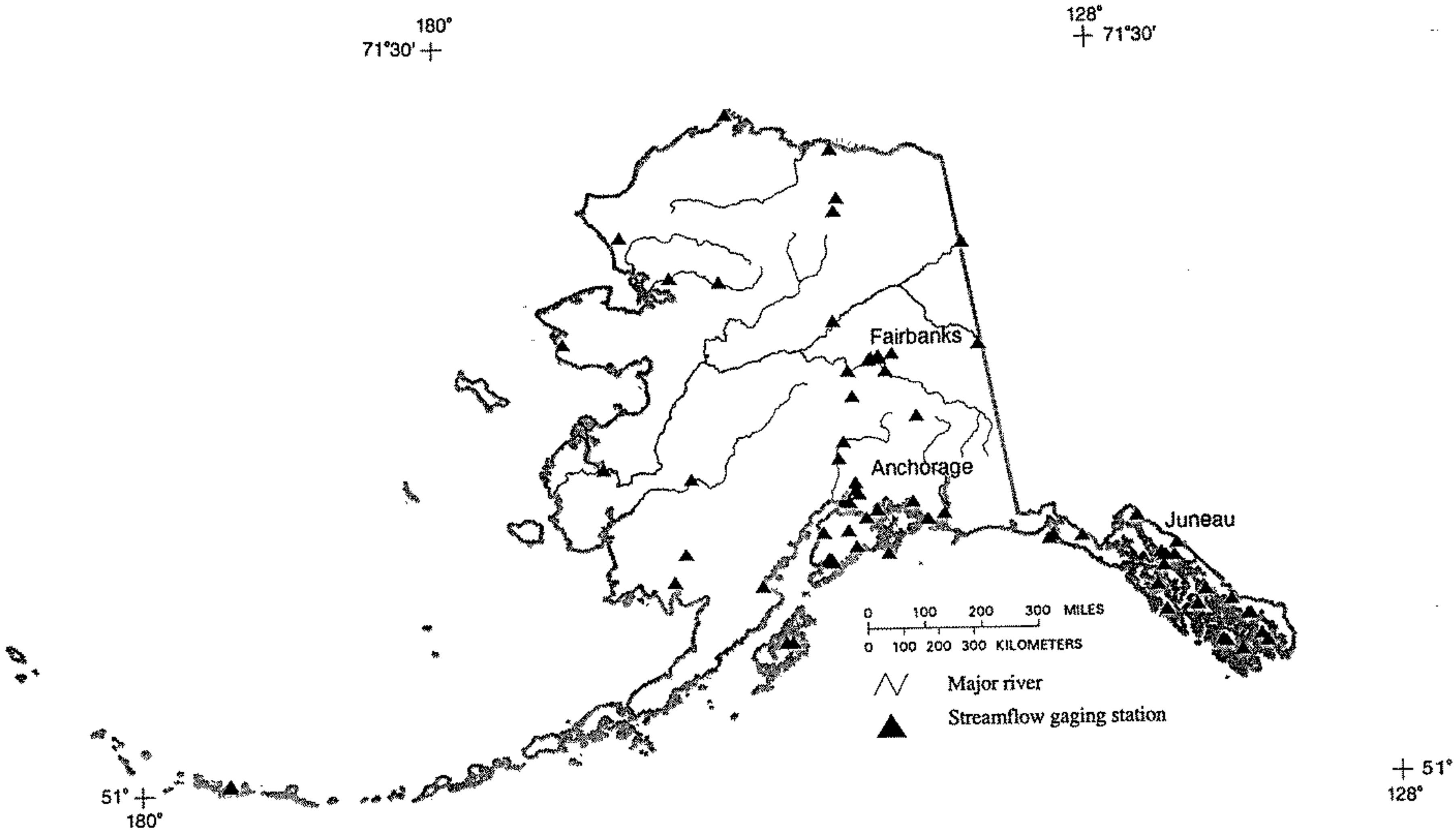


Figure 3. Streamflow-gaging network of Alaska - 1994

Streamflow Data

The data collected at streamflow-gaging stations are used for a variety of purposes. Examples are:

Regional Hydrology: Discharge data at a station where streamflow characteristics have not been significantly altered by man are used to develop empirical relations between streamflow characteristics (such as the 50-year flood, average annual flow, and 7-day 10-year low flow) and basin characteristics (geographic traits, climatic conditions). These relations can be used to estimate streamflow characteristics at ungaged sites on streams within a region.

Hydrologic Systems: Data are used to define current hydrologic conditions and to document changes and trends in these conditions. For example, as an urban area becomes increasingly developed, stations can yield data that quantify changing streamflow conditions.

Planning and Design: Data from gaging stations are used to plan and design a specific project, such as a dam or bridge.

Project Operation: Data are used to assist water managers in making operational decisions, such as reservoir releases at hydroelectric power plants and storage and release of water at flood-control projects.

Hydrologic Forecasts: Data provide information to various government agencies and the public for flood or low-flow forecasts.

Water-Quality Monitoring: Continued monitoring of streams can detect changes in physical, chemical, and biological quality of water. Some gaging stations in Alaska are part of a nationwide network designed to assess the water quality of major streams.

Although it is somewhat difficult to assign a monetary value to streamflow data, the following examples illustrate the consequences of both collecting and not collecting hydrologic data (refer to fig. 1 for locations).

Dalton Highway: The Dalton Highway was built to facilitate the construction of the Trans-Alaska Pipeline and to provide an overland transportation corridor to the Prudhoe Bay oilfields. Hydrologic data in this region of Alaska were virtually non-existent when the highway was built and, as a result, the bridges and culverts were designed on the basis of theoretical concepts. Unfortunately, some structures were undersized, resulting in additional maintenance expense to function properly. The floods of August 1994 alone caused about $5 million in damages to the Dalton Highway (Alaska Department of Transportation and Public Facilities, oral commun., 1995). If adequate hydrologic information had been available, culverts and bridges could have been better designed to pass high flows, thus alleviating some of the subsequent damage costs.

Chena River Flood Control Project: In 1967, major flooding occurred in Fairbanks. As a result of these floods, the Chena River Lakes Project was constructed to prevent future flooding in Fairbanks. Today, this project is considered a success story. Gaging stations equipped with satellite telemetry instrumentation are located on the Little Chena and Chena Rivers. During high flow periods, data are transmitted to offices of the U.S. Army Corps of Engineers. Personnel at the Corps are then able to predict stage and flows and decide if water needs to be impounded at the Moose Creek Dam. The operation of the Chena River Flood Control Project has saved countless dollars by preventing flooding and damage to homes and infrastructures in the Fairbanks area.

Koyukuk Floods of 1994: The floods that occurred on the Koyukuk River in 1994 are estimated to have had a recurrence interval of 100 years. Damages exceeded $70 million, and most of the damage was concentrated in three small rural communities: Alatna, Allakaket, and Hughes. Could a disaster such as this been avoided? Perhaps. If sufficient hydrologic data had been available, the 100-year flood plain could have been delineated fairly accurately. Moving these communities outside the 100-year flood plain would have significantly reduced the damages caused by the August floods. This is not an isolated situation that exists along the Koyukuk River—many small communities located near numerous other rivers are unaware of the flood risk.

Magnitude and Frequency of Floods in Alaska: Jones and Fahl (1994) analyzed floods that occurred in gaged basins in Alaska. In addition, the authors developed equations for estimating peak flows of various recurrence intervals at ungaged sites. The report has many users. For example, placer miners who need to design sedimentation ponds for a particular flood recurrence interval utilize these equations. Personnel in the Alaska Department of Transportation and Public Facilities (ADOT & PF) use these equations in designing bridges. By collecting long-term data, particularly in areas where data are sparse or non-existent, the accuracy and usefulness of the equations can be improved. Better accuracy translates into better design of structures, which translates into lower capital costs.

In summary, the collection of regional hydrologic data in Alaska is an investment in the future. Planners and designers of facilities such as dams and bridges use streamflow data to consider what may happen in the future. Data are needed not solely in terms of specific past events, such as floods, but in terms of the probability of future occurrence. For example, many highway bridges are designed on the basis of the flood that will be exceeded on the average of once in 50 years. Storage reservoirs are designed on the basis of the probability of deficiency of storage for an intended use, such as municipal water supply. The ability to predict these characteristics depends on long-term, spatially distributed, continuous flow records at many sites.

Alaska's land area covers more that 580,000 mi^2, which is equivalent to about 20 percent of the conterminous United States. There are tens of thousands of streams and rivers, most of which will never have gaging stations because of physical and economic limitations. Thus, it is critical that the most effective streamflow-gaging network is in place in order to transfer streamflow information from stations to points where there are no streamflow data (ungaged sites).

Purpose and Scope

This report summarizes the evaluation of the streamflow-gaging network in Alaska in providing regional streamflow information. The objective of the study was to examine the adequacy of the existing network in providing regional streamflow characteristics and determine if additional streamflow-gaging stations are needed. Using both historical and current data, regional regression equations were developed to estimate selected average-flow, low-flow, and peak flow statistics. Active, discontinued, and new gaging stations that will provide the most effective regional streamflow information for the next 10 years are identified.

Previous Studies

Three previous studies have dealt with the regional streamflow network of Alaska. Childers (1970) developed a proposed streamflow network. However, this proposed network was limited to the Southeast, Southcentral, and Yukon (interior) regions of Alaska. Lamke (1984) focused primarily on the cost effectiveness of the existing streamflow-gaging network to determine how often a site should be visited. Parks and Madison (1985) used all existing streamflow and water quality data in Alaska to develop estimating equations for selected flow and water quality characteristics. No equations were developed for Arctic and Northwest Alaska because of the lack of data. In all three studies, the authors recommended areas where additional data should be collected.

Acknowledgments

The author wishes to express his thanks to the Water Survey of Canada for providing streamflow information from streamflow-gaging stations located in Canada. Daniel B. Hawkins, professor emeritus, University of Alaska Fairbanks, developed the crisp expert system that was used to determine the value of a gaging station. Mark Inghram, Alaska Division of Mining and Water Management, tabulated the results of the customer survey and assisted in developing the hydrologic unit map of Alaska. Finally, the support and suggestions of the Interagency Hydrology Committee of Alaska are greatly appreciated.

METHODS OF STUDY

Thomas (1993) stated that a network analysis should answer some of the following questions: (1) Are data being collected at the proper locations? (2) What types of data should be collected? (3) What is a sufficient duration of each data-collection activity? Techniques such as those developed by Benson and Carter (1973) and Moss and Gilroy (1980) have been used to answer these questions. For this study, statistical techniques developed by Tasker (1986), cluster analysis, surveys, and a crisp expert system were used to evaluate the effectiveness of the current streamflow-gaging network of Alaska in providing regional streamflow information and to suggest improvements.

Hydrologic Regions and Flow Characteristics

The land cover of Alaska ranges from tundra in the Arctic (average annual precipitation less than 5 in. near the Arctic Ocean) to the maritime rain forest in the Southeast (average annual precipitation about 320 in. in parts of Southeast Alaska) (Lamke, 1991). Much of this precipitation occurs as snow. The average temperature ranges from 10 °F in the Arctic to 45 °F in Southeast Alaska. A thick continuous layer of permafrost exists in the Arctic, whereas no permafrost is present in Southeast. Alaska has six major hydrologic regions: Arctic, Northwest, Southcentral, Southeast, Southwest, and Yukon (fig. 4). For each of the six regions, the effectiveness of the streamflow-gaging network in providing regional streamflow information was evaluated.

At the beginning of this study, a two-day workshop was held to solicit input from water resources scientists and managers concerning their water resources data needs. In addition to the workshop, surveys were sent to interested parties requesting their input as well. After all responses were compiled, the following goals were established for each hydrologic region:

(1) Evaluate the adequacy of the streamflow-gaging network in each region in providing information on the 50-year peak discharge. Although Jones and Fahl (1994) developed flood-frequency equations for all of Alaska, a large part of the state consisting of Arctic, Northwest, part of Southwest, and part of Yukon, was combined into one flood-frequency area. Because each region has unique hydrologic characteristics, efforts were made to determine whether or not regression equations could be developed for each hydrologic region.

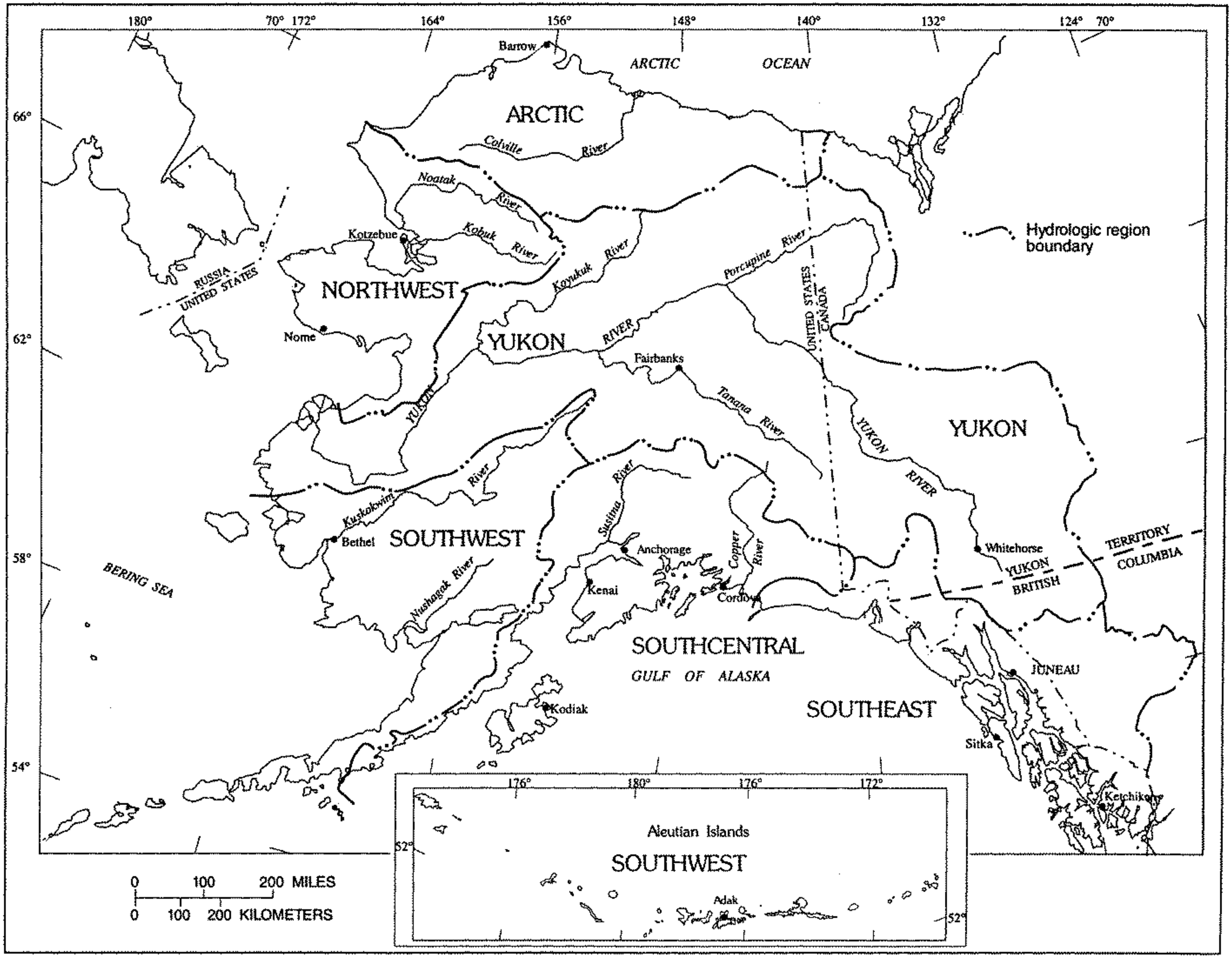


Figure 4. Hydrologic regions of Alaska and conterminous basins of Canada.

(2) Evaluate the adequacy of the streamflow-gaging network in each region in providing information on the annual average discharge.

(3) Evaluate the adequacy of the streamflow-gaging network in each region in providing information on the following low-flow statistics:

Arctic: average discharge for October
Northwest: average discharge for October
Southcentral: 7-day 10-year low flow
Southeast: 7-day 10-year low flow for October through March
7-day 10-year low flow for April to September
Southwest: average discharge for March
Yukon: average discharge for March

Cluster and Spatial Analysis

As the analysis proceeded, it was found that the Arctic, Northwest, and Southwest regions had few current or discontinued streamflow-gaging stations. Thus, regional regression equations could not be developed for these areas. Because these areas are relatively large, potential sites should be chosen that have a wide range of basin characteristics to describe the hydrology of the region and to develop adequate regional estimating equations. Efforts were concentrated on using cluster and spatial-analysis techniques to develop streamflow-gaging networks in these regions.

Cluster analysis is a statistical technique designed to perform classification by assigning observations to groups, so that each group is more or less homogeneous and distinct from other groups. For this study the *k*-means clustering technique was used. In *k*-means clustering, a fixed number of groups or clusters is selected in order to limit the computational procedure. A matrix of similarities between the groups and *n* observations is calculated with the most similar observations clustered with a particular group. Thus, cluster analysis served as a useful tool in assuring that potential sites would include the different groups.

For these three hydrologic regions, the *k*-means cluster analysis was accomplished using Geographic Information Systems (GIS) techniques. Coverages available to use in the cluster analysis that are related to hydrology were precipitation (Jones and Fahl, 1994), permafrost (Ferrians, 1980), and physiography (Wahrhaftig, 1965). Using the GIS techniques, each coverage was converted to a grid with a cell size of 1 mile by 1 mile and each cell was assigned a unique number representing the amount of precipitation, type of permafrost, or physiographic type. The *k*-means clustering procedure was then performed, with a maximum number of 10 groups specified. The result of the procedure was a grid with each cell assigned to a particular group or classification area. Potential sites were then plotted on the cluster map to ensure that all classification areas would be included in the proposed network.

A visual spatial analysis was done in these regions by plotting potential sites on the precipitation, physiographic, and hydrologic unit maps of the regions to check for spatial distribution. Potential sites were added or removed to ensure the spatial distribution. As a general guide, efforts were made to ensure at least one potential site in each hydrologic unit.

As a final check, boxplots and probability plots of the drainage areas of the proposed sites were developed. Boxplots are a graphical means of summarizing data to show the symmetry of the distribution. A boxplot will show the median, the 25 and 75 percent values, and the corresponding low and high extremes. Another graphical technique, the probability plot, was used in this study to detect non-normality. If data are normally distributed, the probability plot will be approximately a straight line. Although it is not a requirement that these data have a normal distribution, certain statistical tests such as analysis of variance or hypothesis tests may be of questionable value when applied to non-normal data.

Index Gaging Stations

It is important for each region to have a number of streamflow gaging stations that are considered to be index or long-term stations. These select sites serve many purposes such as indicators of climate change or changes in long-term trends. One use of index-station data is to estimate flow characteristics at ungaged sites. For example, historical daily discharge data commonly are needed at an ungaged site. An often-used procedure to estimate these flows is to collect some data at the ungaged site concurrently with the gaged site (Savard and Scully, 1984). By establishing a correlation between the two sites, discharge data for the ungaged site for historical periods can then be estimated.

A recent example of the use of long-term streamflow data is the index site on the Little Susitna River near Palmer (fig. 1). There has been considerable interest in developing the Hatcher Pass area into an alpine ski resort. One important item planners and designers needed to address was snowmaking. Water for snowmaking would have to be withdrawn from tributaries of the Little Susitna River. However, because this river supports an important fishery, a minimum flow is required to maintain a healthy fish habitat. Long-term flow information from the gaging station on the Little Susitna River (47 years of record), in conjunction with miscellaneous measurements, determined the low-flow statistics of these tributaries, and thus the quantity of water available for snowmaking.

In evaluating the streamflow-gaging station network for Alaska, a number of select sites were chosen as index stations for each region. Some of these stations are currently operating and have long-term records. In those areas with few streamflow stations, the proposed index stations were selected on the basis of location and basin characteristics.

Generalized Least Squares

In the early 1960's, various studies (Benson, 1962, 1964) suggested that flood-peak discharges and other flow characteristics could be estimated directly using watershed and climatic characteristics based on multiple regression techniques. On the basis of this work by Benson and later work by Thomas and Benson (1970), direct regression on flood-frequency recurrence intervals became the standard approach of the USGS for regionalizing flood characteristics in the 1970's.

The regression equations that Thomas and Benson (1970) used to relate flood-peak discharges of a particular recurrence interval to watershed and climatic characteristics were computed using ordinary-least-squares techniques. In ordinary-least-squares regression, equal weight is given to all stations in the analysis regardless of record length and the possible correlation of flood estimates among stations. Ordinary-least-squares regression procedures do not account for variable errors in flood characteristics that exist due to unequal record lengths at gaging stations.

A new procedure, generalized-least-squares regression, was proposed by Stedinger and Tasker (1985, 1986). This procedure accounts for both the unequal reliability and the correlation of flood characteristics between sites. The authors showed that generalized-least-squares regression procedures provide more accurate estimates of regression coefficients and better estimates of model error than do ordinary-least-squares procedures.

In generalized least squares (GLS), there is a model error and a sampling error. The model error is defined to be the underlying error in a regression equation even if an infinite number of gaging stations with infinite record lengths were used in the regression analyses. It is a measure of how well the regression equation approximates the real world hydrology and is not a function of data deficiencies. The sampling error is defined to be the error in determining the regression coefficients and includes both time-sampling and spatial-sampling errors. Only the sampling error can be reduced by adding more gaging stations or collecting additional data at current stations. The only way to reduce the model error is to specify another form of the regression equation or perhaps change the size and boundaries of the study area.The generalized least squares estimate of model error does not include the sampling error, whereas the ordinary least squares estimate of the model error does include the sampling error. Thus, by considering the model and sampling error separately, the generalized least squares regression technique offers a better chance of evaluating the worth of additional data collection.

GLS procedures were used in the Southcentral, Southeast, and Yukon hydrologic regions because sufficient data existed in these areas. For each region, regression equations for the 50-year peak flow, average discharge, and the low-flow statistic were developed. Then, using the network analysis procedure, streamflow-gaging networks for each of these regions were designed that would lower the sampling error.

Crisp Expert System

One of the inputs the GLS network-analysis program requires is the cost of a gaging station. However, in Alaska, the cost of a gaging station varies significantly depending on its location. For example, a site in Barrow may cost twice as much to operate as a site along the highway. Because the network analysis program optimizes the regional information subject to a budget constraint, less expensive stations will usually rank higher than more expensive stations. Thus, an alternative was needed and the crisp expert system was developed. This system produces a numerical value for a given station in an objective and consistent manner and was substituted for cost in the network analysis program.

The crisp expert system was prepared by first asking a group of 28 hydrologists and hydrologic technicians of the U.S. Geological Survey in Alaska the following question: What are the important factors that must be considered in placing a gaging station at a particular site? The responses were grouped into two categories: (1) those that dealt mainly with the use of the data and (2) those concerned primarily with the characteristics of the site (table 1). The various factors were grouped accordingly and the list distributed again to Alaska personnel of the U.S. Geological Survey. However, this time personnel were asked to assign a numerical value between 0 and 1 representing the importance of the factor in the overall evaluation of the gaging site. The responses were summarized and the mean values of the response for each of the factors were taken to be the weights for those factors (table 1).

Table 1. Factors, weights, and values used in the crisp expert system

Factor	Weight			Values
Public use	(.483)			
Data used by many		(.366)		(low=.1, high=.9)
Many affected		(.284)		(low=.1, high=.9)
Future development		(.223)		(low=.1, high=.9)
Litigation likely		(.127)		(low=.1, high=.9)
		1.000		
Characteristics of the site	(.517)			
Record quality		(.433)		
Length of record (years)			(.321)	(<5=.1, 5-10=.2, 10-25=.3, >25=.4)
Year round			(.213)	(low=.1, high=.9)
Low flow			(.236)	(low=.4, high=.6)
Control			(.230)	(poor=.1, fair=.3, good=.6)
			1.000	
Basin properties		(.337)		
Area (square miles)			(.315)	(<100=.4, 100-10,000=.4, >10,000=.2)
Areal distribution			(.255)	(poor=. 1, ave=.4, good=.5)
Gage correlates with other gages			(.213)	(no=.9, yes=.1)
Gage correlates with climate			(.217)	(no=.3, yes=.7)
			1.000	
Site properties		(.230)		
Accessibility			(.361)	(easy=.5, moderate=.35, difficult=.15)
Proximity (nearby gaging stations)			(.235)	(none=.2, few=.35, many=.45)
Safety			(.404)	(easy=.5, average=.40, moderately dangerous=.10, dangerous=0)
			1.000	
		1.000		
	1.000			

To compute the value of a gaging station, descriptors such as low, fair, or high, are assigned to each factor. A discrete or crisp numerical value is associated with each of the descriptors. For example, under "Site Properties," if accessibility is easy, the value is 0.50; if accessibility is moderate, the value is 0.35; if accessibility is difficult, the value is 0.15. These crisp numbers are multiplied by the respective weights and then summed to obtain the value of a particular gaging station.

An example calculation of the crisp expert system for the streamflow-gaging station at Indian River near Tenakee (table 2) resulted in a value of 0.61. For example, the relatively high values given to the public use factors show that the information from this station is used by many people, many are affected, and future development is likely in this area. However, no litigation is likely and thus this factor was assigned a relatively low value. Similarly, the high values assigned to the site characteristics factors indicate that year-round record can be obtained from this site and that the streamflow record correlates well with climate. However, because only 6 years of record have been obtained, a low value is assigned to the length of record factor.

The crisp expert system was used for computing the value of gaging stations in Southcentral, Southeast, and Yukon Alaska. Assigning values to discontinued or current sites was done by personnel familiar with the sites. For proposed new stations, values for some of the factors are

Table 2. Example calculation of the value of streamflow-gaging station Indian River near Tenakee, Alaska using the crisp expert system

Factor	Weight	Value	(Weight x Value)	
1. Calculation of value of gaging station from public use (weight = .483)				
Data used by many	.366	.9	.329	
Many affected	.284	.9	.256	
Future development	.223	.9	.201	
Litigation likely	.127	.1	.013	
			Subtotal	.799
Value of gaging station from public use = (.483) x (.799) = .386				
2. Calculation of value of gaging station from site characteristics (weight = .517)				
Record quality (weight = .433)				
Length of record	.321	.2	.064	
Year round	.213	.9	.192	
Low-flow	.236	.4	.094	
Control	.230	.6	.138	
			Subtotal	.488
Record quality value = (.433 x .488) = .211				
Basin properties (weight = .337)				
Physical properties	.315	.4	.126	
Areal distribution	.255	.4	.102	
Gage correlates with other gages	.236	.1	.021	
Gage correlates with climate	.217	.7	.152	
			Subtotal	.401
Basin property value = (.337 x .401) = .135				
Site properties (weight = .230)				
Accessible	.361	.35	.126	
Proximity	.235	.2	.047	
Safety	.404	.5	.202	
			Subtotal	.375
Site property value = (.230 x .375) = .086				
Total of record quality, basin properties, and site properties value = .211 + .135 +. 086 = .432				
Value of gaging station from site characteristics = (.517 x .432) = .223				
TOTAL VALUE OF GAGING STATION = .386 + .223 = .61				

unknown because the site of the proposed station has not been visited. In these cases, average values were assigned. Because our knowledge of most of the Canadian stations is limited, it was decided to assign equal values for all Canadian sites.

The value of a streamflow-gaging station computed by use of the crisp expert system was converted to a pseudo-cost so that the network analysis program could be used. This was accomplished by subtracting the value of the gage from 1.0. For example, the cost of the Indian River near Tenakee (table 2) would be 0.39 (1.00 - 0.61). Thus, a high value of a gaging station would correspond to a station assigned a relatively low cost in the network analysis program.

Network Analysis

Network analysis evolved from work done by Moss and others (1982). Their approach, commonly called network analysis for regional information (NARI), was based on the regional regression approach developed by Benson and Matalas (1967) and was an evaluation of the likelihood of improving regression equations by the collection of additional data. NARI used ordinary least squares to develop the regression equation and then attempted to improve the regression model based on simulation by means of stochastic hydrology. Network analysis by use of generalized least squares (GLS) was found by Moss and Tasker (1990) to provide a better estimate of the value of additional streamflow data than the NARI method and was thus used in this study.

The network analysis program was utilized in the Southcentral, Southeast, and Yukon regions. The program uses the output from the generalized least squares program along with the cost of a streamflow station and attempts to lower the sampling error, both spatially and temporally subject to a budget constraint. By adding many stations having short record to the regression analysis, the network analysis program reduces the spatial-sampling error. By increasing the length of record, particularly those at stations having a long record, the network analysis program attempts to reduce the time-sampling error. Therefore, the objective of the gaging strategy is to obtain the largest reduction in sampling error which corresponds to the greatest improvement in regional information. The options are to operate each station in the present network or a subset of the present network for a longer period of time, to add gaging stations to the present network, and to operate this modified network for a period of time, or some combination of these options.

A planning period of 10 years was chosen for this study. Although somewhat arbitrary, the USGS considers a minimum of 10 years of streamflow data necessary to calculate statistics such as flood frequencies. In addition, a statistical technique that has been widely used is to relate the standard error of a given streamflow characteristic to record length (fig. 5). Usually, after 10 years of data have been collected at a site, the standard error (and corresponding variability) has been significantly lowered. Additional years of data collection will continue to lower the standard error but at a lower rate.

For this study, the network analysis program was used for two different scenarios: (1) a 10-year planning period with no new streamflow-gaging stations and (2) a 10-year planning period with additional gaging stations. The output of the network analysis program consists of the stations to be operated in the network and their effect or contribution in reducing the sampling error. Stations are ranked in order, with the station having the most effect on the sampling error ranked first and the station having the least effect on the sampling error ranked last.

The network analysis program was used for selected flow characteristics (peak, average, low-flow) of the Southcentral, Southeast, and Yukon regions. A tabulation was made of the most important stations in reducing the sampling error of a particular equation. Thus, one station may be highly influential in reducing the sampling error for the 50-year peak flow equation but may have no influence on reducing the sampling error for the low-flow equation. The proposed network for a region was based on a final tabulation of those streamflow-gaging stations that would be most effective in reducing the sampling error in all three equations.

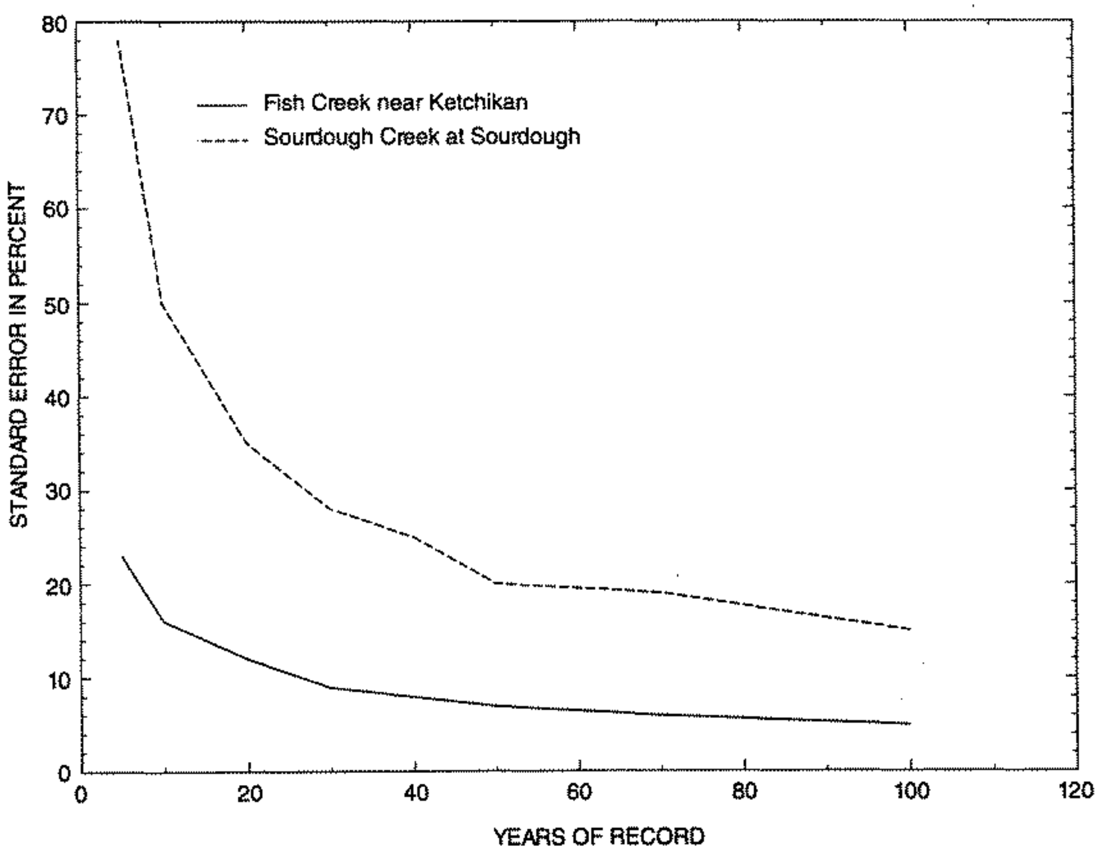


Figure 5. Standard error as a function of record length.

EVALUATION OF THE STREAMFLOW GAGING NETWORK

Arctic Alaska

Arctic Alaska encompasses an area of 79,000 mi^2. The streams and rivers in Arctic Alaska flow generally northward from the Brooks Range into the Arctic Ocean (fig. 6). The largest river in the Arctic, the Colville River, flows eastward for 200 mi before turning to the north: its basin covers 30 percent of the subregion (23,200 mi^2). The area is underlain by continuous permafrost. More than half of the flat, western part of the coastal plain is covered by shallow lakes. Reconnaissance studies by Childers and others (1977, 1979) have shown that many of the rivers probably have no-flow periods during the winter.

Knowledge of the water resources in this area is important, whether it be for resource development or management of ecosystems. The largest oilfield in North America, Prudhoe Bay, is located in Arctic Alaska. Considerable interest exists for future petroleum development in the Arctic. Some of the more prominent areas mentioned include the Arctic National Wildlife Refuge (ANWR), the Colville River Delta, and the National Petroleum Reserve of Alaska (NPRA) (fig. 6). If future petroleum development does occur, infrastructure such as pipelines and roads will be constructed. Development of an adequate water supply will also be essential.

Streamflow information is also needed for management of ecosystems. Some of the largest caribou herds—the Porcupine and the Western Arctic—graze over large areas of this region. The arctic wetlands support large populations of ducks, geese, and shorebirds. Many of the streams and rivers support various species of fish.

Hydrologic data for the Arctic are sparse. Only nine streamflow-gaging stations have sufficient data for peak-flow analysis and only seven have sufficient data for average and low-flow analysis (table 3). In addition, with the exception of Nunavak Creek near Barrow, most of the sites are located along the Dalton Highway (fig. 6). Given the size of Arctic Alaska, the lack of data, and the spatial distribution of the existing data, no attempts were made to use GLS or network analysis procedures. Instead, cluster and spatial analysis techniques were utilized.

To design a proposed network for Arctic Alaska, the following procedure was used. First, potential sites were selected, using the hydrologic unit map (U.S. Geological Survey, 1987) as a guide. It was assumed that drainage area would be a significant variable for any statistical analysis and thus potential sites in each hydrologic unit were chosen to ensure that a wide distribution of this variable was obtained.

Using GIS procedures, a cluster analysis was done using the precipitation, physiography, and permafrost coverages of the Arctic region. Results of the cluster analysis indicated three distinct classification areas. The potential sites were then overlaid on the cluster map (fig. 7), to ensure that sites would represent the different classification areas. Potential sites were also overlaid on the precipitation, physiographic, and hydrologic unit boundary maps (fig. 8-10) for visual analysis to ensure spatial distribution. Sites were added or removed to adjust the distribution. Finally, a boxplot and a probability plot of the variable drainage area were developed (fig. 11-12) which indicate a good symmetrical distribution and a good normal distribution.

The proposed streamflow-gaging network for Arctic Alaska consists of 57 sites (table 4, fig. 10). Of these sites, the Meade (No. 14 on fig. 10), Colville (35), Kuparuk (38), and Jago (52) Rivers, and Nunavak Creek (13) would be index stations. These stations would provide a good spatial distribution across the Arctic, as well as good distribution of drainage areas. In addition, continuing data collection on the Kuparuk River and Nunavak Creek would provide long-term data necessary to detect trends in streamflow.

If the proposed network can not be implemented in its entirety, several alternative approaches are suggested. One approach would be to establish the index stations; another approach would be a reconnaissance of the 57 sites. After the reconnaissance was completed, a value for each of the proposed sites could be obtained using the crisp expert system. Sites with the highest value would then be selected. Another alternative would be to select a subregion within Arctic Alaska, such as eastern Arctic, and and operate those stations within the subregion.

Table 3. Streamflow data available for Arctic Alaska

Station No.	Station name	Flow data available			Remarks
		Peak	Average	Low	
15798700	Nunavak Creek near Barrow	X	X	X	Active gaging station
15896000	Kuparuk River near Deadhorse	X	X	X	Active gaging station
15896700	Putuligayuk River near Deadhorse	X	X	X	Discontinued gaging station
15904900	Atigun River tributary near Pump Station 4	X	X	X	Discontinued gaging station
15906000	Sagavanirktok River tributary near Pump Station 3	X	X	X	Active gaging station
15908000	Sagavanirktok River near Pump Station 3	X	X	X	Active gaging station
1591000	Sagavanirktok River near Sagwon	X	X	X	Discontinued gaging station
15910200	Happy Creek at Happy Valley Camp near Sagwon	X			Active crest-stage gage
15918200	Sagavanirktok River tributary near Deadhorse	X			Active crest-stage gage
TOTAL		9	7	7	

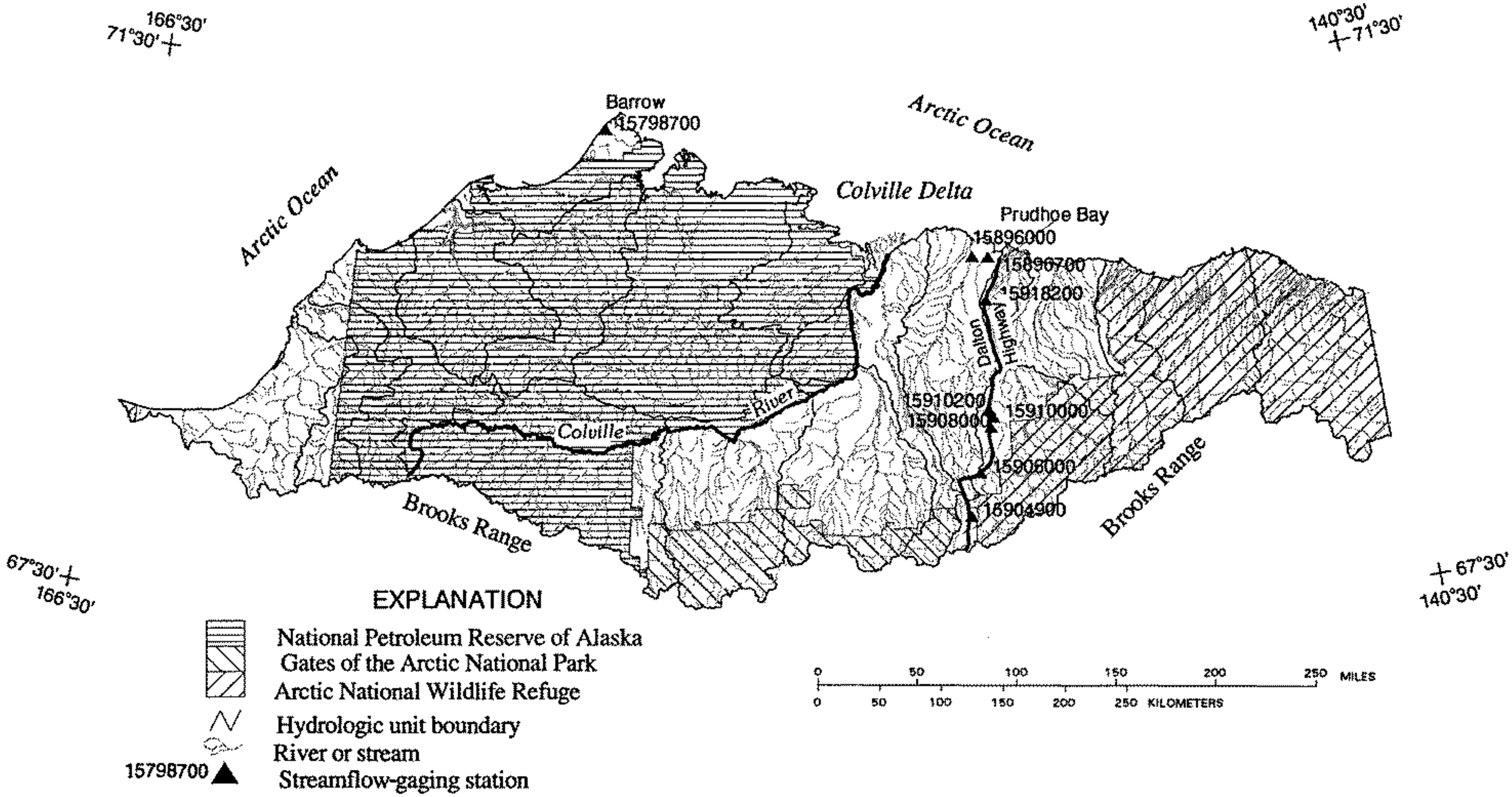


Figure 6. Land uses of Arctic Alaska and locations of past and current streamflow-gaging stations.

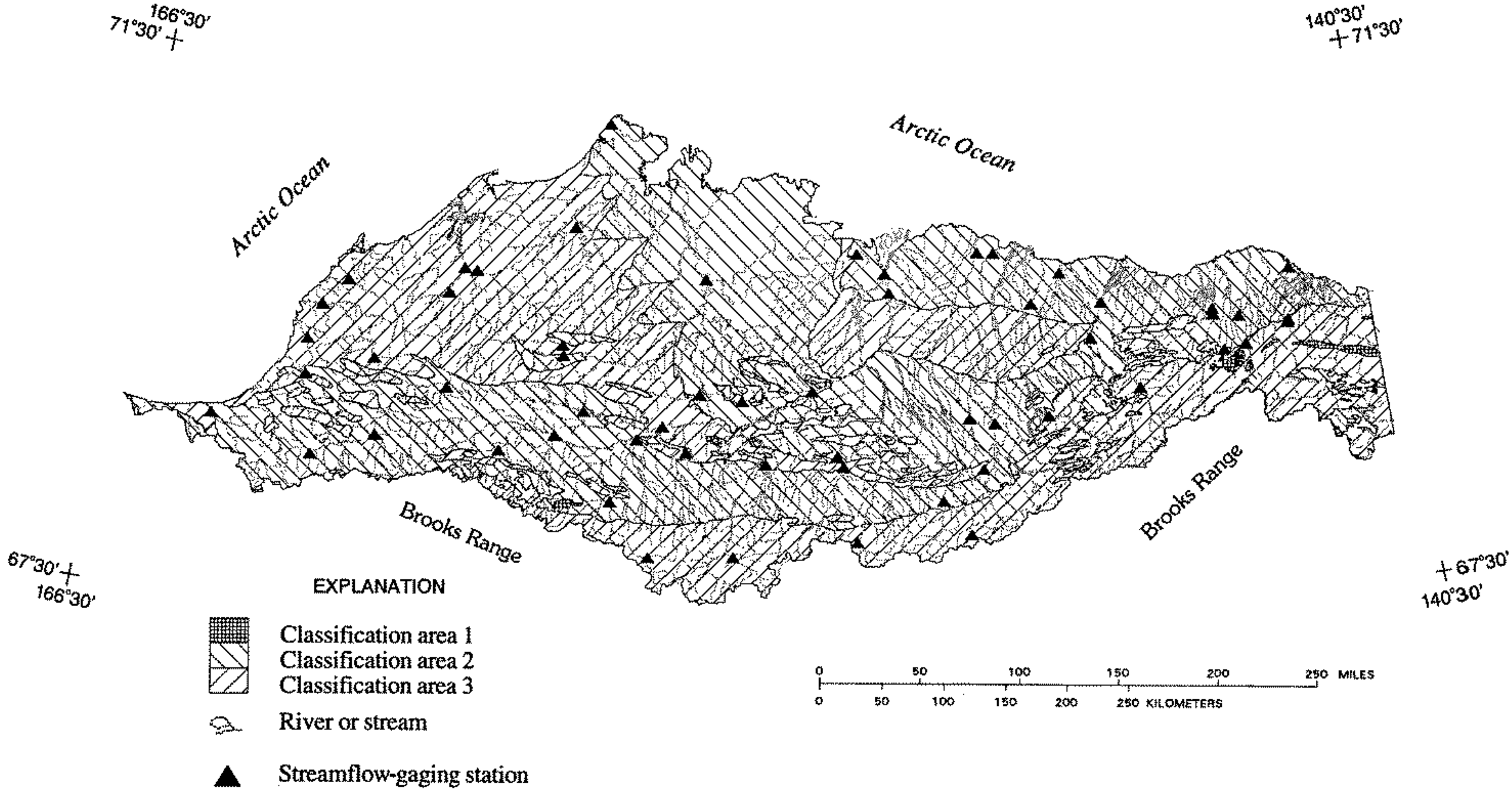


Figure 7. Proposed streamflow-gaging network and classification areas for Arctic Alaska.

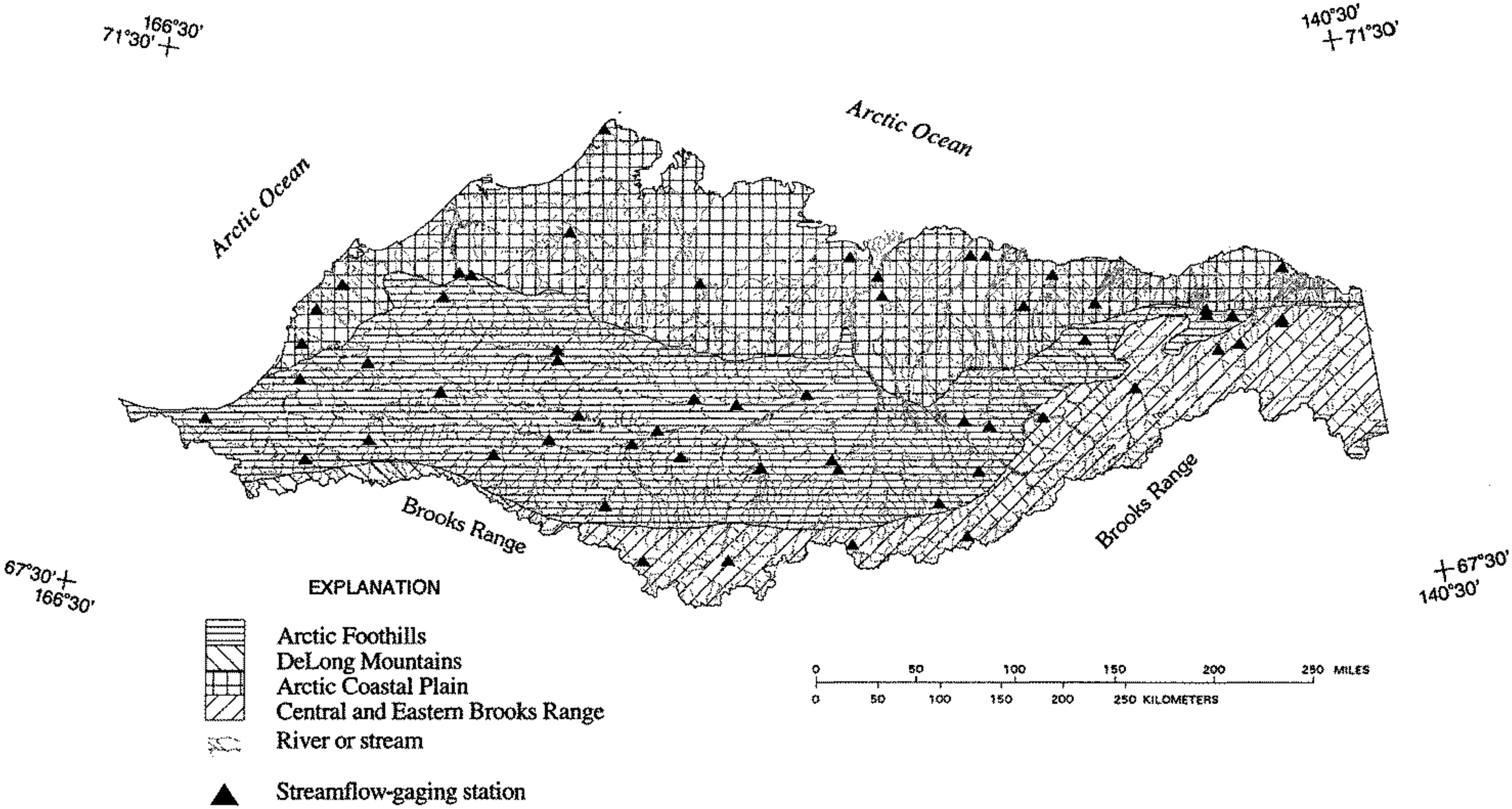


Figure 8. Proposed streamflow-gaging network and physiographic regions for Arctic Alaska (from Wahrhaftig, 1965).

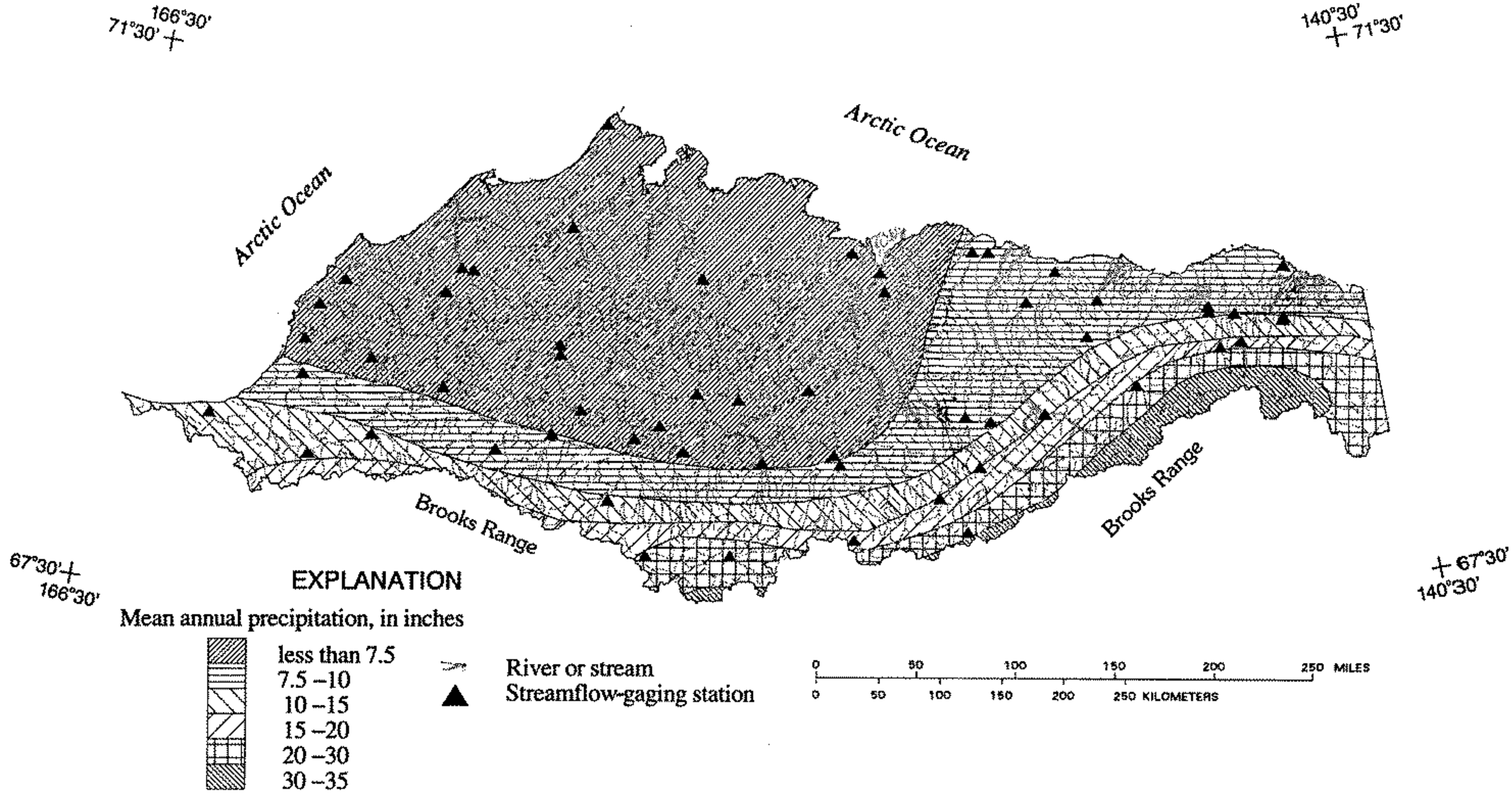


Figure 9. Proposed streamflow-gaging network and precipitation areas for Arctic Alaska (from Jones and Fahl, 1994).

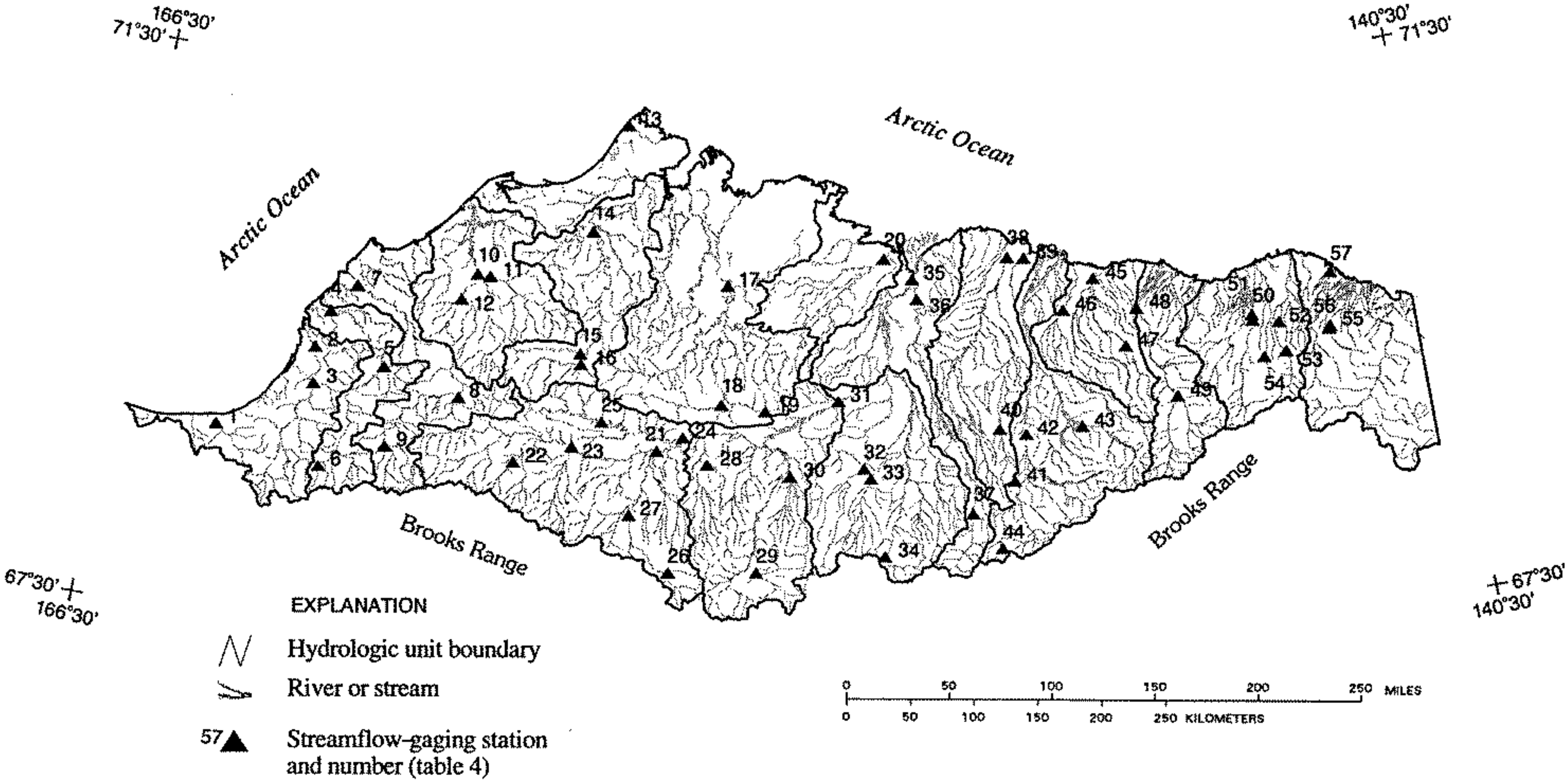


Figure 10. Proposed streamflow-gaging network and hydrologic unit boundaries for Arctic Alaska.

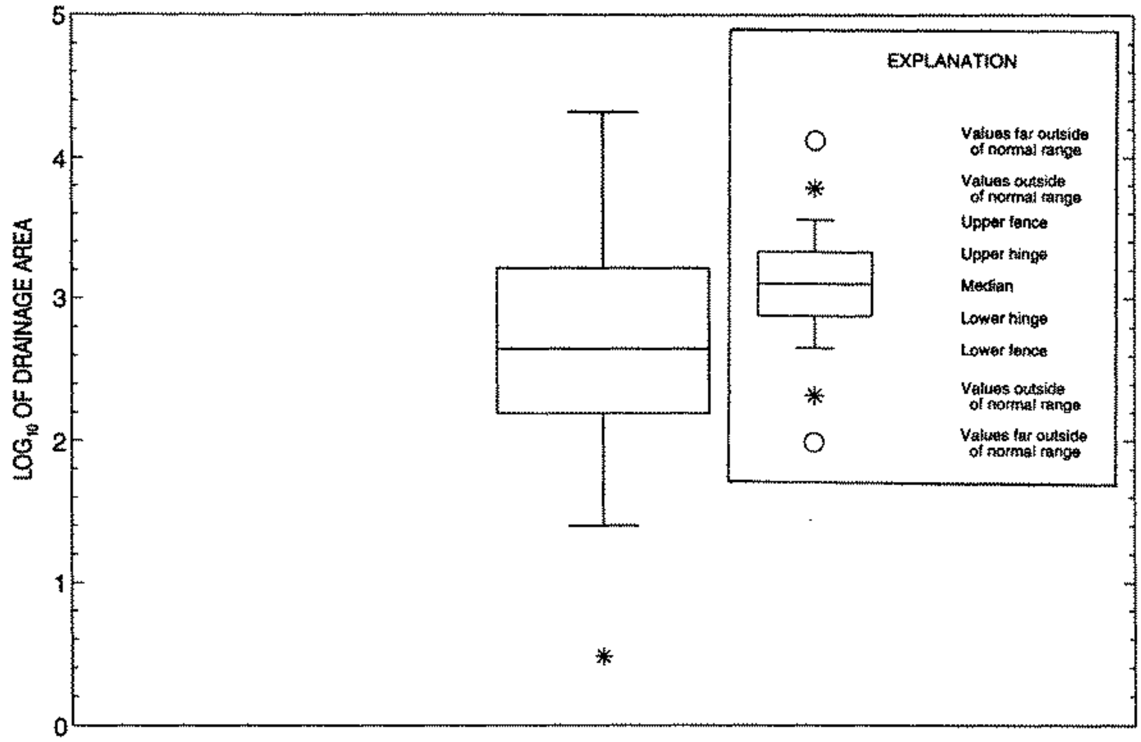


Figure 11. Boxplot of drainage areas of proposed streamflow-gaging stations for Arctic Alaska.

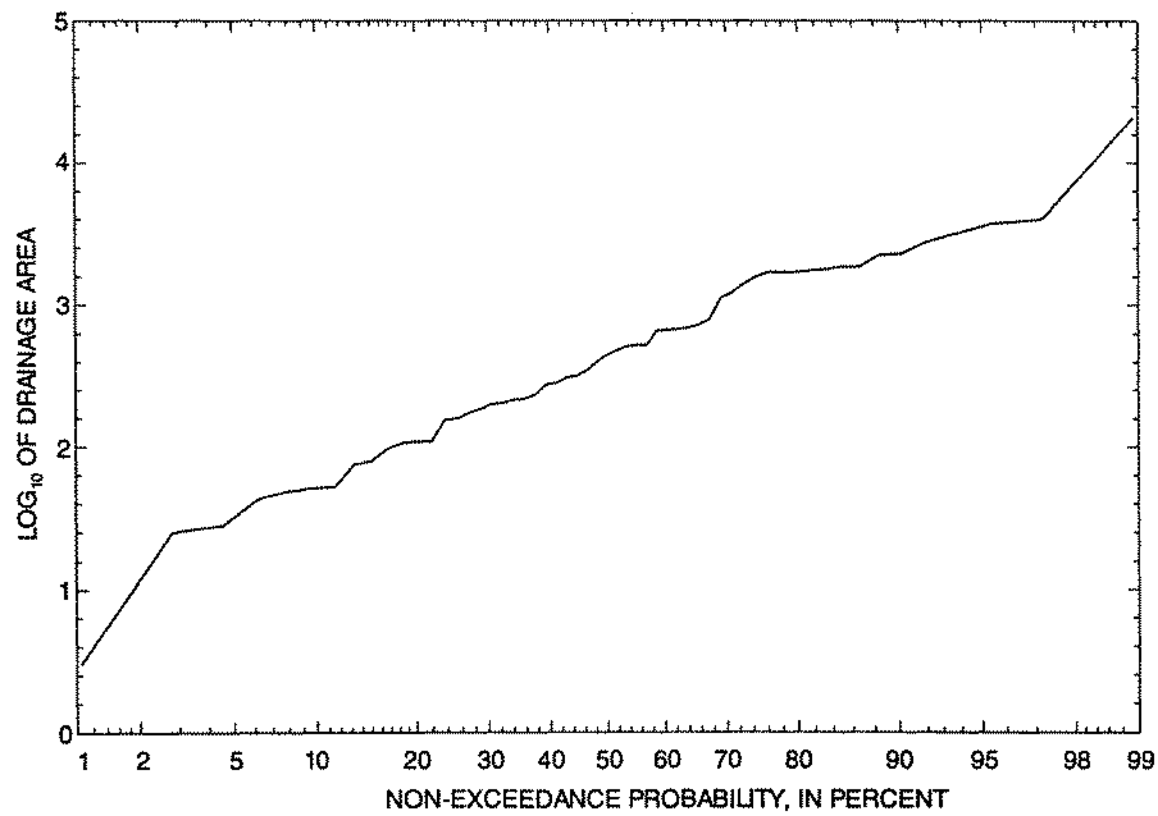


Figure 12. Probability plot of drainage areas of proposed streamflow-gaging stations for Arctic Alaska.

Table 4. Proposed streamflow-gaging network, Arctic Alaska
[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig.10)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
1	19060101	3,560	Pitmegea River	68°51'15"164°25'36"	480
2			Kukpowruk River	69°29'50"162°43'30"	1,690
3			Deadfall Creek	69°14'03"162°40'20"	107
4	19060102	2,360	Kokolik River	69°45'39"162°31'00"	2,270
5			Avingak Creek	69°24'41"161°20'56"	284
6			Tingmerkpuk River	68°39'06"162°22'16"	52.0
7	19060103	3,830	Utukok River	69°57'48"162°03'12"	2,760
8			Disappointment Creek	69°14'43"159°50'21"	200
9			Adventure Creek	68°50'46"161°10'00"	50.7
10	19060201	4,230	Kuk River	70°08'06"159°40'42"	3,690
11			Avalik River	70°07'30"159°25'12"	1,130
12			Kaolak River	69°56'49"159°57'16"	309
13	19060202	2,120	Nunavak Creek (15798700)[1]	71°15'35"156°46'57"	2.79
14	19060203	4,160	Meade River[1]	70°29'20"157°24'40"	1,800
15			Shaningarok Creek	69°37'01"157°32'16"	353
16			Pahron Creek	69°32'31"157°30'55"	110
17	19060204	9,190	Ikpikpuk River	70°08'12"154°38'30"	3,980
18			Kigalik River	69°17'16"154°43'41"	532
19			Anak Creek	69°14'33"153°51'53"	43.5
20	19060205	2,630	Fish Creek	70°19'00"151°28'36"	1,700
21	19060301	7,920	Etivluk River	68°56'42"155°57'42"	2,260
22			Jubilee Creek	68°48'57"158°40'51"	154
23			Kuna River	68°57'04"157°36'18"	730
24			Awuna River	69°02'47"155°27'18"	1,420
25			Quartzite Creek	69°08'25"157°02'41"	97.2
26			Itilyiargiok Creek	68°04'49"155°39'45"	110
27			Nigu River	68°28'55"156°26'29"	511
28	19060302	5,850	Heather Creek	68°51'18"154°58'40"	187
29			Easter Creek	68°05'27"154°01'24"	394
30			Okokmilaga River	68°46'39"153°23'22"	789
31			Prince Creek	69°18'42"152°26'38"	217
32	19060303	5,540	Chandler River	68°49'33"151°58'31"	1,750
33			Siksikpuk River	68°45'09"151°50'59"	681
34			Anaktuvuk River	68°11'37"151°37'13"	206

Table 4. Proposed streamflow-gaging network, Arctic Alaska--Continued

[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig.10)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
35	19060304	3,930	Colville River near Nuiqsut[1]	70°09'56"150°55'00"	20,700
36			Itkillik River	70°01'21"150°50'34"	1,720
37			Itikmalak River	68°28'18"149°55'01"	80.0
38	19060401	4,300	Kuparuk River (15896000)[1]	70°16'54"148°57'35"	3,130
39			Putuligayuk River (15896700)	70°16'03"148°37'41"	176
40			Toolik River	69°03'51"149°19'05"	233
41	19060402	5,280	Sagavanirktok River Tributary (15906000)	68°41'13"149°05'42"	28.4
42			Sagavanirktok River near Pump Station #3 (15908000)	69°00'54"148°49'02"	1,860
43			Ivishak River	69°02'34"147°43'48"	660
44			Atigun River (15904800)	68°12'54"149°24'13"	48.7
45	19060403	2,790	Shaviovik River	70°05'07"147°16'30"	1,580
46			Kadleroshilik River	69°52'39"147°55'11"	454
47			Kavik River	69°35'02"146°44'12"	279
48	19060501	2,670	Canning River	69°50'38"146°27'10"	1,870
49			Marsh Fork	69°11'19"145°49'55"	700
50	19060502	3,610	Sadlerochit River	69°39'13"144°12'10"	529
51			Hulahula River	69°41'47"144°12'10"	681
52			Jago River[1]	69°37'02"143°41'06"	321
53			McCall Creek	69°24'17"143°36'57"	24.7
54			Okpilak River	69°23'06"144°04'04"	159
55	19060503	4,590	Egaksrak River	69°32'05"142°41'05"	215
56			Kongakut River	69°30'54"142°42'34"	1,240
57			Sikrelurak River	69°54'43"142°30'52"	74.7

[1]Index station

Northwest Alaska

Northwest Alaska is approximately 68,000 mi^2 in area, and consists of streams and rivers that flow westward into Kotzebue and Norton Sounds (fig. 13). The principal rivers are the Kobuk and the Noatak Rivers, each of which drains an area of about 12,000 mi^2. Selawik Lake—a tidal, saline lake (400 mi^2)—is the largest in the region. Four national parks are located in the region—Noatak, Kobuk Valley, Cape Krusenstern, and Bering Land Bridge. The Noatak National Park and Preserve protects the largest pristine river basin in the United States and in 1976 was designated as an International Biosphere Reserve by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). One of the largest lead and zinc mines in North America, the Red Dog Mine, is located near Kivalina. Areas near the Baird Mountains may contain copper, gold, lead, and zinc (National Park Service, 1986). The DeLong Mountains probably contain metals such as chromium, nickel, copper, lead, and zinc (National Park Service, 1986).

Surface water is used mainly for rural domestic purposes, public-water supply, and mining. Future requirements for hydrologic data and information probably will be related to development of known mineral reserves, extension and (or) connection of local road systems, and development and protection of the quality of community water supplies at the larger communities in the region such as Nome, Unalakleet, and Golovin. Water-resources information from the Noatak River would provide considerable knowledge on a large, pristine watershed.

Data were available for 14 gaging stations in northwest Alaska for analysis of peak flows and for 6 gaging stations for average and low flows (fig. 13, table 5). Because of the limited data set and the lack of spatial distribution, the generalized least squares and network analysis procedures were not used. The cluster and spatial analysis techniques were used in this region.

The proposed streamflow-gaging network was developed by using the hydrologic unit map as a guide. It was assumed that drainage area would be a significant variable for any statistical analysis and thus potential sites within each hydrologic unit were chosen, to ensure a wide distribution of this variable. Cluster analysis for this region was done using the precipitation, physiography, and permafrost coverages. Results of the cluster analysis indicated three major classification areas (fig. 14). The proposed sites were overlaid on the cluster map (fig. 14) to ensure that all classification areas would be represented. Proposed sites were also plotted on the physiographic, precipitation, and hydrologic unit maps (fig. 15-17) for visual analysis and to ensure spatial distribution. A boxplot and a probability plot of the variable drainage area (fig. 18-19) indicated a good symmetrical and normal distribution of this variable.

The proposed network consists of 57 stations (table 6, fig. 17). The Kobuk (No. 97 on fig. 17), Kuzitrin (70), Wulik (109), Noatak (107), Buckland (78), and Unalakleet (58) Rivers are the proposed index stations. Two of the stations—the Kobuk and the Wulik—are currently active and have more than 10 years of record each. The remaining stations would provide sufficient spatial distribution. If the proposed network could not be implemented entirely, possible alternatives are the same as those mentioned for Arctic Alaska.

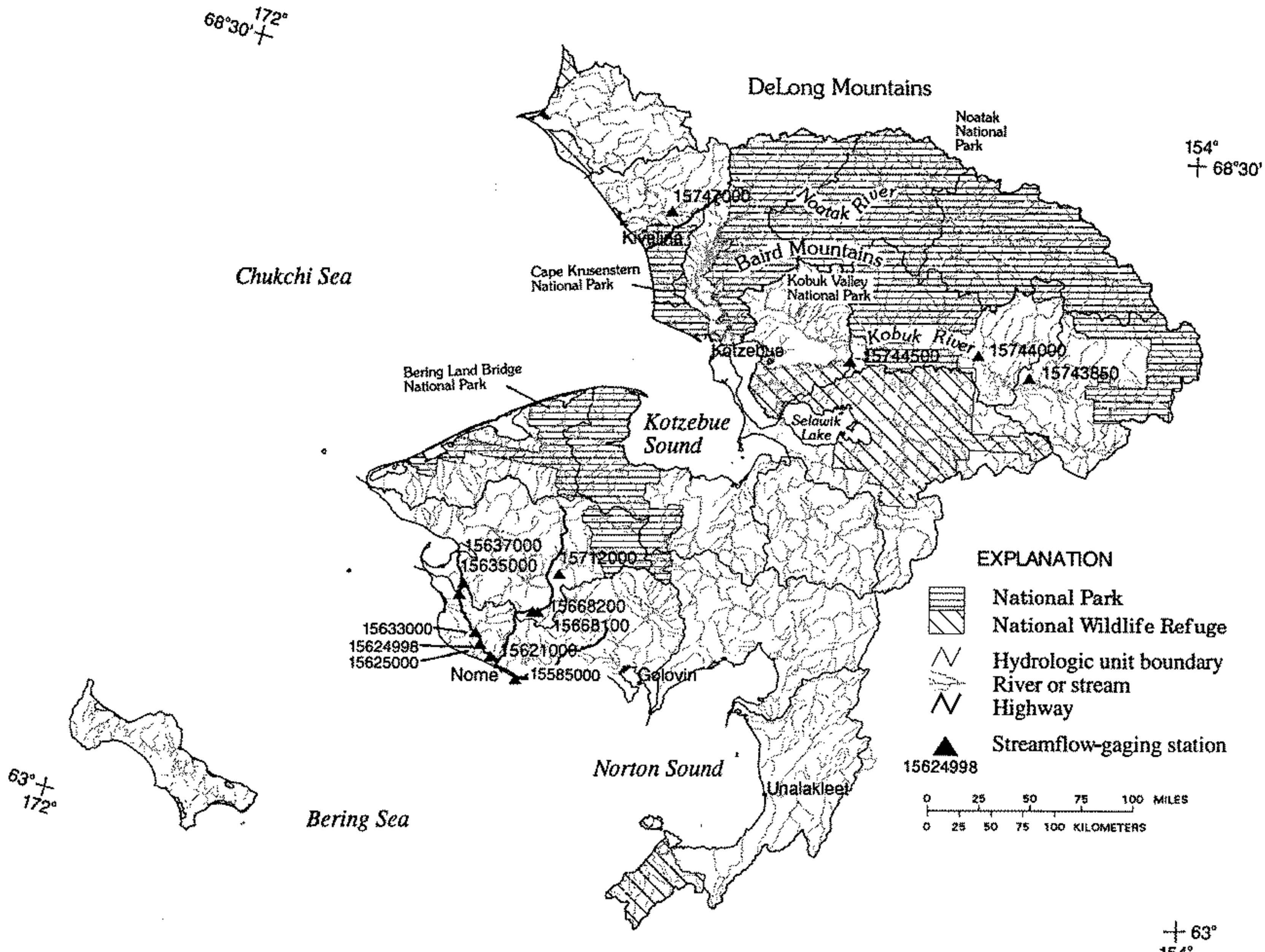


Figure 13. Land uses of Northwest Alaska and locations of past and current streamflow-gaging stations.

Table 5. Streamflow data available for Northwest Alaska

Station No.	Station name	Flow data available			Remarks
		Peak	Average	Low	
15585000	Goldengate Creek near Nome	X			Crest-stage gage, active
15621000	Snake River near Nome	X	X	X	Discontinued gaging station
15624998	Arctic Creek above tributary near Nome	X			Crest-stage gage, active
15625000	Arctic Creek near Nome	X			Crest-stage gage, discontinued
15633000	Washington Creek near Nome	X			Crest-stage gage, active
15635000	Eldorado Creek near Teller	X			Crest-stage gage, active
15637000	Gold Run Creek near Teller	X			Crest-stage gage, active
15668100	Star Creek near Nome	X			Crest-stage gage, discontinued
15668200	Crater Creek near Nome	X	X	X	Discontinued gaging station
15712000	Kuzitrin River near Nome	X	X	X	Discontinued gaging station
15743850	Dahl Creek near Kobuk	X			Crest-stage gage, active
15744000	Kobuk River at Ambler	X	X	X	Discontinued gaging station
15744500	Kobuk River near Kiana	X	X	X	Active gaging station
15747000	Wulik River near Kivalina	X	X	X	Active gaging station
TOTAL		14	6	6	

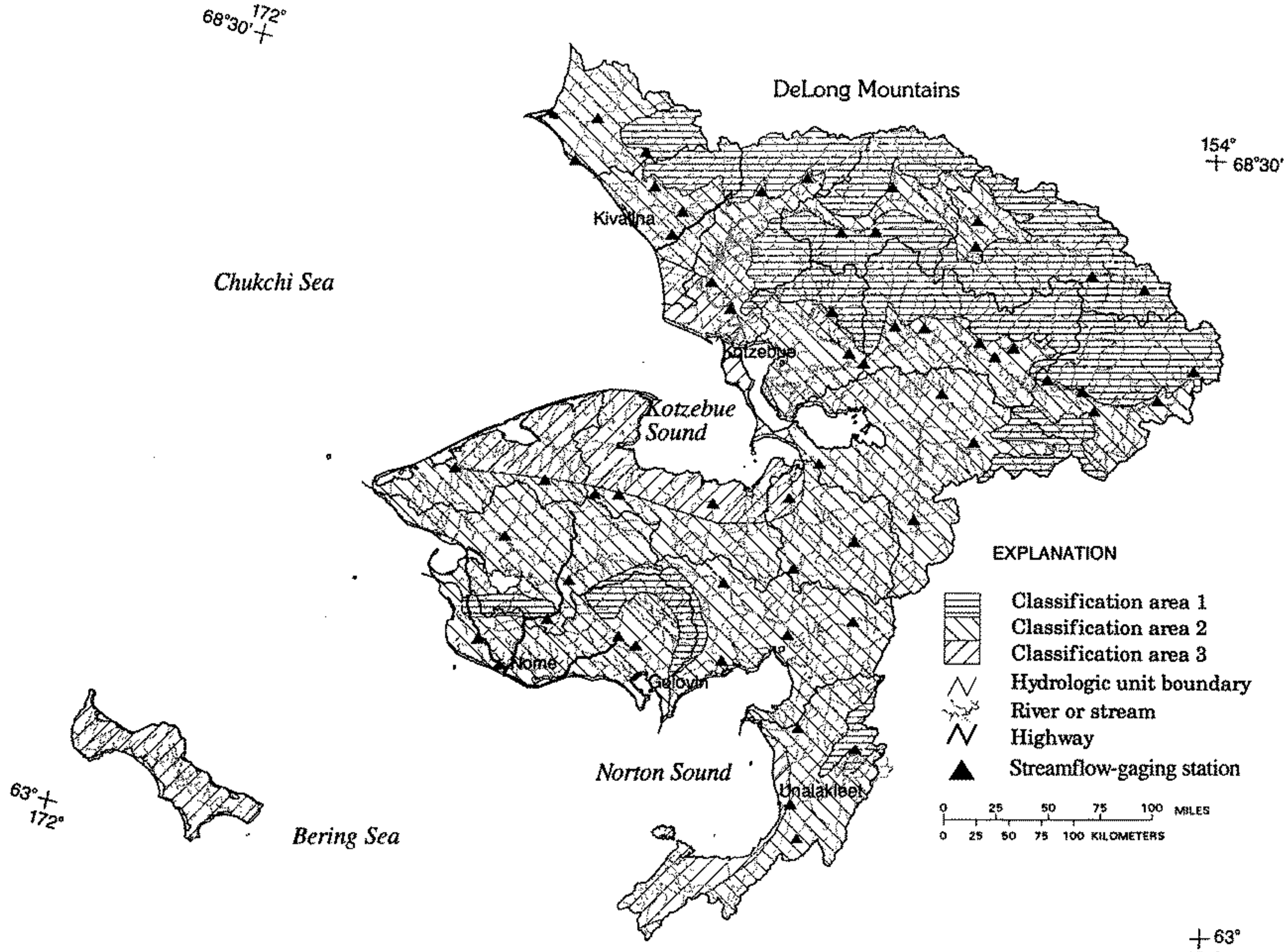


Figure 14. Proposed streamflow-gaging network and classification areas for Northwest Alaska.

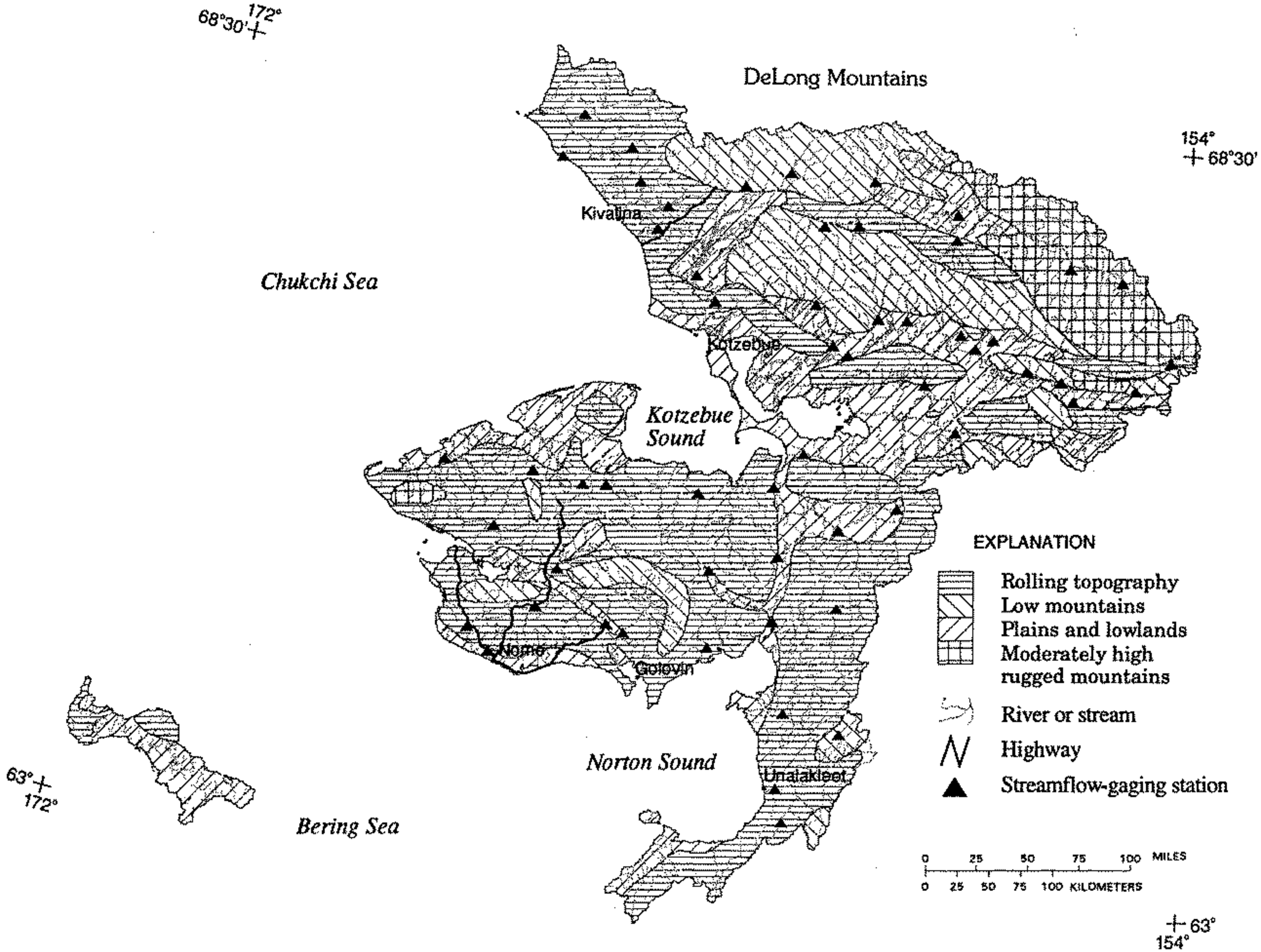


Figure 15. Proposed streamflow-gaging network and physiographic regions for Northwest Alaska (from Wahfhaftig, 1965).

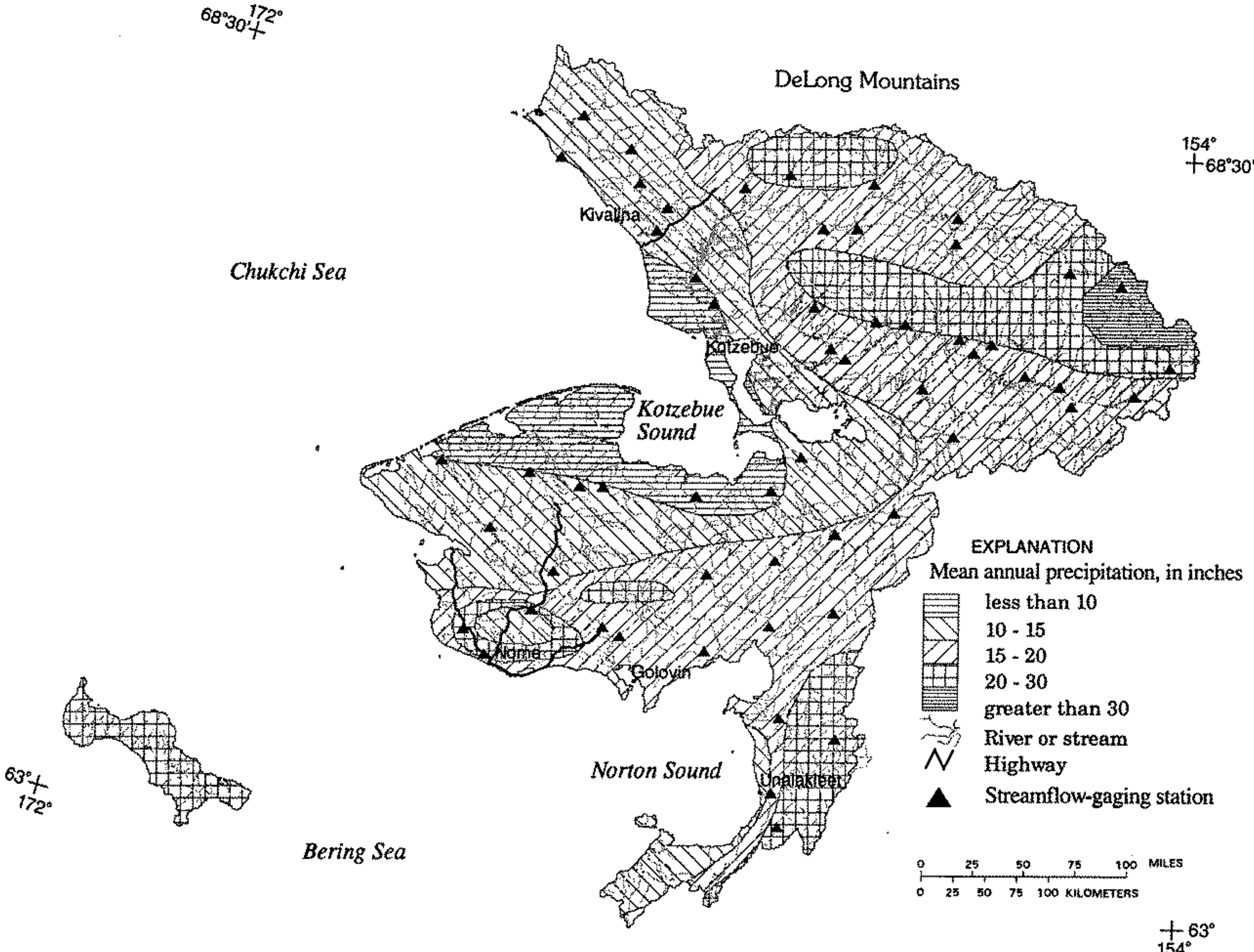


Figure 16. Proposed streamflow-gaging network and precipitation areas for Northwest Alaska (from Jones and Fahl, 1994).

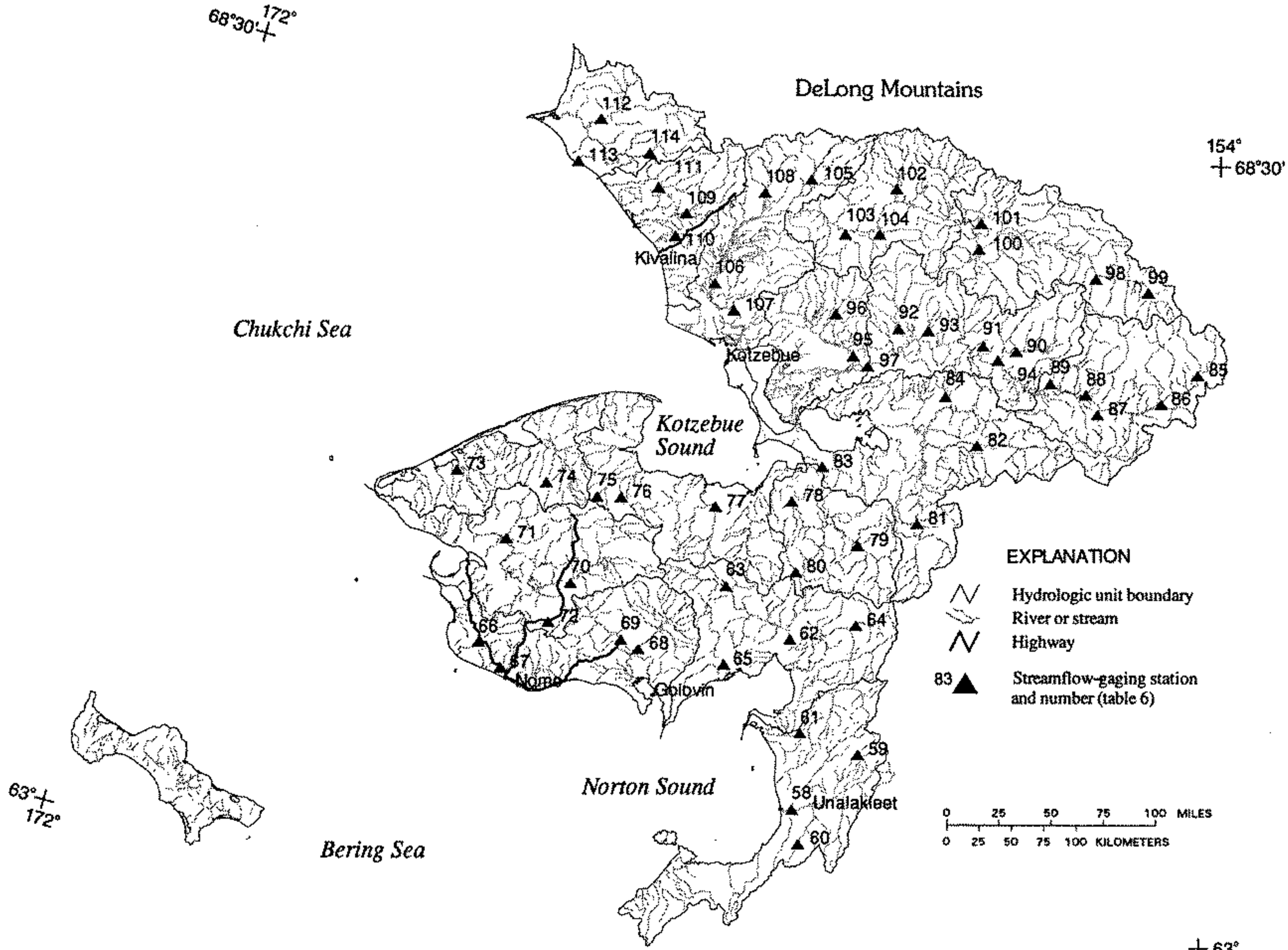


Figure 17. Proposed streamflow-gaging network and hydrologic unit boundaries for Northwest Alaska.

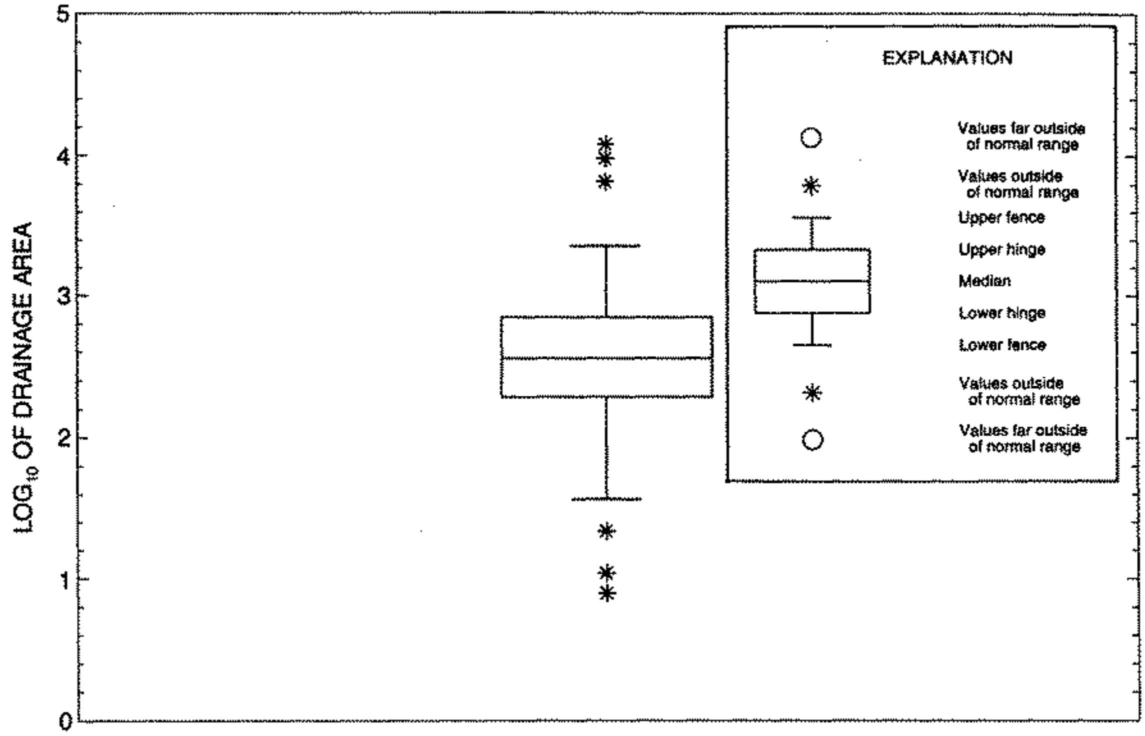


Figure 18. Boxplot of drainage areas of proposed streamflow-gaging stations for Northwest Alaska.

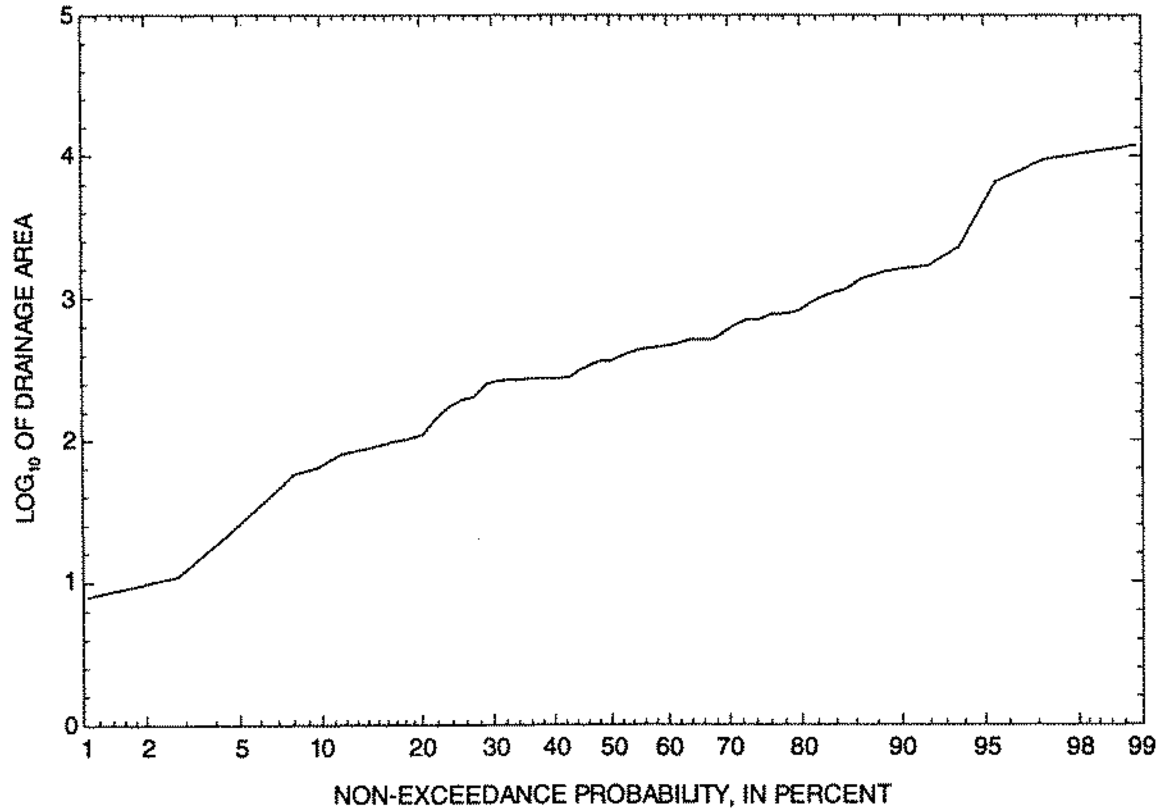


Figure 19. Probability plot of drainage areas of proposed streamflow-gaging stations for Northwest Alaska.

Table 6. Proposed streamflow-gaging network, Northwest Alaska
[HUC, Hydrologic unit code; mi², square mile; USGS station number indicated after site name]

Map No. (fig. 17)	HUC	HUC area (mi²)	Site name	Latitude/Longitude	Drainage area (mi²)
	19050101	1,840	St. Lawrence Island		
58	19050102	4,890	Unalakleet River[1]	63°52'35"160°36'43"	1,390
59			North Fork Unalakleet River	64°17'33"159°40'24"	103
60			Chiroskey River	63°38'46"160°27'33"	80.0
61			Shaktoolik River	64°24'16"160°36'53"	783
62	19050103	4,950	Koyuk River	65°02'20"160°56'45"	1,520
63			Upper Koyuk	65°21'11"162°05'51"	414
64			Inglutalik River	65°10'28"159°54'03"	359
65			Tubutulik River	64°48'39"161°58'12"	394
66	19050104	4,450	Sinuk River	64°42'48"165°55'29"	206
67			Snake River (15621000)	64°33'51"165°30'26"	85.7
68			Fish River	64°50'15"163°22'19"	1,140
69			Niukluk River	64°53'10"163°40'23"	702
70	19050105	4,920	Kuzitrin River (15712000)[1]	65°13'17"164°37'15"	1,720
71			American River	65°27'09"165°47'29"	468
72			Crater Creek (15668200)	64°55'48"164°52'12"	21.9
73	19050201	2,930	Nuluk River	65°51'27"166°49'40"	249
74			Serpentine River	65°53'04"165°18'10"	197
75	19050202	4,100	Humboldt Creek	65°50'40"164°25'31"	8.15
76			Goodhope River	65°51'53"164°01'39"	263
77			Kugruk River	65°53'31"162°26'43"	452
78	19050203	2,890	Buckland River[1]	65°59'31"161°10'19"	2,290
79			Upper Buckland River	65°43'46"160°00'11"	770
80			Bear Creek	65°30'14"160°58'25"	64.9
81	19050301	6,640	Tagagawik River	65°55'00"159°02'35"	443
82			Selawik River	66°29'07"158°07'22"	650
83			Kauk River	66°15'04"160°42'57"	175
84			Kuchuk Creek	66°48'35"158°43'44"	96.8
85	19050302	4,650	Kobuk River above Walker Lake	67°01'37"154°20'36"	285
86			Reed River	66°49'25"154°57'31"	364
87			Pah River	66°44'30"156°03'48"	956
88			Mauneluk River	66°52'40"156°16'45"	573
89			Dahl Creek (15743850)	66°56'46"156°54'32"	11.0

Table 6. Proposed streamflow-gaging network, Northwest Alaska--Continued
[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 17)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
90	19050303	4,800	Ambler River	67°09'18"157°32'23"	716
91			Jade Creek	67°10'49"158°07'47"	57.0
92			Salmon River	67°15'12"159°38'58"	515
93			Kaliguricheark River	67°15'24"159°07'46"	143
94			Kobuk River (15744000)	67°05'13"157°50'51"	6,570
95	19050304	2,820	Squirrel River	67°02'00"160°24'00"	1,610
96			Omar River	67°18'54"160°46'29"	268
97			Kobuk River (15744500)[1]	66°58'25"160°07'51"	9,520
98	19050401	4,690	Ipnelivik River	67°41'01"156°11'16"	109
99			Noatak River (15746000)	67°35'49"155°14'03"	276
100			Cutler River	67°50'54"158°19'20"	273
101			Makpik Creek	68°01'39"158°19'20"	273
102	19050402	3,870	Nimiuktuk River	68°12'57"159°55'23"	516
103			Nakolik River	67°52'14"160°45'42"	317
104			Aklumayuak Creek	67°53'32"160°09'09"	272
105	19050403	4,480	Kugururok River above Trail Cr.	68°13'17"161°29'14"	441
106			Eli River	67°25'28"162°59'05"	514
107			Noatak River near Noatak[1]	67°15'24"162°35'09"	12,000
108			Kelly River	68°05'27"162°18'15"	489
109	19050404	2,570	Wulik River (15747000)[1]	67°52'34"163°40'28"	822
110			Omikviorok River	67°42'36"163°48'22"	91.2
111			Kivalina River	68°01'18"164°14'24"	336
112	19050405	2,660	Ipewik River	68°25'30"165°29'00"	1,070
113			Ogotoruk Creek (15748000)	68°06'40"165°45'10"	36.9
114			Kukpuk River	68°14'53"164°29'58"	276

[1]Index station

Southwest Alaska

Southwest Alaska (112,000 mi^2 in area) includes basins that drain to the southwest into Kuskokwim and Bristol Bays. The area also includes the Aleutian Islands. The principal river basins are the Kuskokwim, Nushagak, and Kvichak Rivers (fig. 1) which cover 64 percent of the region. The area includes several large lakes, such as Iliamna, Becharof, and Naknek (fig. 20) that have surface areas ranging from 100 to 1,000 mi^2; 50 more lakes have areas of 10 mi^2 or larger. The interconnected stream and lake systems draining to Bristol Bay constitute the most productive area for salmon in Alaska. Many of these streams and lakes are popular tourist destinations for sport fishing. Thus, water-resource information is critical for Southwest Alaska in order to manage and maintain this renewable resource.

A sufficient data base for analyzing the streamflow-gaging network does not exist in this region. Only 18 sites have peak flow data (fig. 20, table 7); however, 5 of these sites are located at the outlet of large lakes which attenuate peak flows and might bias any peak-flow analysis. Only 14 sites have sufficient data to analyze for average flow and only 10 sites have sufficient data to analyze for low-flow statistics. Thus, for this region, cluster and spatial analyses techniques were used to design the proposed streamflow-gaging network.

Assuming that drainage area would be a significant variable for any statistical analyses, potential sites were chosen that had a wide distribution of this variable. Cluster analysis of the precipitation, physiographic, and permafrost maps indicated three classification areas in the region (fig. 21). The proposed sites were overlaid on the cluster map (fig. 21) to ensure that all classification areas would be represented. Proposed sites were also plotted on the physiographic, precipitation, and hydrologic units maps (fig. 22-24) for visual analysis and to ensure spatial distribution. A boxplot and a probability plot of the drainage areas of the proposed sites (figs. 25-26) indicated a good symmetrical and normal distribution of this variable.

The proposed streamflow-gaging network consists of 48 sites (table 8, fig. 24). Only two sites are currently active and another site is used for collecting seasonal streamflow record. For the southwest network, the Kuskokwim River (No. 157 on fig. 24) (more than 40 years of record) and the Nushagak River (134) (more than 15 years of record) would serve as index stations. In addition, three new sites—the Togiak (140), North Fork Kuskokwim (141), and Big (144) Rivers—would provide spatial distribution and would also serve as index stations.

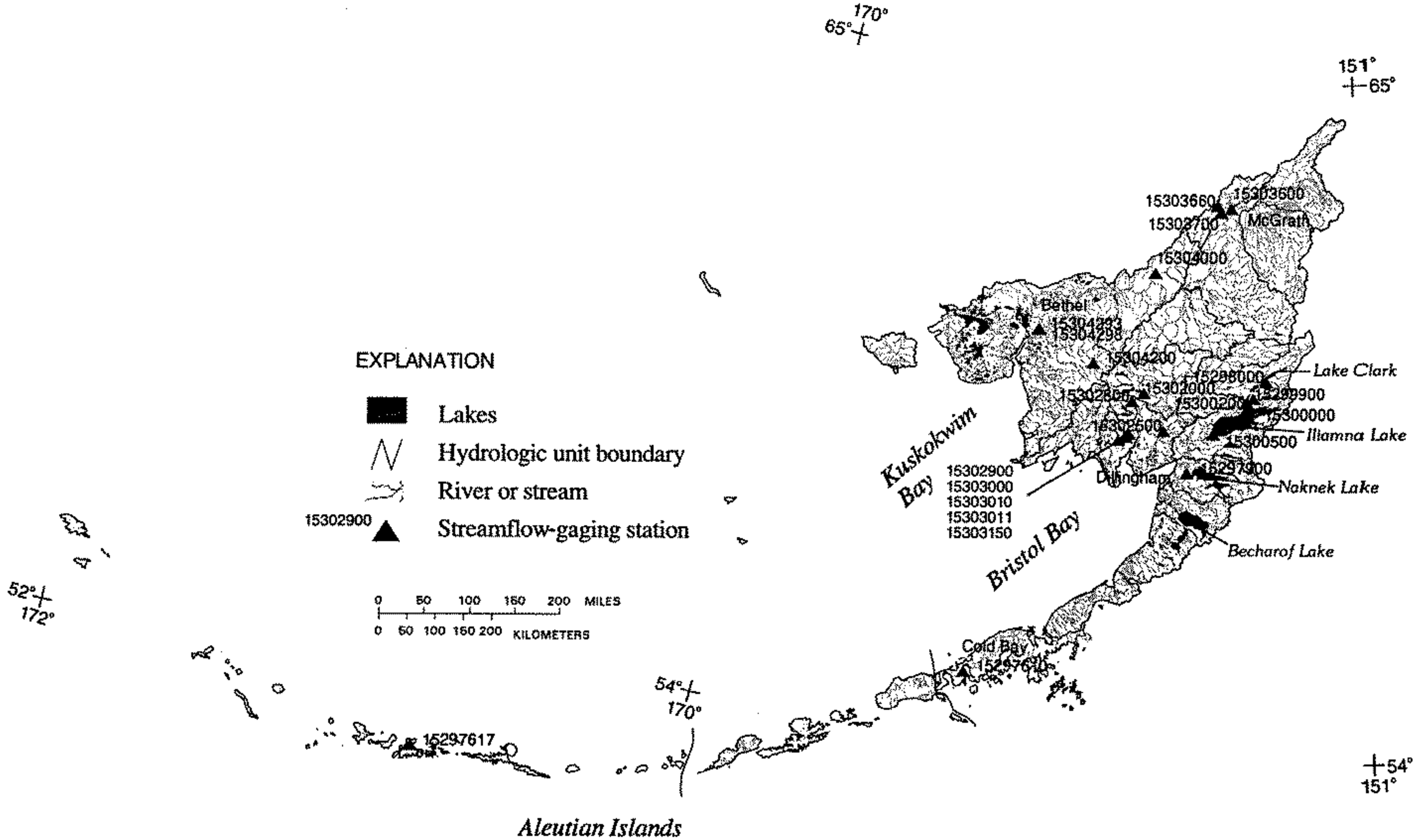


Figure 20. Southwest Alaska and locations of past and current streamflow-gaging stations.

Table 7. Streamflow data available for Southwest Alaska

Station No.	Station name	Flow data available			Remarks
		Peak	Average	Low	
15297617	Sweeper Creek at Adak	X	X	X	Less than 5 years
15297610	Russell Creek at Cold Bay	X	X	X	Less than 5 years, discontinued
15297900	Eskimo Creek at King Salmon	X	X	X	Discontinued gsging station
15298000	Tanalian River near Port Alsworth		X		Outlet of Lake Kontrashibuna, discontinued
15299900	Tazimina River near Nondalton		X		Discontinued gaging station
15300000	Newhalen River near Iliamna	X	X	X	Outlet of Lake Clark, discontinued
15300200	Roadhouse Creek near Iliamna	X			Crest stage gage, discontinued
15300500	Kvichak River at Igiugig	X	X	X	Outlet of Lake Iliamna, discontinued
15302000	Nuyakuk River near Dillingham	X	X	X	Outlet of Tikchik Lake, active
15302500	Nushagak River at Ekwok	X	X	X	Discontinued gaging station
15302800	Grant Lake outlet near Aleknagik		X		Outlet of Grant Lake, discontinued
15302900	Moody Creek at Aleknagik	X			Crest stage gage, active
15303000	Wood River near Aleknagik	X	X	X	Outlet of Lake Aleknagik, discontinued
15303010	Silver Salmon Creek near Aleknagik	X			Crest stage gage, active
15303011	Wood River trib near Aleknagik	X			Crest stage gage, active
15303150	Snake River near Dillingham	X	X	X	Outlet of Lake Nunavaugaluk, discontinued
15303600	Kuskokwim River at McGrath	X	X	X	Discontinued gaging station
15303660	Gold Creek at Takotna	X			Crest stage gage, active
15303700	Tatalina River near Takotna	X			Crest stage gage, active
15304000	Kuskokwim River at Crooked Creek	X	X	X	Discontinued gaging station
15304200	Kisaralik River near Akiak	X	X	X	Discontinued gaging station
15304293	Browns Creek near Bethel	X			Crest stage gage, discontinued
15304298	Browns Creek at Bethel	X			Crest stage gage, discontinued
TOTAL		18	14	10	

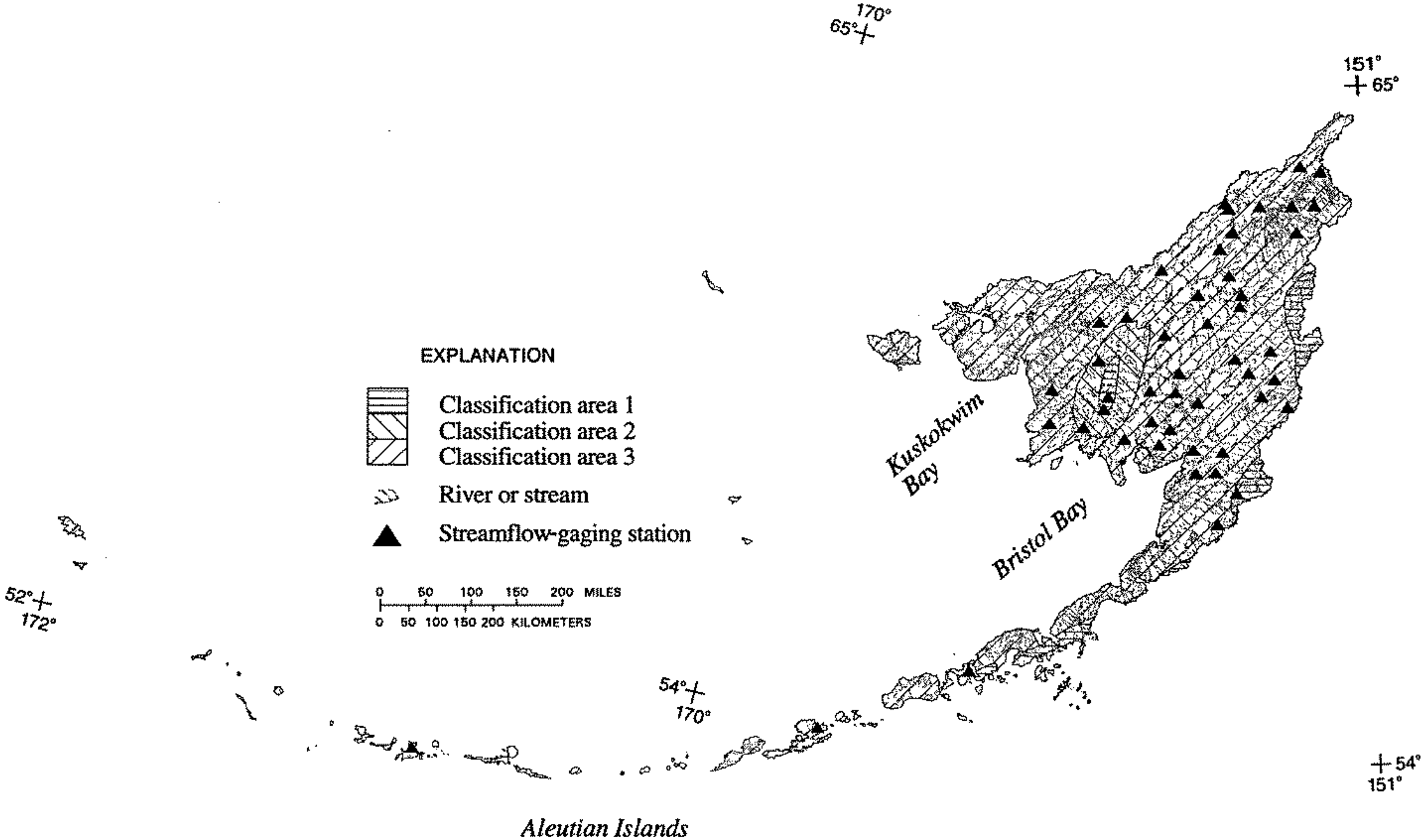


Figure 21. Proposed streamflow-gaging network and classification areas for Southwest Alaska.

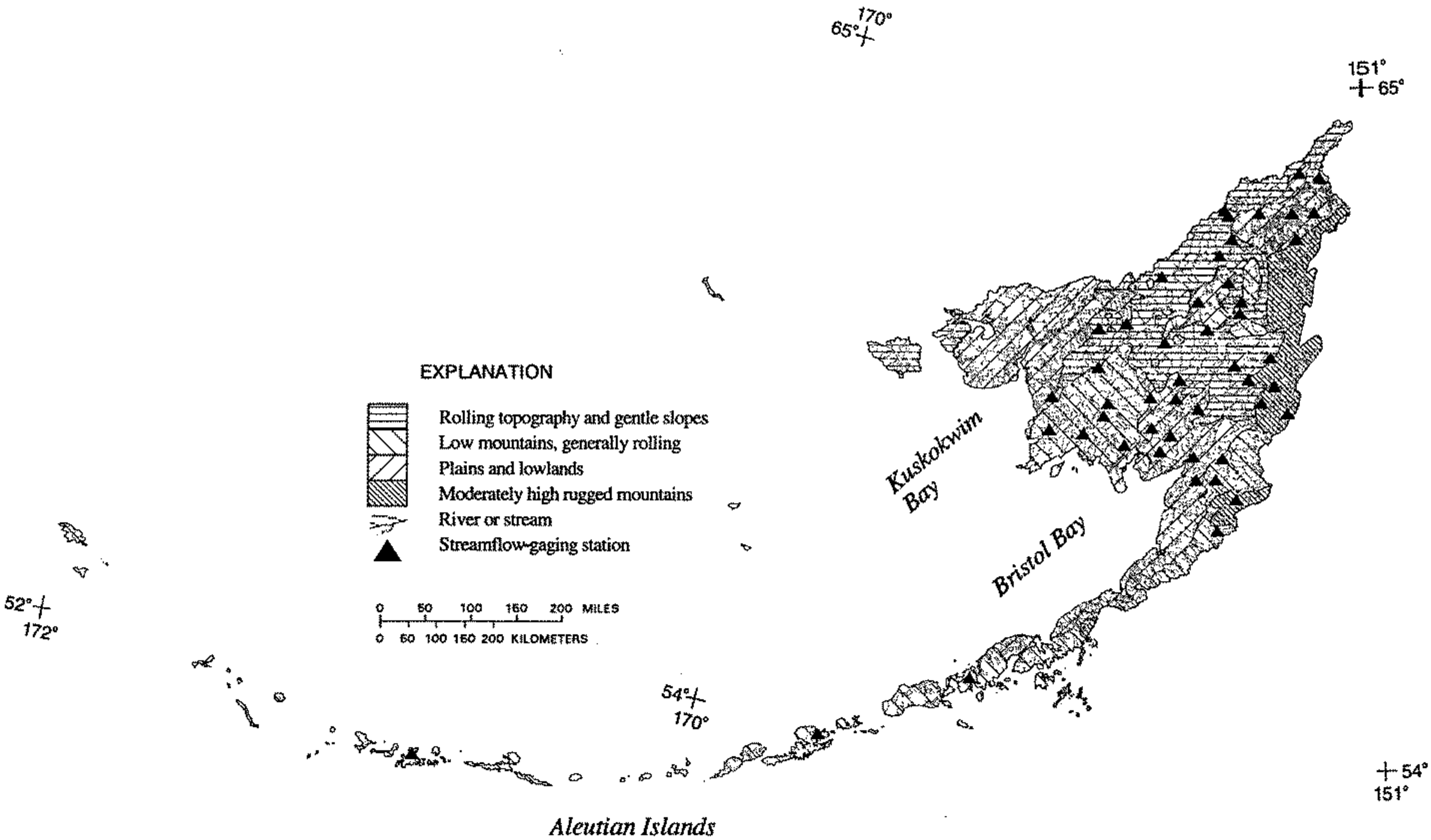


Figure 22. Proposed streamflow-gaging network and physiographic regions for Southwest Alaska (from Wahrhaftig, 1965).

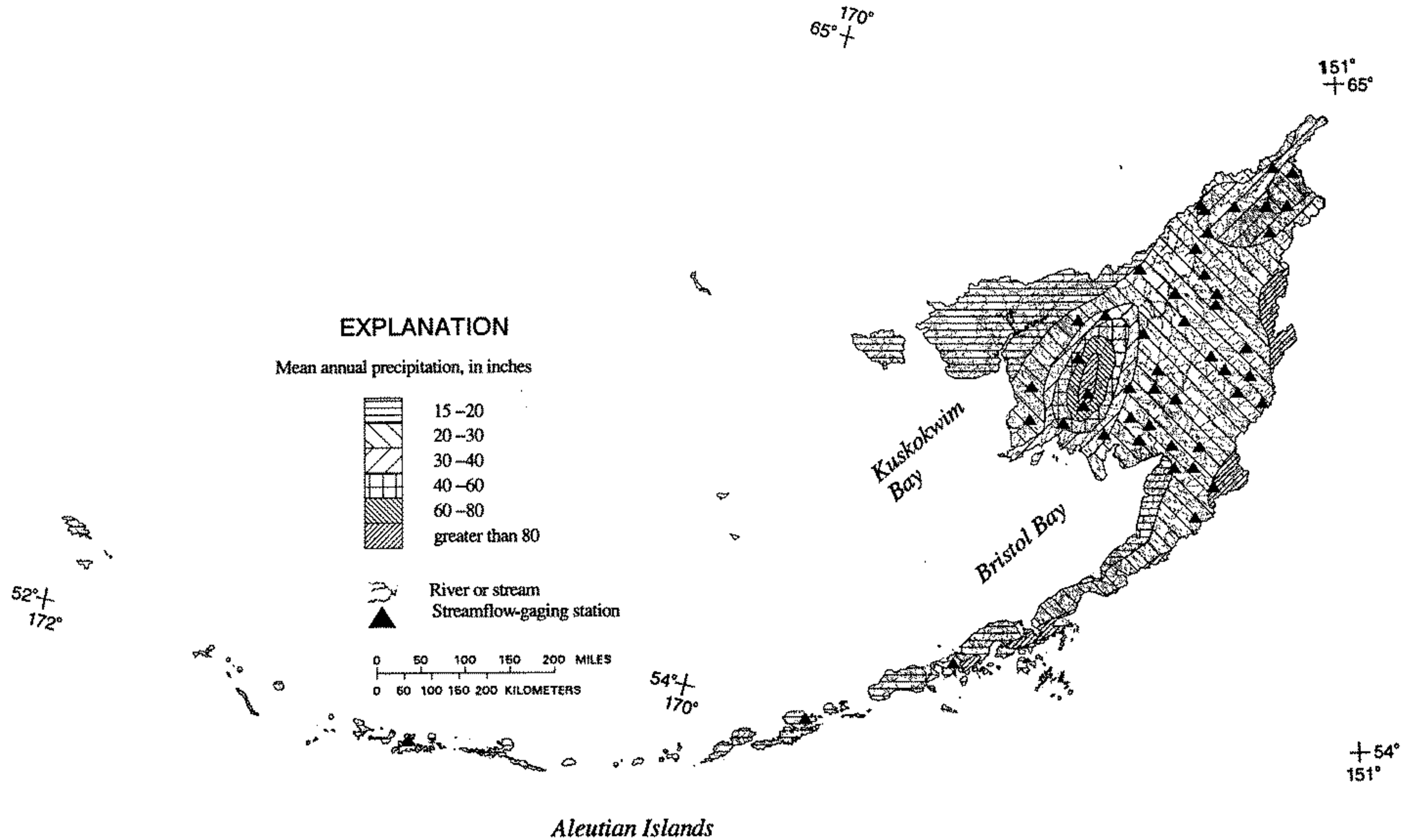


Figure 23. Proposed streamflow-gaging network and precipitation areas for Southwest Alaska (from Jones and Fahl, 1994).

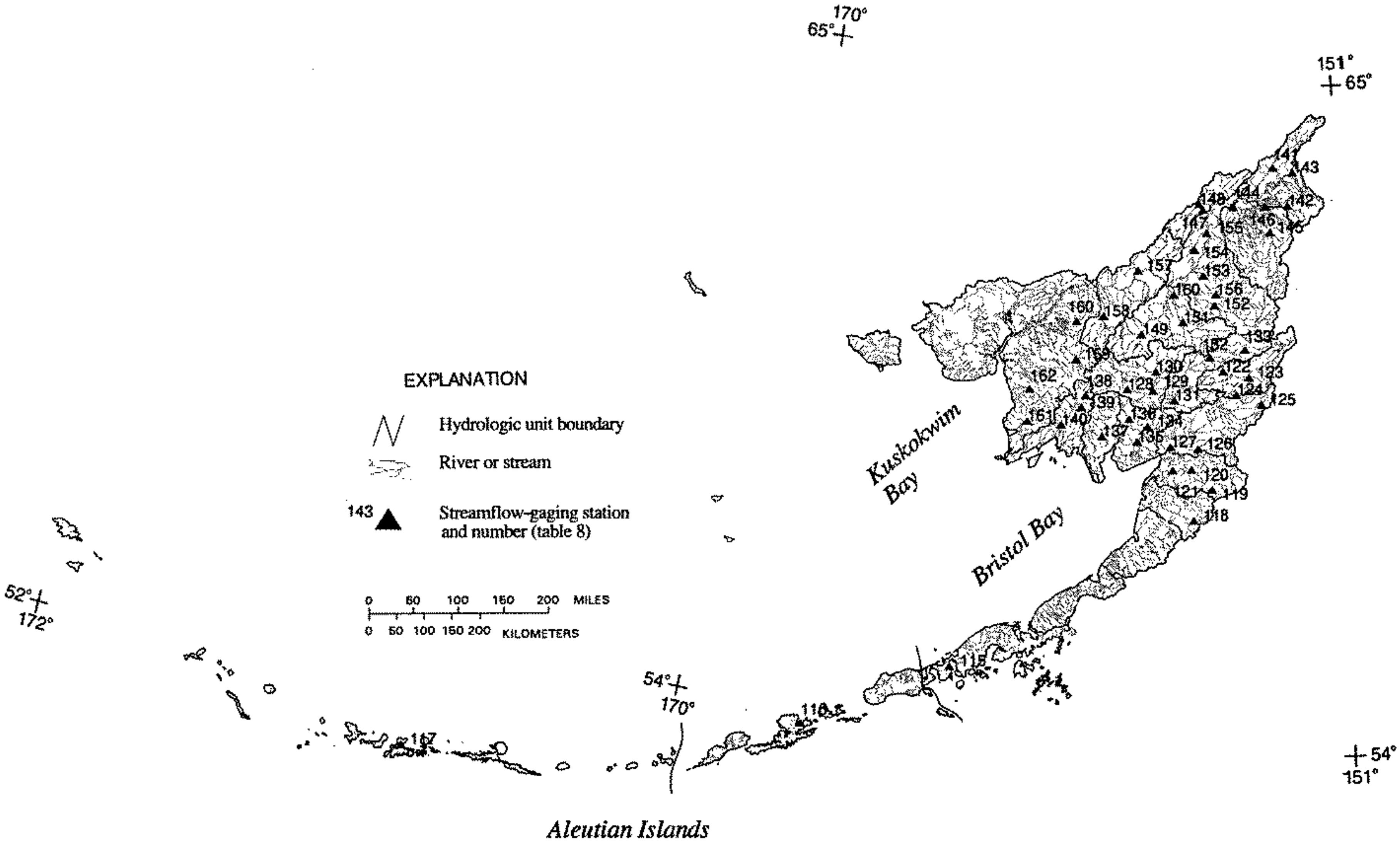


Figure 24. Proposed streamflow-gaging network and hydrologic unit boundaries for Southwest Alaska.

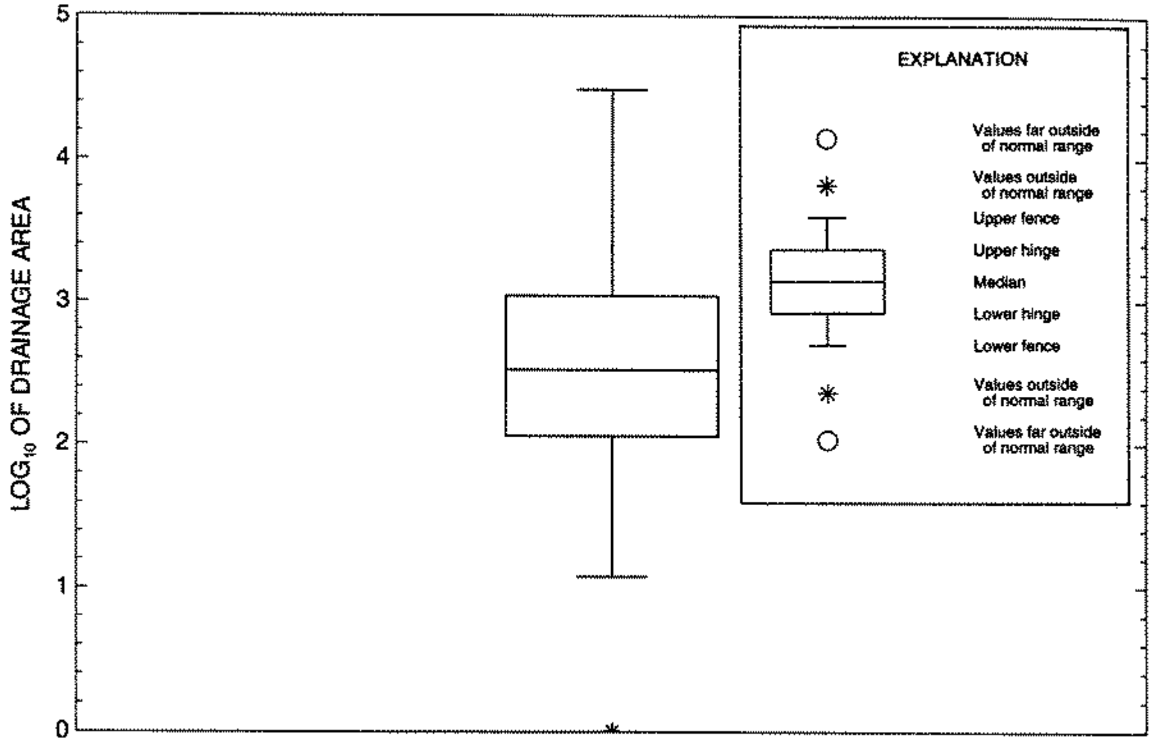


Figure 25. Boxplot of drainage areas of proposed streamflow-gaging stations for Southwest Alaska.

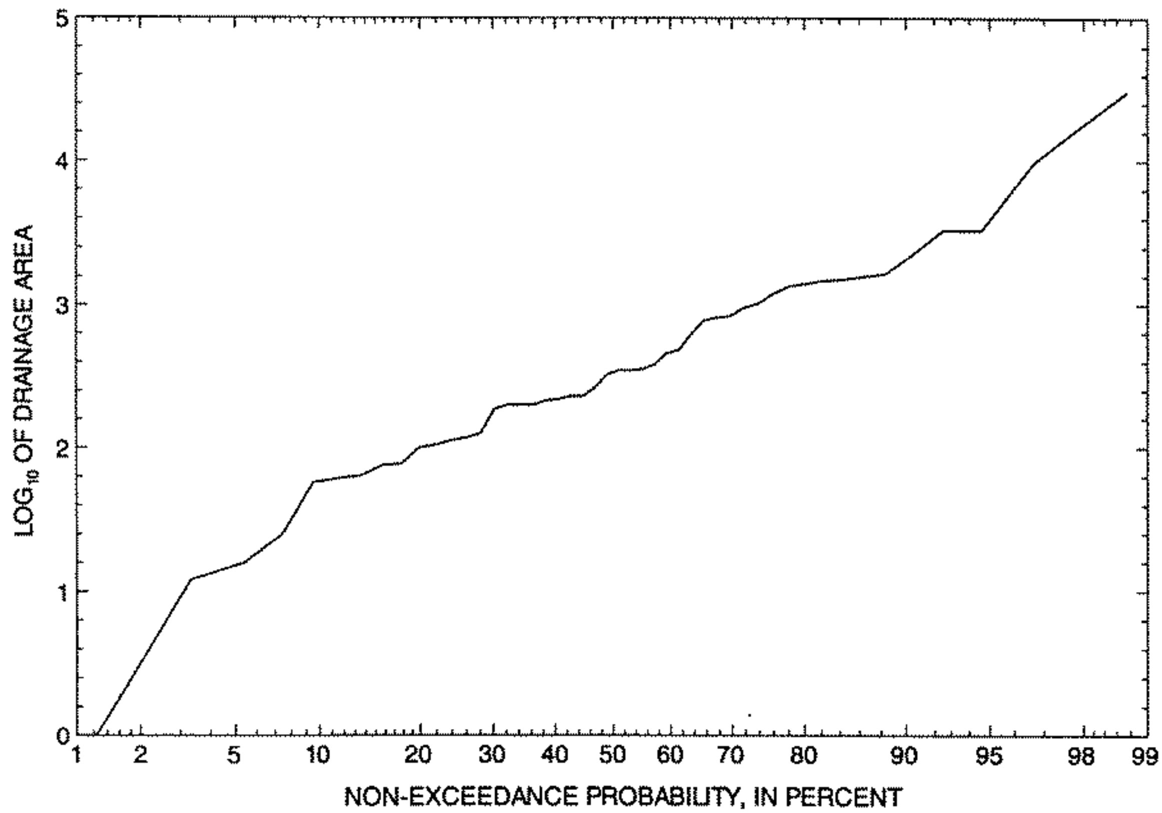


Figure 26. Probability plot of drainage areas of proposed streamflow-gaging stations for Southwest Alaska.

Table 8. Proposed streamflow-gaging network, Southwest Alaska
[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 24)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
115	19030101	4,270	Russell Creek (15297610)	55°10'50"162°41'08"	25.0
116	19030102	3,670	Nateekin River	53°54'00"166°31'48"	75.0
117	19030103	2,530	Sweeper Creek (15297612)	51°52'38"176°39'39"	1.00
	19030104	79.0	Pribilof Islands		
	19030201	2,670			
	19030202	3,610			
118	19030203	3,010	Kejulik River	57°51'36"155°54'22"	200
119	19030204	4,040	Knife Creek	58°22'16"155°22'09"	118
120			Eskimo Creek (15297900)	58°41'08"156°00'80"	16.1
121			Naknek River	58°39'37"156°36'58"	3,360
122	19030205	3,530	Koksetna River	60°17'08"155°05'23"	228
123			Tanalian River(15298000)	60°11'20"154°15'30"	200
124			Tazimina River (15299000)	59°55'05"154°39'34"	327
125	19030206	5,910	Iliamna River	59°45'12"153°50'37"	127
126			Nonvianuk River	59°01'17"155°50'24"	383
127			Alagnak River	59°02'06"156°43'36"	1,020
128	19030301	5,000	Nuyakuk River (15302000)	59°56'08"158°11'16"	1,490
129			Harris Creek	59°56'23"157°22'28"	57.8
130			King Salmon River	60°14'42"157°18'01"	1,670
131	19030302	4,290	Stuyahok River	59°47'33"156°39'38"	198
132			Mulchatna River	60°30'23"155°32'39"	1,520
133			Chilikadrotna River	60°38'38"154°23'48"	221
134	19030303	3,420	Nushagak River (15302500)[1]	59°20'57"157°28'23"	9,850
135			Iowithla River	59°05'37"157°46'24"	185
136			Kokwok River	59°27'23"158°04'27"	347
137	19030304	2,780	Snake River (15303150)	59°08'54"158°53'14"	100
138	19030305	3,540	Trail Creek	59°47'27"159°30'30"	227
139			Bruin Creek	59°35'24"159°36'49"	12.0
140			Togiak River[1]	59°16'44"160°11'48"	1,410
141	19030401	5,110	North Fork Kuskokwim River[1]	63°34'47"153°28'51"	615
142			Tonzona River	62°57'21"152°57'08"	346
143			Highpower Creek	63°29'41"152°44'37"	213
144	19030402	6,110	Big River[1]	62°56'14"154°52'15"	1,340

Table 8. Proposed streamflow-gaging network, Southwest Alaska--Continued

[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 24)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
145			South Fork Kuskokwim River	62°32'02"153°35'01"	1,600
146			South Fork Tonzona River	62°56'35"153°44'23"	104
147	19030403	2,230	Tatalina River (15303700)	62°53'06"155°56'22"	76.9
148			Takotna River	62°58'08"156°05'18"	823
149	19030404	6,430	Kogrukluk River	60°49'57"157°50'44"	778
150			Elutuli Creek	61°30'29"156°49'46"	112
151			Hoholitna River	61°03'49"156°28'39"	2,220
152	19030405	9,360	Stony River	61°21'09"155°25'49"	3,350
153			Cheeneetnuk River	61°49'54"155°50'53"	474
154			Rohn River	62°14'45"156°11'00"	62.1
155			Selatna River	62°31'03"155°47'12"	352
156			Swift River	61°31'55"155°23'41"	946
157	19030501	6,260	Kuskokwim River (15304000)[1]	61°52'16"158°06'03"	31,100
158			Aniak River	61°05'29"159°08'44"	1,200
159	19030502	22,600	Kisaralik River (15304200)	60°21'10"159°55'00"	265
160			Tuluksak River	60°58'28"160°01'34"	65.1
161			Goodnews River	59°17'09"161°16'20"	458
162			Kanektok River	59°48'52"161°18'56"	819
	19060503	1,730	Nelson Island		

[1]Index station

Southcentral Alaska

Southcentral Alaska is approximately 80,000 mi^2 in area, and is characterized by rugged mountainous terrain, glaciers, and extensive coastal areas (fig. 27). This region lies between the crest of the Alaska and Aleutian Ranges and the Gulf of Alaska; it includes Kodiak Island (Alaska's largest island) and several smaller islands. Streams and rivers flow into the Gulf of Alaska and the Pacific Ocean from Stepovak Bay to the west and the Copper River Delta to east. The two principal river basins, the Copper and Susitna (fig. 1), cover 56 percent of the subregion. Several national parks and the Chugach National Forest are located in this region. More than half the State's population resides in Southcentral Alaska. In 1982, a report prepared by the Alaska Water Study Committee "Anticipating Water and Related Land Resources Needs" detailed many of the water-resources problems and needs of Southcentral Alaska. Some of the more notable problems were instream flow requirements, flood-plain management, water supply, water quality, fish and wildlife, recreation, and navigation. These factors were taken into consideration in evaluating the streamflow-gaging network in this region.

In 1995, the streamflow-gaging network in southcentral Alaska consisted of 13 gaging stations located on rivers that drain primarily undeveloped land. Another 11 gaging stations are located at three hydropower sites: Bradley Lake near Homer, Terror Lake near Kodiak, and Solomon Gulch near Valdez. In addition, 24 crest-stage gages are used to record peak stages on small streams (table 9).

An adequate data base exists in southcentral Alaska to use the GLS and network analysis procedures. For the GLS procedures, 120 sites were available for peak-flow analysis and 72 sites were available for average flow and low flow analysis (fig. 27; appendix 1). Results of the GLS procedure (table 10) indicated that the most significant variables at the 5 percent level were drainage area (all equations), precipitation (peak-flow and average-flow equations), area of lakes and ponds (peak-flow equation), and mean basin elevation (low-flow equation). The equation for average discharge had the lowest standard error of prediction, whereas the equation for the 7-day, 10-year low flow had the highest standard error of prediction. The model error of all three equations is significantly higher than the respective sampling error.

In choosing additional gaging stations for the network, several items were considered. Southcentral Alaska encompasses most of Alaska's population. Because many communities, such as Seward, are in low-lying areas subject to flooding, some gaging stations were chosen to provide both regional and flood-warning information. Considerably more information is needed on the Kenai River, which is the most popular sports-fishing river in Alaska and is under pressure from many different competing interests. Thus, some sites in the Kenai River basin were chosen to provide both regional information and information for managers of the river. Sites in areas of the Copper River basin that have little or no streamflow information were also selected. Requests from various organizations were considered, and discontinued stations that had between 5 and 10 years of record were considered as potential new stations.

Twelve new sites were selected to cover gaps in areal coverage, and the network analysis procedure was performed. By adding these new sites as well as reactivating 11 gaging stations, the sampling error for all three equations could be lowered (fig. 28). The sampling error for the peak-flow equation would be reduced slightly, from 14 to 17 percent. Sampling errors for the average discharge and for the low-flow equation would be reduced to a greater extent: from 2 percent to 12

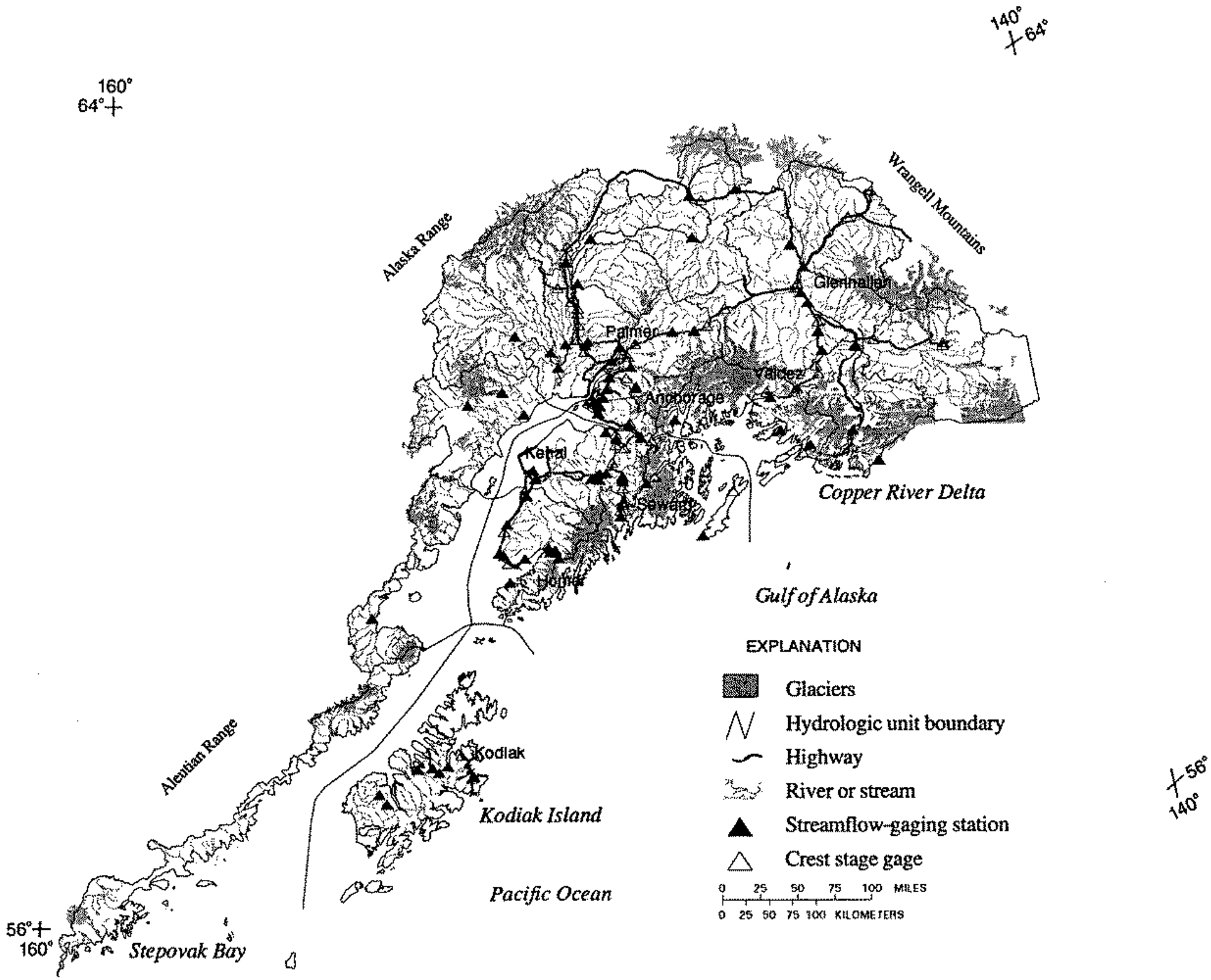


Figure 27. Current and historic streamflow-gaging stations used in network analysis for Southcentral Alaska.

Table 9. Active streamflow-gaging stations and crest stage gages, 1995 water year, Southcentral Alaska

Station No.	Station name	Station No.	Station name
	Current streamflow-gaging station		Crest stage gage
15214000	Copper River at Million Dollar Bridge near Cordova[1]	15198500	Station Creek near Mentasta
15216000	Power Creek near Cordova	15201000	Dry Creek near Glennallen
15236000	Hobo Creek near Whittier[1]	15210025	McCarthy Creek at McCarthy
15237360	San Juan River near Seward[1]	15211700	Strelna Creek near Chitina
15238600	Spruce Creek near Seward	15211900	O'Brien Creek near Chitina
15258000	Kenai River at Cooper Landing	15212500	Boulder Creek near Tiekel
15266300	Kenai River at Soldotna	15227500	Mineral Creek near Valdez
15272280	Portage Creek at lake outlet near Whittier[1]	15236200	Shakespeare Creek at Whittier
15276000	Ship Creek near Anchorage	15237550	Mount Alice Creek near Seward
15290000	Little Susitna River near Palmer	15237900	Glacier Creek at Bruce Road near Seward
15292000	Susitna River at Gold Creek	15238010	Salmon Creek at highway bridge near Seward
15292700	Talkeetna River near Talkeetna	15238400	Rudolph Creek at Seward
15294900	Paint River near Kamishak[1]	15239500	Fritz Creek near Homer
		15272530	California Creek at Girdwood
	Station not used in network analysis because of hydropower regulation	15281500	Camp Creek near Sheep Mountain
15225996	Solomon Gulch Tailrace near Valdez	15282400	Purinton Creek near Sutton
15225997	Solomon Gulch at top of falls near Valdez	15283500	Eska Creek near Sutton
15225998	Solomon Gulch bypass near Valdez	15285000	Wasilla Creek near Palmer
15226000	Solomon Gulch near Valdez	15290200	Nancy Lake tributary near Willow
15238648	Upper Nuka River near park boundary near Homer	15291100	Raft Creek near Denali
15238978	Battle Creek Diversion above Bradley Lake near Homer	15294025	Moose Creek near Talkeetna
15238990	Upper Bradley River near Nuka Glacier near Homer	15297200	Myrtle Creek near Kodiak
15239000	Bradley River below dam near Homer		
15239050	Middle Fork Bradley River near Homer		
15239070	Bradley River near tidewater near Homer		
15295700	Terror River at mouth near Kodiak		

[1]less than 10 years of record

percent and from 4 percent to 24 percent, respectively. This proposed network (table 11, fig. 29) would consist of 40 stations. The Little Susitna River (No. 196 on fig. 29) and Power Creek (174) gaging stations, each of which have more than 40 years of record, would serve as two index stations for this region. In addition, gaging stations on the Talkeetna River (192) (more than 30 years of record), the Kenai River near Soldotna (185), the Gulkana River (164), and the Chitina River (169) would also serve as index stations.

Table 10. Equations produced and statistics used by the GLS analysis for Southcentral Alaska
[Discharge is in cubic feet per second; $(\log_{10})^2$, $\log_{10}$ units squared]

Equation	Standard error of prediction (percent)	Model error $[(\log_{10})^2]$	Sampling error $[(\log_{10})^2]$
$Q_{50} = 2.20\,(AREA)^{0.846}(PRECIP)^{1.01}(ST+1)^{-0.208}$	48	.0385	.0022
$Q_{ave} = 0.024(AREA)^{1.025}(PRECIP)^{1.186}$	37	.0237	.0011
$Q_{7,10} = 2.417(AREA)^{0.980}(ELEV)^{-0.302}$	75	.1054	.0049

Statistics of basin characteristics

Variable	Basin characteristic	Maximum	Minimum	Mean	Median
Q_{50} (50-year peak discharge; 120 sites)					
AREA	Drainage area	20,600 mi^2	0.7 mi^2	791 mi^2	32.6 mi^2
PRECIP	Precipitation	220 in.	10.0 in.	57.4 in.	40.0 in.
ST[1]	Area of lakes and ponds	16 percent	0 percent	2.4 percent	1.0 percent
Q_{ave} (Average discharge; 72 sites)					
AREA	Drainage area	20,600 mi^2	1.5 mi^2	1,200 mi^2	70.5 mi^2
PRECIP	Precipitation	220 in.	15.0 in.	60 in.	50.0 in.
$Q_{7,10}$ (7-day, 10-year low flow; 72 sites)					
AREA	Drainage area	20,600 mi^2	1.5 mi^2	1,200 mi^2	70.5 mi^2
ELEV	Mean basin elevation	4,590 ft	140 ft	2,526 ft	2,670 ft

[1]The value 1.0 is added to avoid a zero value

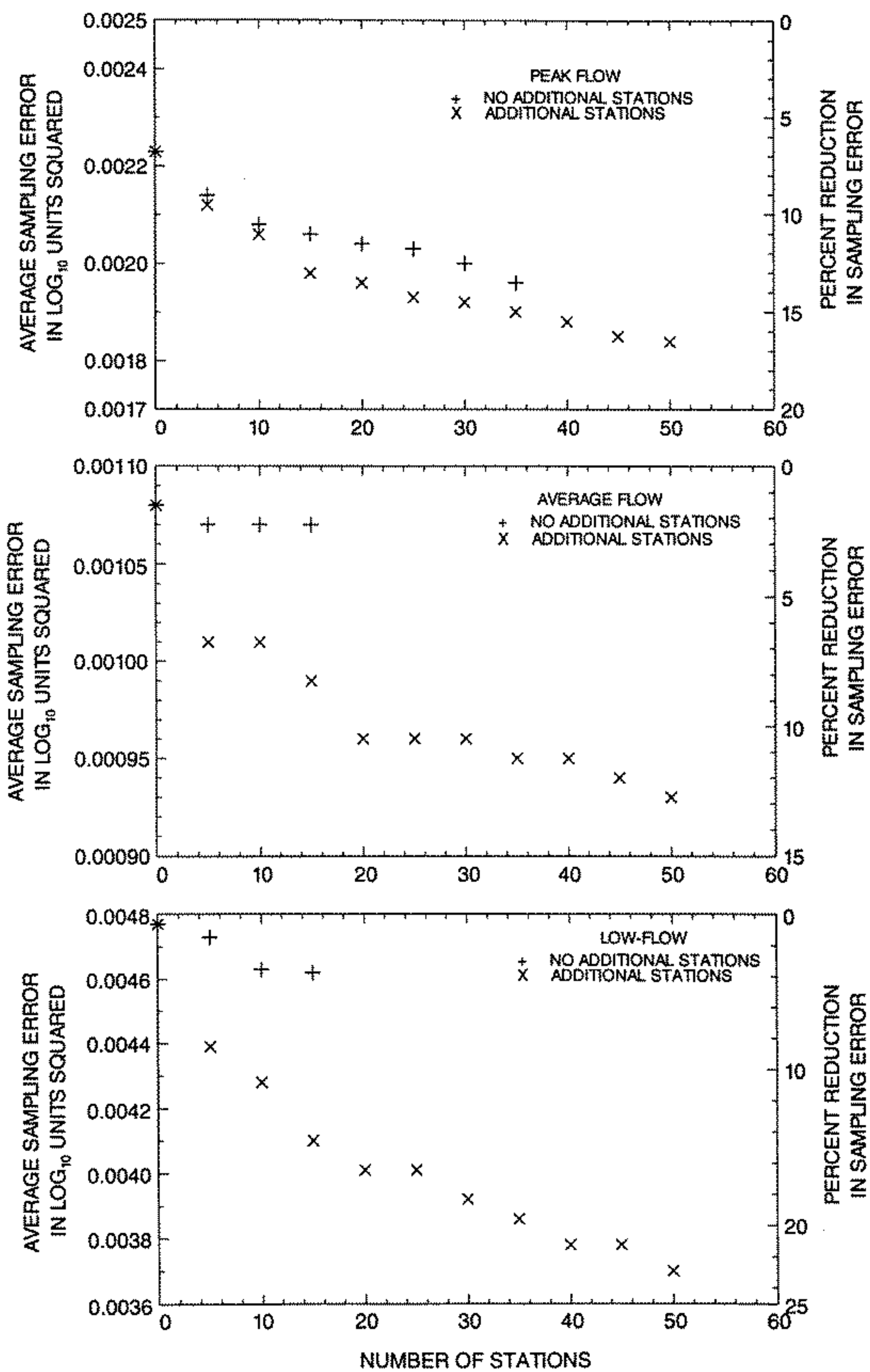


Figure 28. Results of network analysis for Southcentral Alaska with and without additional streamflow-gaging stations.

Table 11. Proposed streamflow-gaging network, Southcentral Alaska

[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 29)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
163	19020101	4,480	Chistochina River	62°36'10"144°38'15"	610
164	19020102	8,170	Gulkana River (15200280)[1]	62°31'15"145°31'51"	1,770
165			Little Nelchina River (15201100)	61°59'17"147°00'34"	7.81
166			Little Tonsina River (15207800)	61°28'49"145°09'05"	22.7
167	19020103	6,710	May Creek (15209100)	61°20'42"142°41'49"	10.4
168			Tana River	61°11'22"142°50'11"	500
169			Chitina River[1]	61°30'31"144°18'31"	8,000
170			Kennicott River	61°26'03"142°55'27"	352
171	19020104	4,260	Tiekel River	61°13'13"144°52'53"	282
172			Tasnuna River	61°01'33"144°57'15"	351
173			Copper River (15214000)	60°40'18"144°44'41"	24,200
174	19020201	3,950	Power Creek (15216000)[1]	60°35'14"145°37'05"	20.5
175			Hobo Creek (15236000)	59°49'05"147°53'00"	5.53
176			Mineral Creek (15227500)	61°08'30"146°21'42"	44.0
177	19020202	3,580	San Juan River (15237360)	60°57'42"148°14'19"	12.4
178			Spruce Creek (15238600)	60°04'10"149°27'08"	9.26
179			Resurrection River	60°11'34"149°35'17"	160
180	19020301	2,710	Deep Creek	60°01'50"151°40'50"	220
181	19020302	3,860	Snow River (15243900)	60°17'11"149°20'19"	128
182			Kenai River (15258000)	60°29'34"149°48'28"	634
183			Russian River (15264000)	60°27'10"149°59'05"	61.8
184			Funny River	60°29'25"150°55'13"	132
185			Kenai River (15266300)[1]	60°28'39"151°04'46"	2,010
186	19020401	1,030	Portage Creek (15272280)	60°48'56"148°56'03"	40.5
187			Ship Creek (15276000)	61°13'32"149°38'06"	90.5
188	19020402	3,700	East Fork Eklutna Creek (15277600)	61°18'44"148°57'12"	38.2
189			Matanuska River (15284000)	61°36'34"149°04'16"	2,070
190	19020501	6,280	Susitna River (15291000)	63°06'14"147°30'57"	950
191			Susitna River (15292000)	62°46'04"149°41'28"	6,160
	19020502	2,590			
192	19020503	2,020	Talkeetna River (15292700)[1]	62°20'49"150°01'01"	2,010
193	19020504	6,140	Yentna River (15294345)	61°41'55"150°39'02"	6,180

Table 11. Proposed streamflow-gaging network, Southcentral Alaska--Continued
[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 29)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
194	19020505	3,700	Deception Creek (15294010)	61°44'52"149°56'14"	48.0
195			Deshka River (15294100)	61°46'05"150°20'13"	592
196			Little Susitna River (15290000)[1]	61°42'32"149°13'36"	61.9
197	19020601	4,180	Capps Creek (15294410)	61°19'45"151°39'56"	10.5
198			Drift River	60°34'16"152°45'48"	149
199	19020602	3,090	Paint River (15294900)	59°09'19"154°15'33"	205
200			Johnson River	60°04'00"152°40'00"	30.0
201	19020701	4,930	Upper Thumb River (15296550)	57°21'03"153°58'04"	18.8
202	19020702	9,410	Aniakchak River	56°47'25"157°36'16"	85.0

[1]Index station

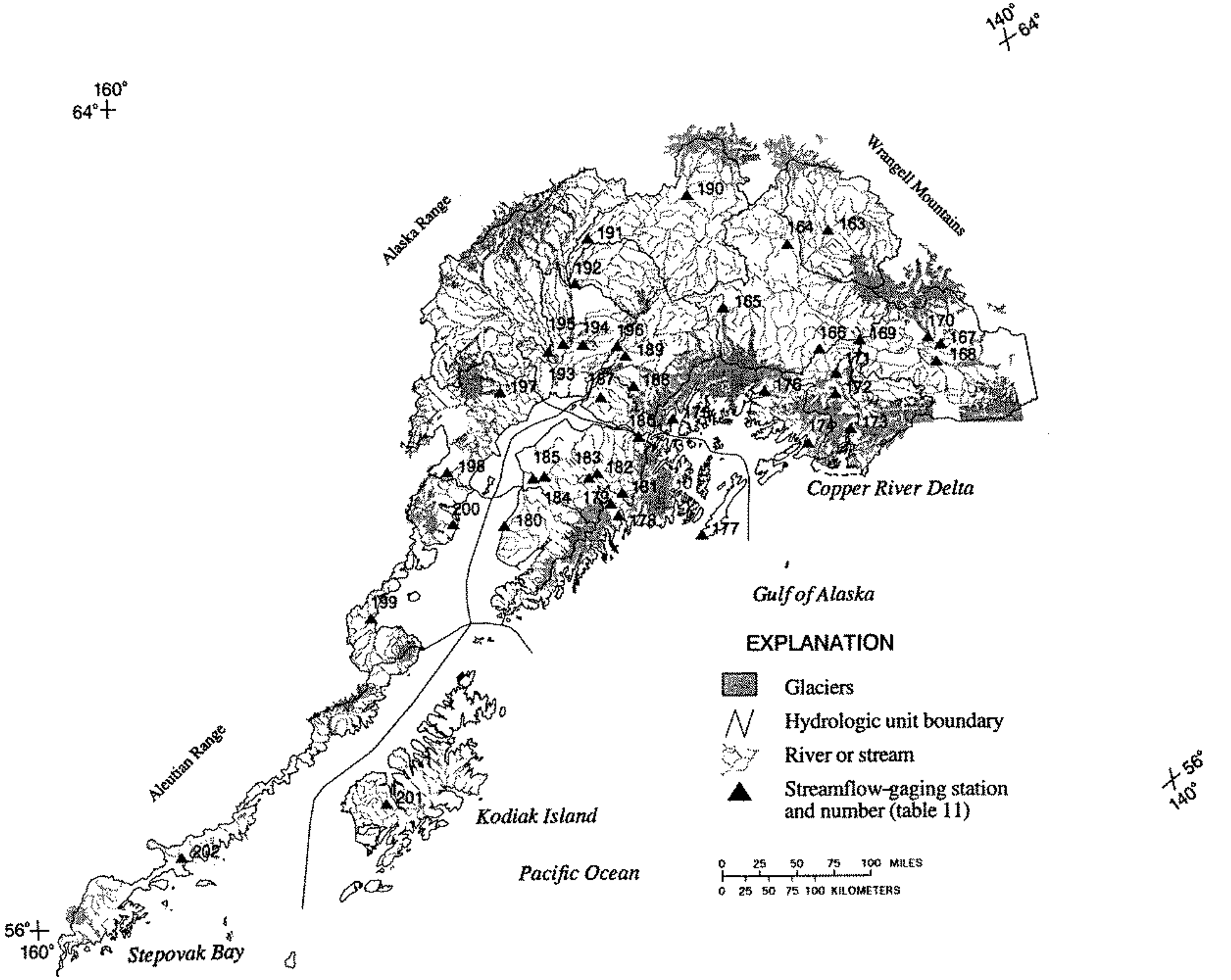


Figure 29. Proposed streamflow-gaging network for Southcentral Alaska.

Southeast Alaska

Southeast Alaska encompasses the mountainous, glaciated southeastern panhandle of Alaska and includes hundreds of islands, which constitute 37 percent of the region's area. The region covers an area of approximately 40,000 mi^2, much of which consists of drainage basins less than 200 mi^2; however, basins such as the Stikine and Alsek Rivers which originate in Canada are larger. The Tongass National Forest covers about 90 percent of southeast Alaska. Water-resources needs in Southeast Alaska are primarily related to logging activities in this forest and to maintaining sufficient flow for fish habitat. In recent years, water managers have expressed interest in the possibility of exporting water from Southeast to areas having water shortages.

A sufficient data base exists in Southeast Alaska to utilize the GLS and network analysis procedures. Streamflow data were available from 100 gaging stations for analysis of the 50-year peak flow and from 83 gaging stations for analysis of average annual and low flows (fig. 30; appendix 2). Currently, 19 streamflow-gaging stations are operating in southeast Alaska (table 12). Of these 19 sites, 3 sites are affected either by urbanization or hydropower, and 9 sites have been operated for less than 10 years.

Results of the GLS procedures (table 13) indicated that the most significant variables at the 5 percent level were drainage area (all four equations), precipitation (peak-flow and average-flow equations), area of lakes and ponds (peak-flow and both low-flow equations), mean minimum January air temperature (peak-flow equation), area of glaciers (low-flow equation for April to September), and mean basin elevation (low-flow equation for April to September). The equation for average discharge had the lowest standard error of prediction, whereas the two low-flow equations had the highest standard error of prediction. The model error in all four equations was significantly higher than the sampling error.

The network analysis program was run assuming there would be no change in the operation of the current network and also with additional stations added. New stations were selected by consultation with the U.S. Forest Service, National Park Service, and by visual analysis of figure 30.

The results of the network analysis runs (fig. 31) indicate that operation of the current network would reduce the sampling errors of the equations from about 15 percent (average-flow equation and low-flow equation for October to March) to about 40 percent (peak-flow equation). This is not unexpected, because more than half the stations currently being operated have less than 10 years of record. Additional gaging stations would not have any significant effect on the sampling error for the average discharge equation. However, additional stations would reduce the sampling error slightly for the peak discharge equation (40 to 44 percent) and for the low-flow equations (15 to 20 percent and 20 to 24 percent).

The proposed network (fig. 32, table 14) would consist of a net gain of eight sites, of which six would be re-activated gaging stations. Two of the sites would be new stations while two stations—Hamilton Creek near Kake and Kadashan River above Hook Creek near Tenakee—would be discontinued. The remaining sites have some record, but generally it is less than 10 years. Three sites would serve as index stations: Indian Creek near Sitka (No. 211 on fig. 32), Harding River near Wrangell (203), and Fish Creek near Ketchikan (204).

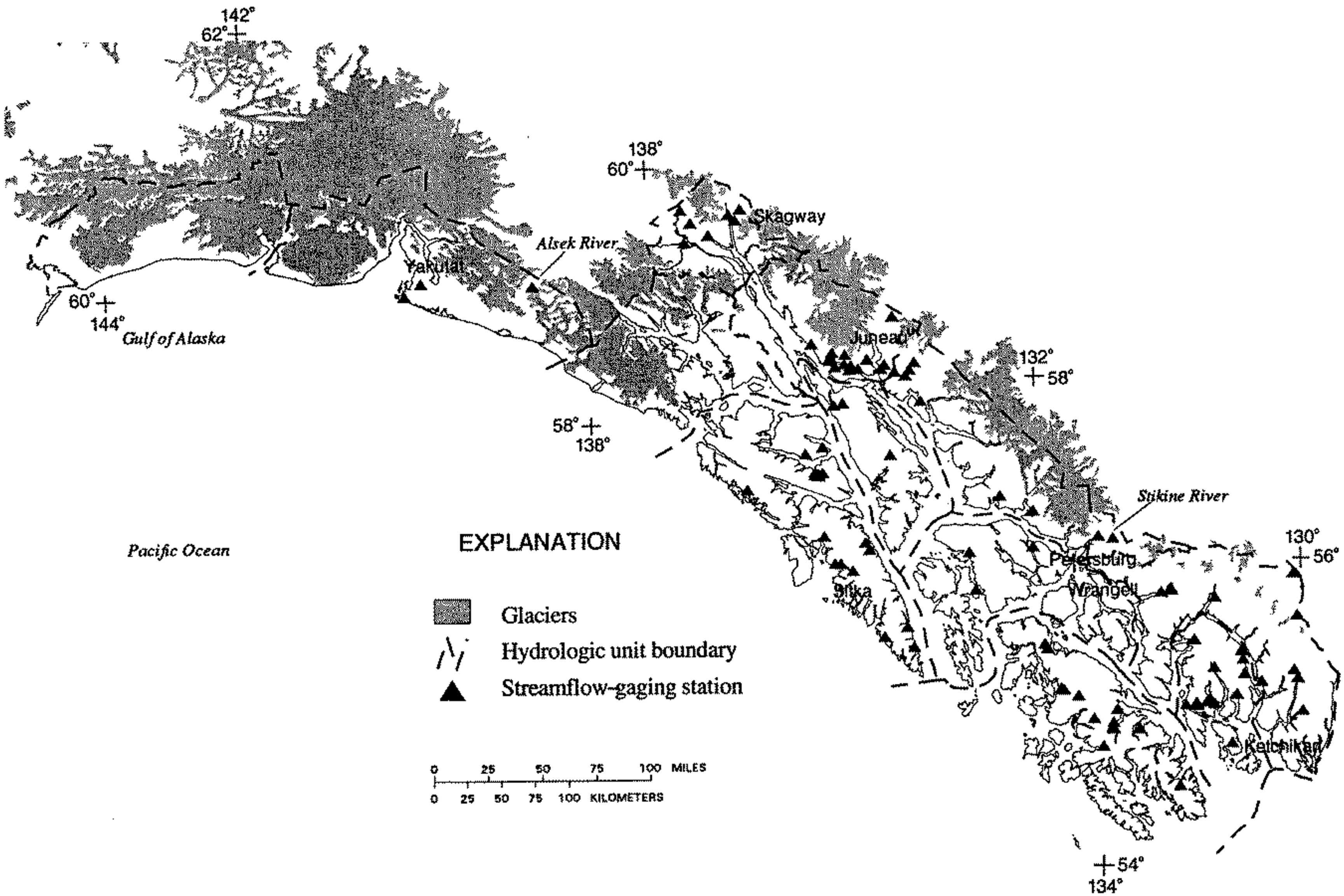


Figure 30. Current and historic streamflow-gaging stations used in network analysis for Southeast Alaska.

Table 12. Active streamflow-gaging stations, 1995 water year, Southeast Alaska

Station No.	Station name
15019990	Tyee Lake outlet near Wrangell[1]
15022000	Harding River near Wrangell
15024800	Stikine River near Wrangell
15039900	Dorothy Lake outlet near Juneau[2]
15041200	Taku River near Juneau[2]
15049900	Gold Creek near Juneau
15051010	Salmon Creek near Juneau[1]
15053200	Duck Creek near Auke Bay[1]
15056095	Goat Lake outlet near Skagway[2]
15056280	Upper Chilkoot Lake outlet near Haines[2]
15072000	Fish Creek near Ketchikan
15081495	North Fork Staney Creek near Klawock[2]
15081497	Staney Creek near Klawock[2]
15085100	Old Tom Creek near Kasaan
15087570	Hamilton Creek near Kake
15106920	Kadashan River above Hook Creek near Tenakee
15129000	Alsek River near Yakutat[2]
15129500	Situk River near Yakutat[2]
15129600	Ophir Creek near Yakutat[2]

[1]Station not used in GLS analysis because of man-made diversion or urbanization

[2]Station not used in GLS analysis because length of record is less than 10 years

Table 13. Equations produced and statistics used by the GLS analysis for Southeast Alaska
[Discharge is in cubic feet per second; $(\log_{10})^2$, $\log_{10}$ units squared]

Equation	Standard error of prediction (percent)	Model error $[(\log_{10})^2]$	Sampling error $[(\log_{10})^2]$
$Q_{50} = .080(AREA)^{0.809}(PRECIP)^{0.651}(ST+1)^{-0.365}(JANMIN + 32)^{1.415}$	39	.0238	.0026
$Q_{AVE} = .090(AREA)^{0.970}(PRECIP)^{0.965}$	21	.0074	.0003
$Q_{7,10,O\text{-}M} = 0.40(AREA)^{0.910}(ST+1)^{0.378}$	71	.0778	.0036
$Q_{7,10,A\text{-}S} = 0.0002(AREA)^{0.989}(ST+1)^{0.307}(GLACIER + 1)^{-0.344}(ELEV)^{1.069}$	97	.1245	.0087

Statistics of basin characteristics

Variable	Basin characteristic	Maximum	Minimum	Mean	Median
Q_{50} (50-year peak discharge; 100 sites)					
AREA	Drainage area	19,920 mi^2	1.4 mi^2	230 mi^2	15.5 mi^2
PRECIP	Precipitation	300 in.	40 in.	140 in.	140 in.
ST[1]	Area of lakes and ponds	26 percent	0 percent	3.6 percent	1 percent
JANMIN	Mean minimum January temperature	32 °F	-6 °F	24.6 °F	26 °F
Q_{ave} (Average discharge; 83 sites)					
AREA	Drainage area	19,920 mi^2	1.8 mi^2	354 mi^2	15.6 mi^2
PRECIP	Precipitation	300 in.	35 in.	145 in.	150 in.
$Q_{7,10}$ (7-day, 10-year low flow, October to March; 83 sites)					
AREA	Drainage area	19,920 mi^2	1.8 mi^2	354 mi^2	15.6 mi^2
ST[1]	Area of lakes and ponds	27 percent	0 percent	4.4 percent	1.0 percent
$Q_{7,10}$ (7-day, 10-year low flow, April to September; 83 sites)					
AREA	Area	19,920 mi^2	1.8 mi^2	354 mi^2	15.6 mi^2
ST[1]	Area of lakes and ponds	27 percent	0 percent	4.4 percent	1.0 percent
GLACIER[1]	Area of glaciers	67 percent	0 percent	7.5 percent	0 percent
ELEV	Mean basin elevation	4,820 ft	358 ft	1,940 ft	1,630 ft

[1]The value 1.0 is added to avoid a zero value

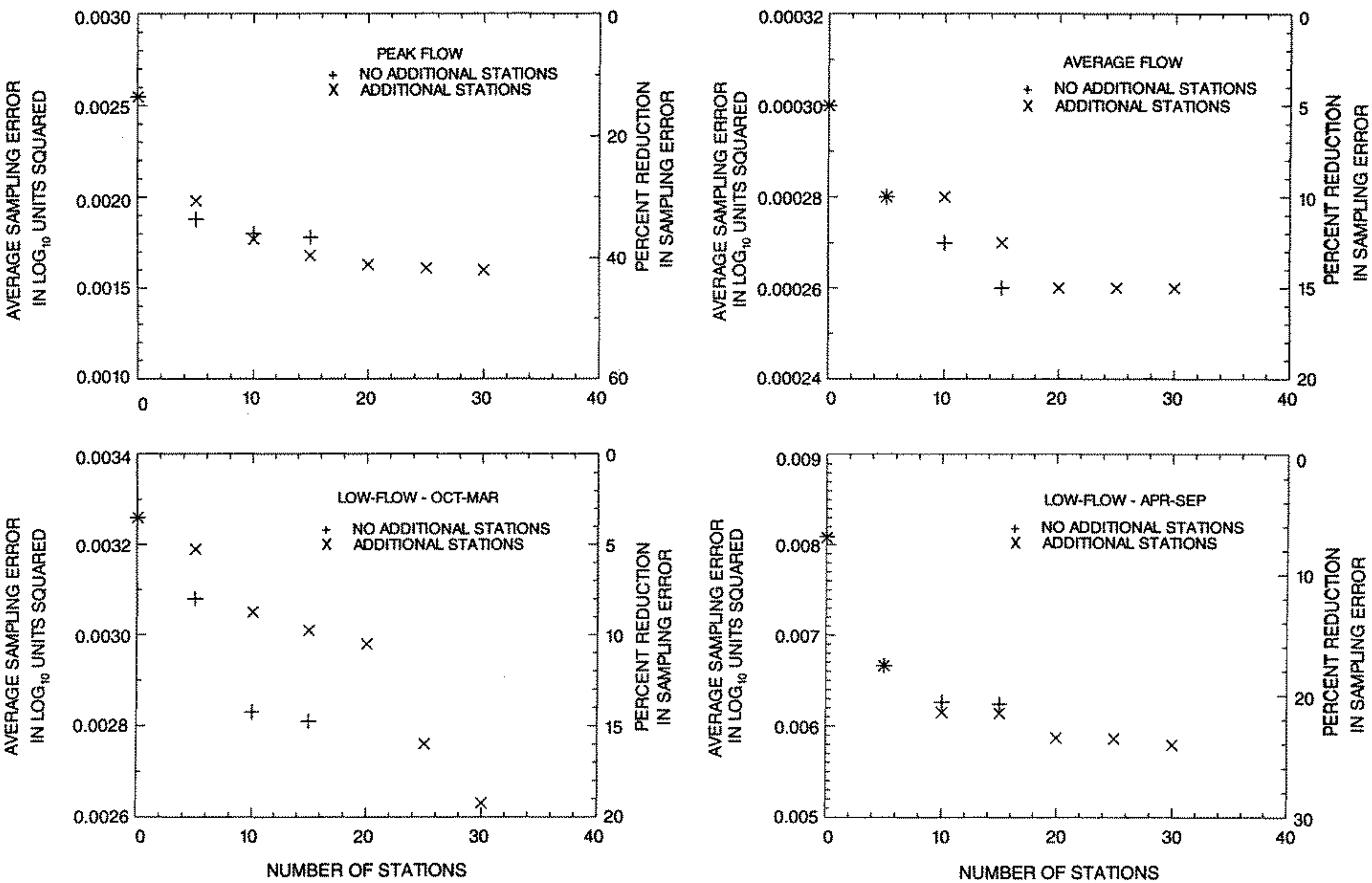


Figure 31. Results of network analysis for Southeast Alaska with and without additional streamflow-gaging stations.

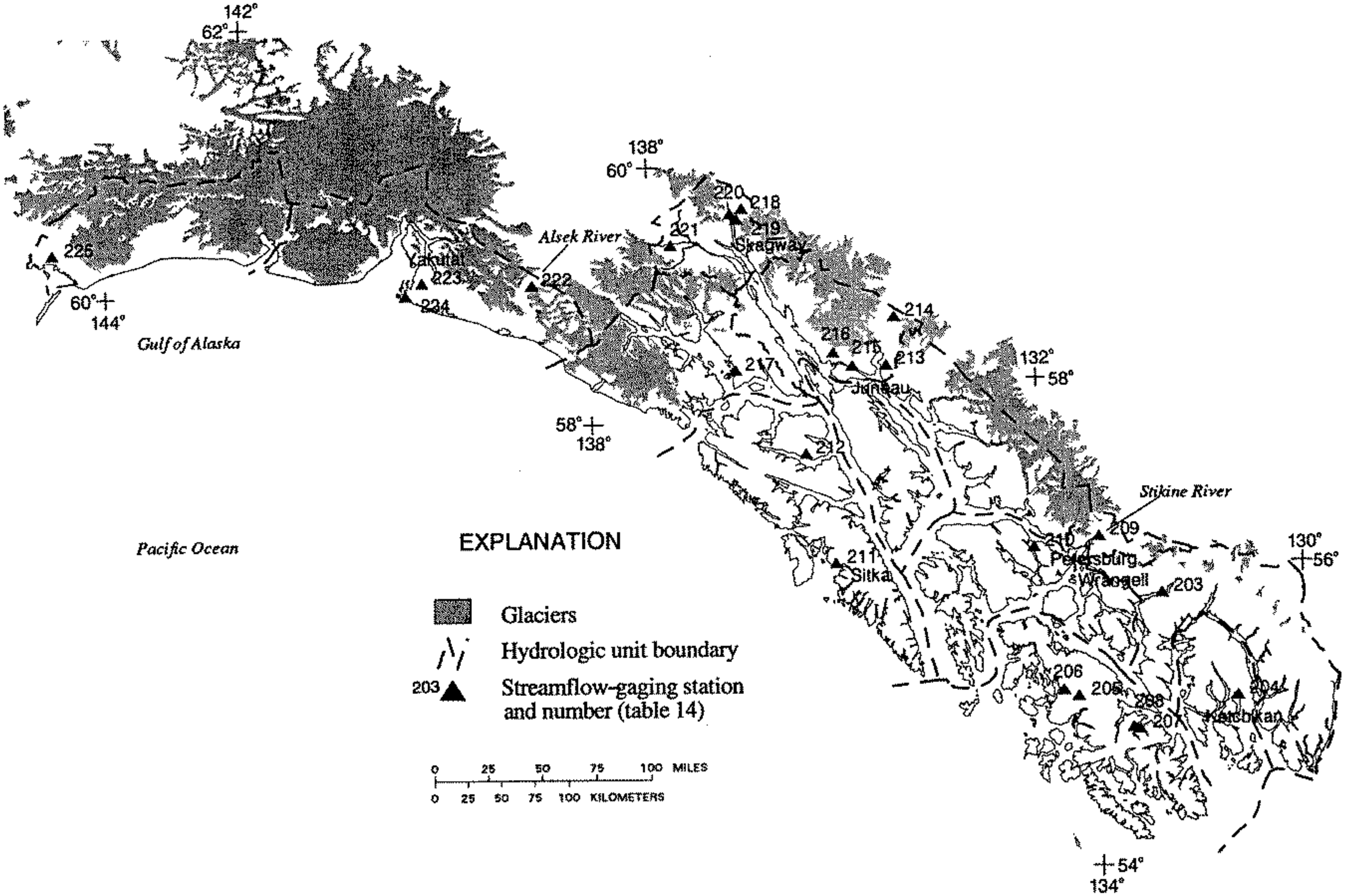


Figure 32. Proposed streamflow-gaging network for Southeast Alaska.

Table 14. Proposed streamflow-gaging network, Southeast Alaska
[HUC, Hydrologic unit code; mi^2, square mile; USGS station number indicated after site name]

Map No. (fig. 32)	HUC	HUC area (mi^2)	Site name	Latitude/Longitude	Drainage area (mi^2)
203	19010101	4,890	Harding River (15022000)[1]	56°12'48"131°38'12"	67.4
204	19010102	1,440	Fish Creek (15072000)[1]	55°23'31"131°11'38"	32.1
205	19010103	3,540	North Fork Staney Creek (15081495)	55°43'58"132°58'02"	3.07
206			Staney Creek (15081497)	55°48'05"133°06'31"	50.6
207			Old Tom Creek (15085100)	55°23'44"132°24'25"	5.90
208			Old Franks Creek	55°25'12"132°28'12"	31.2
209	19010201	3,960	Stikine River (15024800)	56°42'29"132°07'49"	19,900
210	19010202	2,840	Municipal Watershed Creek (15087545)	56°46'40"132°55'07"	2.20
211	19010203	4,020	Indian River (15087690)[1]	57°04'01"135°17'42"	10.1
212			Indian River (15107920)	57°49'50"135°16'00"	12.9
	19010204	1,680			
213	19010301	2,730	Dorothy Lake outlet (15039900)	58°14'46"133°58'54"	11.0
214			Taku River (15041200)	58°32'19"133°42'00"	6,600
215			Gold Creek (15049900)	58°18'26"134°23'12"	8.41
216			Mendenhall River (15052500)	58°25'47"134°34'22"	85.1
217	19010302	3,480	Bartlett River	58°30'00"135°50'00"	37.0
218	19010303	1,900	Goat Lake outlet (15056095)	59°31'37"135°10'38"	2.92
219			Skagway River (15056100)	59°28'02"135°17'00"	145
220			Taiya River (15056210)	59°30'43"135°20'40"	149
221			Upper Chilkoot Lake outlet (15056280)	59°25'12"136°12'36"	4.59
222	19010401	5,110	Alsek River (15129000)	59°23'42"138°04'55"	10,800
223			Situk River (15129500)	59°35'00"139°29'31"	36.0
224			Ophir Creek (15129600)	59°31'26"139°44'37"	2.50
225	19010402	4,240	Bering River	60°14'00"144°15'00"	75.0

[1]Index station

Yukon Alaska

Yukon Alaska is the largest hydrologic region in the State and extends across interior Alaska between the Alaska Range and the Brooks Range. This region, which is the Yukon River basin, is approximately 325,000 mi^2, of which about 200,000 mi^2 is located in Alaska. The average outflow at the mouth of the Yukon River is about 230,000 ft^3/s and the average inflow from Canada is about 100,000 ft^3/s. Major tributaries to the Yukon River that are located in Alaska are the Tanana, Porcupine, and Koyukuk Rivers (fig. 1). Mining, both hard-rock and placer, is the primary industry in this region. Water-resource information is needed to adequately design mining facilities, such as sedimentation ponds, to help define flood-prone areas where numerous small villages are located, and to properly design public water-supply systems.

Spatial distribution of past and present gaging stations in Alaska is poor (fig. 33). Most of the gaging stations have been located along the highway system and thus the use of any regression equations would be limited. However, because the data base was sufficient and because these procedures can still provide considerable information concerning the contribution of a gaging station, the GLS and network analysis procedures were utilized in this region.

For Interior Alaska, peak-flow data were available for 132 sites for generalized least squares analysis. Of these sites, 39 were streamflow-gaging stations located in Alaska, 43 were crest-stage gages located in Alaska, and 50 sites are located in the Yukon River basin in Canada (data provided by the Water Survey of Canada) (appendix 3 and 4). Data were available from 39 sites in Alaska for analysis of average discharge and from 30 sites in Alaska for analysis of low flow. Most of these sites have drainage areas more than 1,000 mi^2 in size. Currently, 13 streamflow-gaging stations and 27 crest-stage gages are operating in this region (table 15).

Results of the GLS procedures (table 16) indicated that the variables significant at the 5 percent level were drainage area (all equations), precipitation (average and peak discharge equations), percentage of lakes and ponds (peak discharge equation), and average minimum temperature for January (peak discharge equation). The standard error of prediction ranged from 29 percent to 92 percent. The model error in all three equations was significantly higher than the sampling error. Given the spatial distribution of the data, the equations would probably be useful only in areas near the current highway system.

In selecting additional stations, the following procedures were used. Sites were selected using the hydrologic unit map for interior Alaska to ensure spatial distribution. The potential sites were also plotted on the precipitation and physiographic maps of the region to ensure distribution (fig. 34-35). After sites were selected and their basin characteristics determined, the network analysis procedure was performed. The results indicated that the sampling errors for all three equations could be lowered significantly by adding stations (fig. 36). For example, the percent reduction in sampling error for peak discharge would be 26 percent with additional stations versus 10 percent with no additional stations. Similarly, the percent reduction in sampling error for the average discharge and low-flow discharge equations would be about 30 and 32 percent respectively with additional stations, versus 5 and 2 percent reduction with no additional stations. It should also be noted that with additional data, the form of the equations may change.

The proposed network consists of 83 stations (table 17, fig. 37). Three long-term current stations—the Salcha River (No. 258 on fig. 37), the Tanana River at Nenana (263), and the Yukon River at Pilot Station (308)—would continue to serve as index stations. In addition, the Charley (243), John (273), Christian (240), and the Anvik (298) Rivers would also serve as index stations, providing spatial distribution.

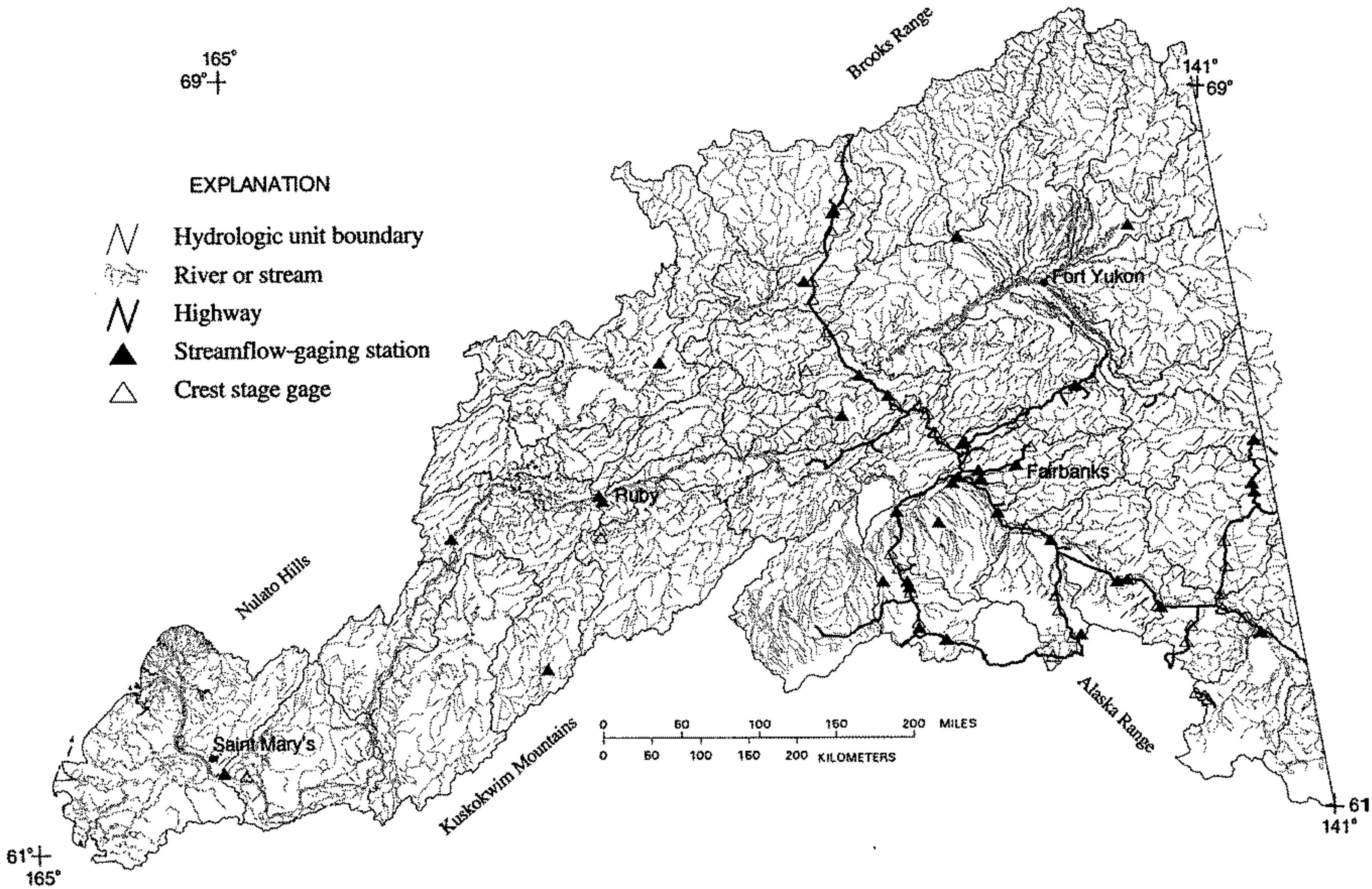


Figure 33. Current and historic streamflow-gaging stations used in network analysis for Yukon Alaska.

Table 15. Active streamflow-gaging stations and crest stage gages, 1995 water year, Yukon Alaska

Station No.	Station name	Station No.	Station name
	Currently operated streamflow-gaging station		Crest-stage gage--Continued
15356000	Yukon River at Eagle	15453610	Ray River tributary near Stevens Village
15388960	Porcupine River at International Boundary	15457700	Erickson Creek near Livengood
15453500	Yukon River near Stevens Village	15470300	Little Jack Creek near Nabesna
15478040	Phelan Creek near Paxson	15476049	Tanana River tributary near Cathedral Rapids
15484000	Salcha River near Salchaket	15476300	Berry Creek near Dot Lake
15485500	Tanana River at Fairbanks	15478093	Suzy Q Creek near Pump Station 10
15493000	Chena River near Two Rivers	15478499	Ruby Creek above Richardson Highway near Donnelly
15493700	Chena River below Moose Creek Dam	15480000	Banner Creek at Richardson
15511000	Little Chena River near Fairbanks	15490000	Monument Creek at Chena Hot Springs
15514000	Chena River at Fairbanks	15516198	Slime Creek at Intertie near Cantwell
15515500	Tanana River at Nenana	15516200	Slime Creek near Cantwell
15518080	Lignite Creek above mouth near Healy	15517980	Dragonfly Creek near Healy
15565447	Yukon River at Pilot Station	15541600	Globe Creek near Livengood
		15564445	Long Creek tributary near Ruby
	Crest-stage gage	15564450	Long Creek at Long near Ruby
15305900	Dennison Fork near Tetlin Junction	15564868	Snowden Creek near Wiseman
15305920	West Fork tributary near Tetlin Junction	15564872	Nugget Creek near Wiseman
15344000	King Creek near Dome Creek	15564879	Slate Creek at Coldfoot
15439800	Boulder Creek near Central	15564884	Prospect Creek near Prospect Camp
15442500	Quartz Creek near Central	15564887	Bonanza Creek tributary near Prospect Camp
15453481	West Fork Dall River tributary near Stevens Village	15565449	Municipal Reserve Creek at Pilot Station

Table 16. Equations produced and statistics used by the GLS analysis for Yukon Alaska

[Discharge is in cubic feet per second; $(\log_{10})^2$, $\log_{10}$ units squared]

Equation	Standard error of prediction (percent)	Model error $[(\log_{10})^2]$	Sampling error $[(\log_{10})^2]$
$Q_{50} = 19.1(AREA)^{0.805}(PRECIP)^{0.729}(ST + 1)^{-0.325}(JANMIN + 32)^{-0.272}$	60	.0593	.0037
$Q_{AVE} = .009(AREA)^{1.064}(PRECIP)^{1.354}$	29	.0153	.0014
$Q_{MAR} = .132(AREA)^{0.977}$	92	.1184	.0083

Statistics of basin characteristics

Variable	Basin characteristic	Maximum	Minimum	Mean	Median
		Q_{50} (50-year peak discharge; 132 sites)			
AREA	Drainage area	321,000 mi^2	1.0 mi^2	15,400 mi^2	174 mi^2
PRECIP	Precipitation	80 in.	10 in.	18 in.	15 in.
ST[1]	Area of lakes and ponds	30 percent	0 percent	1.7 percent	1 percent
JANMIN	Mean minimum January temperature	0 °F	-30 °F	-16.9 °F	-18 °F
		Q_{AVE} (Average discharge; 39 sites)			
AREA	Drainage area	321,000 mi^2	5.9 mi^2	38,900 mi^2	1,200 mi^2
PRECIP	Precipitation	80 in.	10.0 in.	19 in.	15 in.
		Q_{MAR} (Average discharge for March; 30 sites)			
AREA	Drainage area	321,000 mi^2	9.2 mi^2	47,200 mi^2	1,400 mi^2

[1]The value 1.0 is added to avoid a zero value

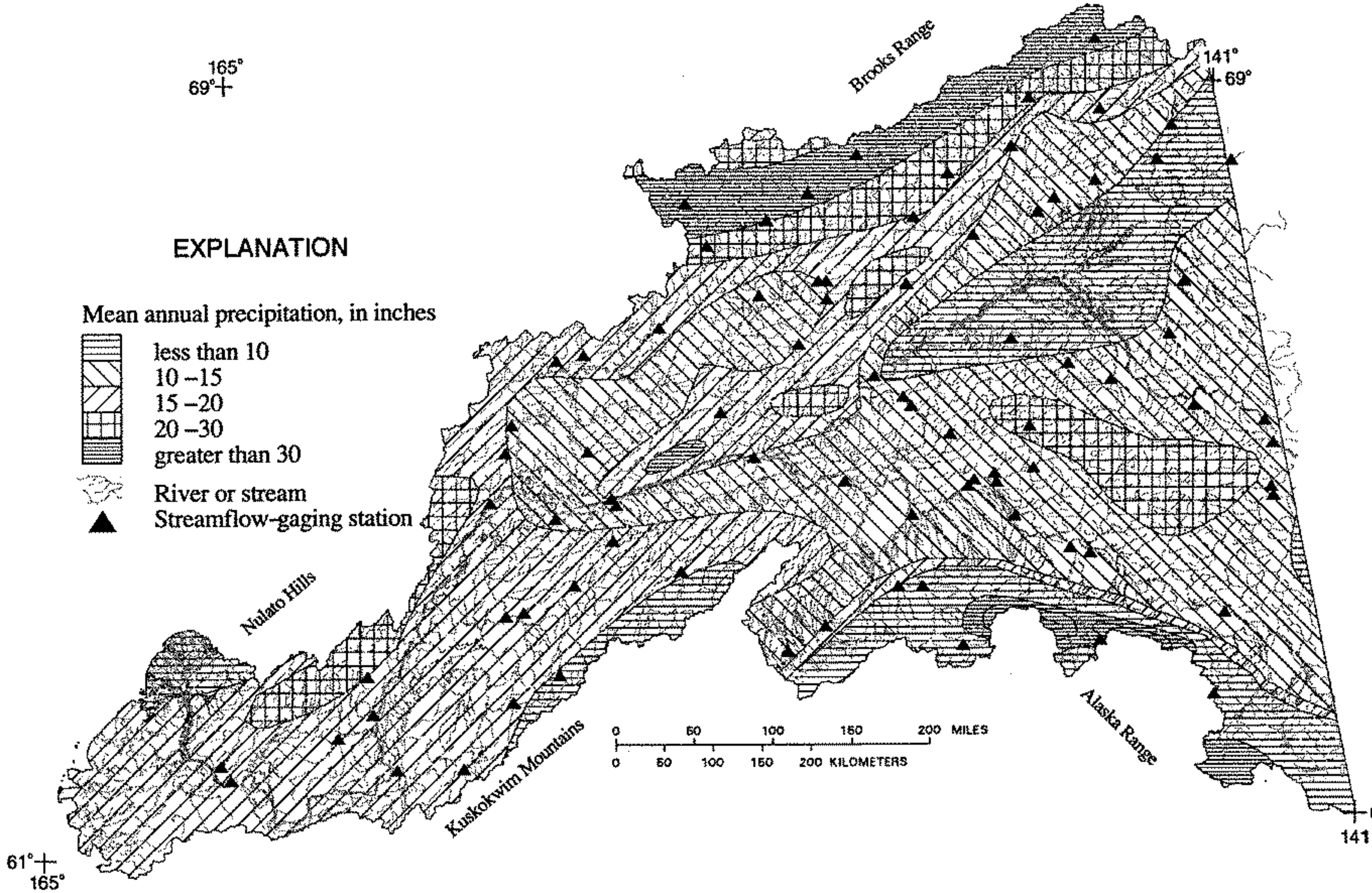


Figure 34. Proposed streamflow-gaging network and precipitation areas for Yukon Alaska (from Jones and Fahl, 1994).

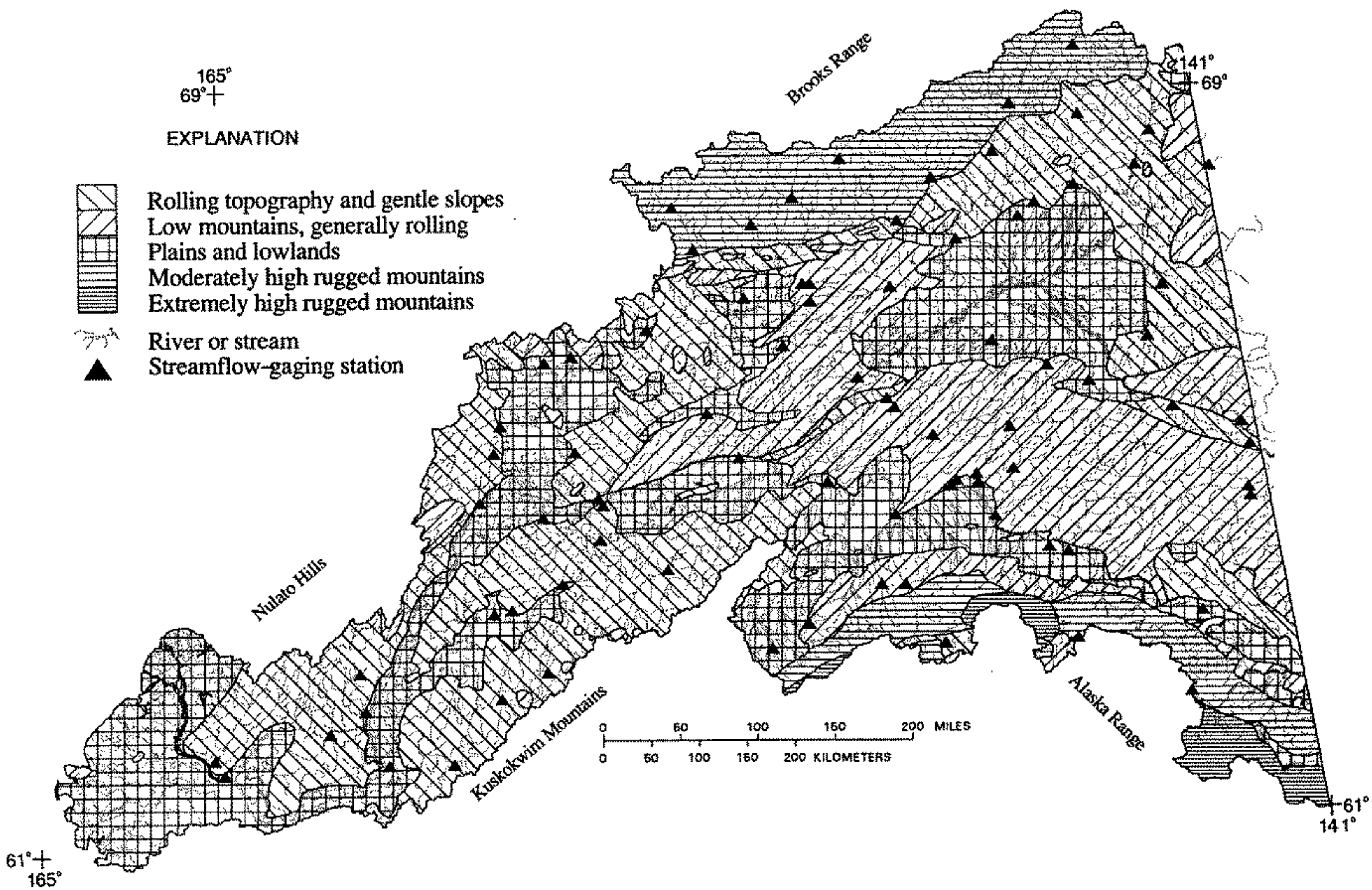


Figure 35. Proposed streamflow-gaging network and physiographic areas for Yukon Alaska (from Wahrhaftig, 1965).

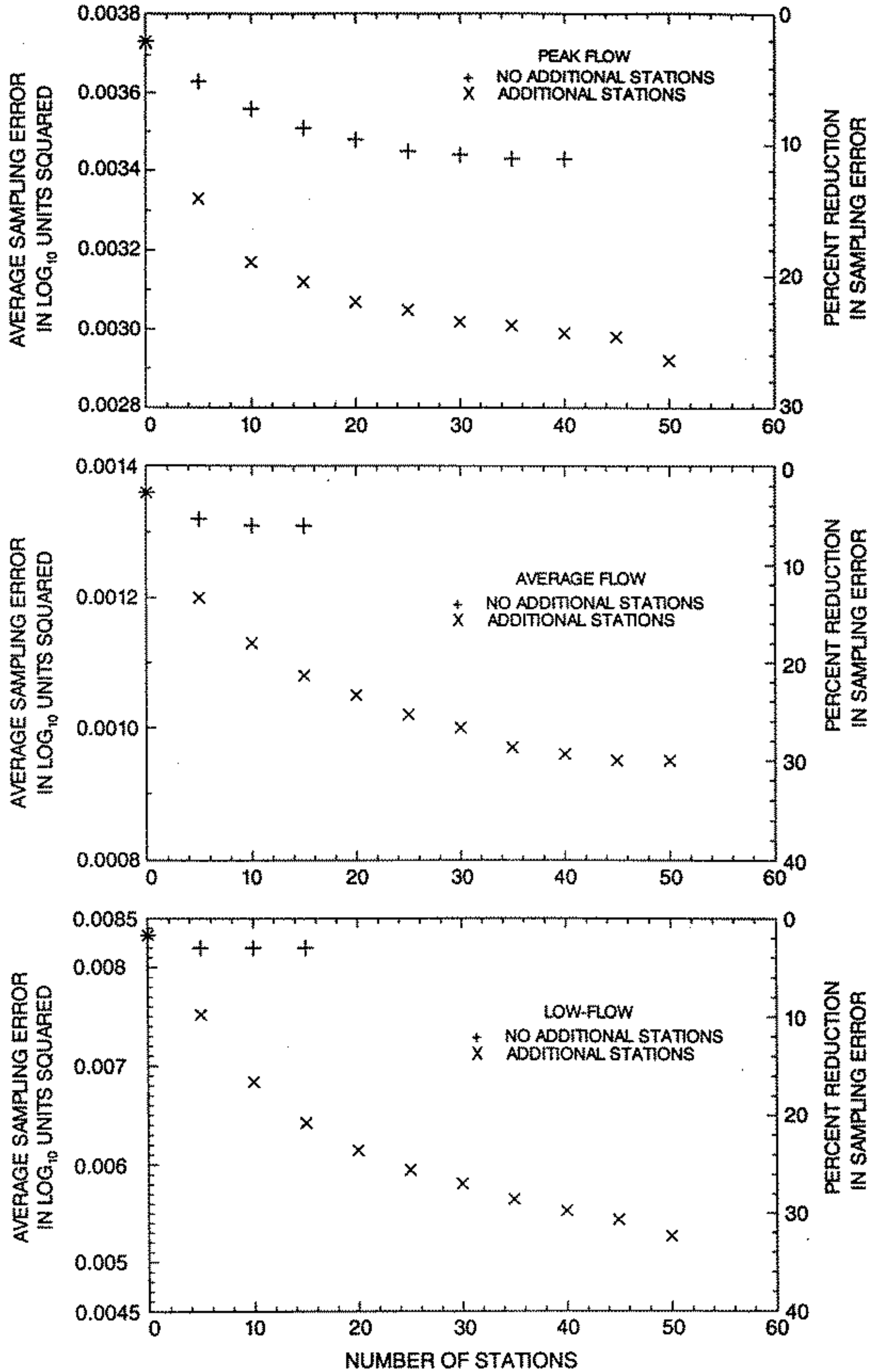


Figure 36. Results of network analysis for Yukon Alaska with and without additional streamflow-gaging stations.

Table 17. Proposed streamflow-gaging network, Yukon Alaska
[HUC, Hydrologic unit code; mi², square mile; USGS station number indicated after site name]

Map No. (fig. 37)	HUC	HUC area (mi²)	Site name	Latitude/Longitude	Drainage area (mi²)
	19040101	2,070			
	19040102	1,240			
	19040103	106			
226	19040104	6,030	King Creek (15344000)	64°23'38"141°24'43"	5.87
227			Fortymile River (15348000)	64°18'33"141°24'08"	5,880
	19040201	673			
228	19040202	4,260	Strangle Woman River	67°51'03"142°09'47"	452
229			Coleen River	67°33'39"142°38'45"	2,570
230	19040203	4,750	Upper Sheenjek River	68°45'24"143°41'14"	294
231			Old Woman Creek	68°06'29"143°49'43"	328
232			Sheenjek River	67°27'41"144°11'10"	4,510
233	19040204	7,830	Black River	66°24'25"142°29'25"	2,190
234			Little Black River	65°56'59"143°01'18"	638
235	19040205	3,830	Porcupine River (Canada) (15388960)	67°25'27"140°53'28"	23,100
236	19040301	3,460	Big Creek	67°19'03"148°32'30"	98.0
237			Middle Fork Koyukuk River (15564875)	67°41'29"147°38'34"	1,300
238	19040302	5,560	Junjik River	68°17'56"145°30'05"	855
239			Smoke Creek	67°52'28"146°03'50"	379
240	19040303	2,480	Christian River[1]	67°20'57"145°11'26"	1,100
241	19040304	2,220	Marten Creek	67°14'26"145°37'29"	125
242			Chandalar River (15389000)	67°05'49"147°11'04"	9,330
243	19040401	5,890	Charley River[1]	65°15'29"142°44'19"	1,500
244			Nation River	65°15'35"141°37'58"	920
245			Yukon River (15356000)	64°47'22"141°11'52"	113,500
246	19040402	8,080	Big Creek	66°06'39"146°34'41"	100
247			Preacher Creek	65°49'01"145°22'27"	822
248			Quartz Creek (15442500)	65°37'09"144°28'55"	17.2
249	19040403	7,480	Hodzana River	66°42'26"148°50'02"	810
250	19040404	3,100	Erickson Creek (15457700)	65°34'30"148°56'18"	26.3
251			Yukon River (15453500)	65°52'32"149°43'04"	196,300
252			Hess Creek (15457800)	65°39'55"149°05'47"	662
253	19040501	4,850	Nabesna River	62°32'39"143°19'22"	2,260
254	19040502	3,010	Tok River (15474000)	63°19'30"142°50'05"	930
255	19040503	5,080	Clearwater Creek	64°03'22"145°26'16"	360

Table 17. Proposed streamflow-gaging network, Yukon Alaska--Continued
[HUC, Hydrologic unit code; mi², square mile; USGS station number indicated after site name]

Map No. (fig. 37)	HUC	HUC area (mi²)	Site name	Latitude/Longitude	Drainage area (mi²)
256	19040504	3,290	Phelan Creek(15478040)	63°14'27"145°28'03"	12.2
257			Delta River	64°07'35"145°50'00"	1,630
258	19040505	2,210	Salcha River (15484000)[1]	64°28'22"146°55'26"	2,170
259	19040506	2,093	Chena River (Two Rivers) (15493000)	64°53'55"146°24'42"	941
260			Chena River (Moose Cr. Dam) (154937000	64°48'03"147°13'40"	1,460
261			Little Chena River (15511000)	64°53'10"147°14'50"	372
262			Chena River (Fairbanks) (15514000)	64°50'45"147°42'04"	2,000
263	19040507	4,470	Tanana River (Nenana) (15515500)[1]	64°33'55"149°05'30"	25,600
264			Tanana River (Fairbanks) (15485500)	64°47'34"147°50'20"	20,000
265	19040508	3,900	Lignite Creek (15518080)	63°54'17"148°59'01"	48.1
266			Teklanika River (15518350)	63°55'14"149°29'51"	490
267			Seattle Creek (15515800)	63°19'32"148°14'49"	36.2
268	19040509	3,360	Globe Creek (15541600)	65°17'08"148°07'56"	23.0
269			Chatanika River	65°17'20"146°23'15"	132
270	19040510	7,100	Moose Creek	63°35'21"151°03'17"	158
271			Foraker River	63°21'57"151°50'50"	192
272	19040511	4,680	Zitziana River	64°55'11"150°30'35"	748
273	19040601	6,930	John River[1]	67°21'28"152°01'45"	2,140
274			North Fork Koyukuk	67°35'52"151°01'25"	663
275			Nutirwik Creek	67°56'05"149°49'00"	29.2
276	19040602	2,310	Jim River (15564885)	66°47'10"150°52'23"	465
277			Prospect Creek (15564884)	66°46'56"150°41'06"	110
278			Bonanza Creek (15564887)	66°36'52"150°41'24"	11.7
279	19040603	7,110	Alatna River	67°08'09"153°26'06"	1,570
280			Kutuk River	67°31'47"153°57'01"	206
281	19040604	3,350	Kanuti River	66°12'18"151°22'42"	664
282	19040605	1,710	Henshaw Creek	66°40'13"152°15'06"	582
283	19040606	1,950	Billy Hawk Creek	66°02'58"156°52'48"	419
284	19040607	1,460	Cottonwood Creek	65°13'09"156°06'23"	190
285	19040608	7,110	Hogatza River	66°22'44"154°32'48"	392
286			Dakli River	66°06'48"156°15'52"	279

Table 17. Proposed streamflow-gaging network, Yukon Alaska--Continued

[HUC, Hydrologic unit code; mi², square mile; USGS station number indicated after site name]

Map No. (fig. 37)	HUC	HUC area (mi²)	Site name	Latitude/Longitude	Drainage area (mi²)
287	19040609	3,070	Gisasa River	65°10'37"157°54'40"	462
288			Honhosa River	65°26'25"157°48'20"	305
289	19040701	1,630	Tozitna River	65°10'26"152°27'22"	1,610
290	19040702	7,180	Nowitna River	64°07'34"154°02'27"	2,220
291			Long Creek (15564450)	64°24'02"155°30'04"	25.4
292	19040703	2,720	Little Melozitna River	65°35'31"153°10'00"	453
293			Melozitna River (15564600)	64°47'34"155°33'39"	2,690
294	19040704	3,480	Big Creek	64°43'48"155°27'33"	100
295	19040705	5,880	Kala River	64°35'23"156°45'18"	217
296			Nulato River	64°42'20"158°09'40"	874
297	19040801	3,900	Yellow River	63°01'02"160°24'23"	210
298			Anvik River[1]	62°40'26"160°13'10"	1,750
299	19040802	4,420	Windy Creek	62°52'36"157°26'34"	162
300			North Fork Innoko River	63°58'34"156°17'16"	212
301			Ophir Creek	63°08'42"156°31'15"	6.20
302	19040803	9,670	Innoko River	62°11'15"159°38'28"	12,000
303			Iditarod River	62°14'32"158°20'11"	481
304			Mud River	63°39'56"157°41'51"	1,120
305			Wapoo Creek	63°42'39"157°19'49"	101
306	19040804	6,500	Stuyahok River	62°25'42"160°52'54"	303
307	19040805	7,770	Andreafsky River	62°03'15"163°06'50"	1,260
308			Yukon River (15565447)[1]	61°56'04"162°52'50"	321,000

[1]Index station

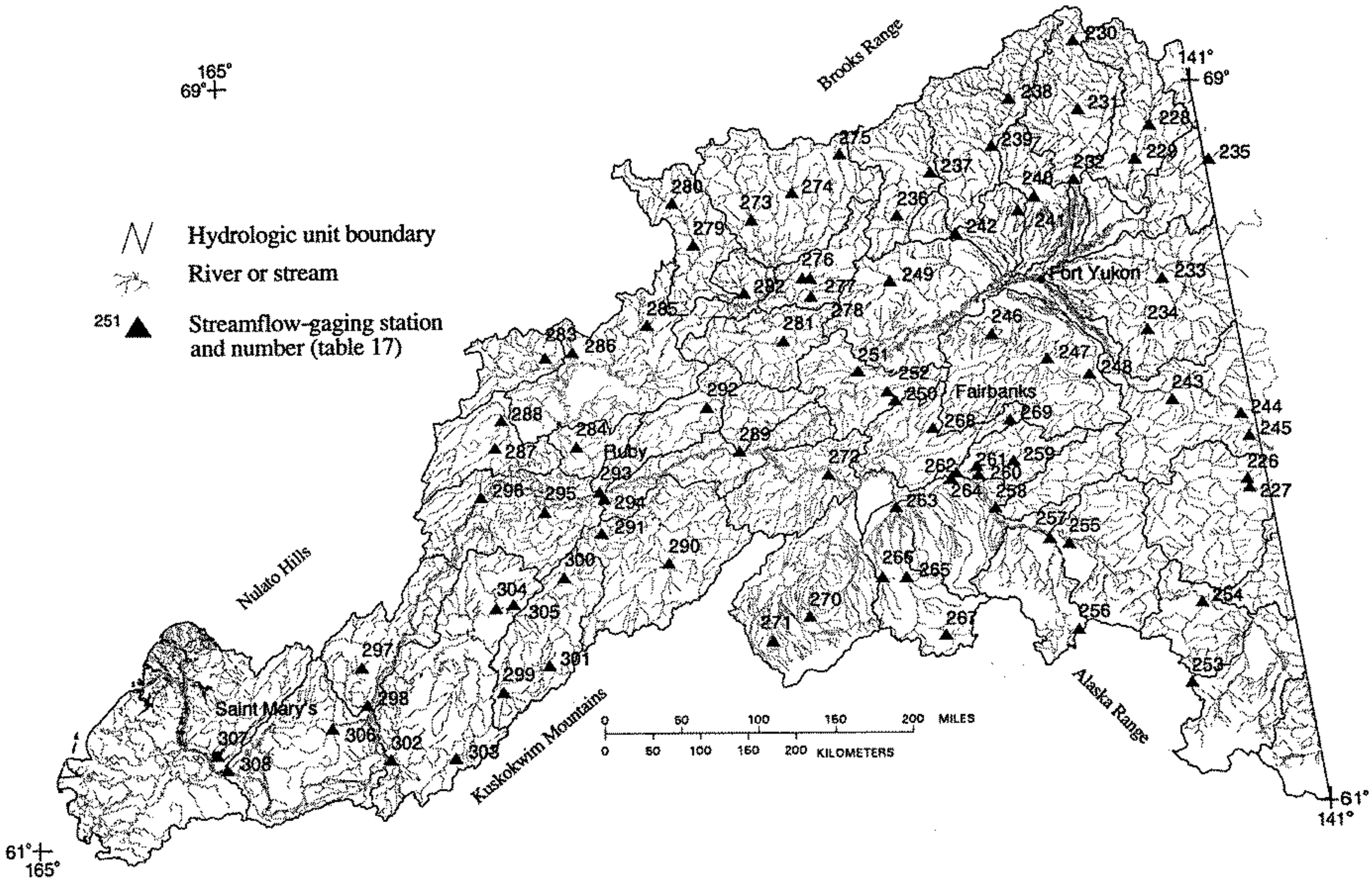


Figure 37. Proposed streamflow-gaging network and hydrologic unit boundaries for Yukon Alaska.

SUMMARY AND CONCLUSIONS

The streamflow-gaging network of Alaska was evaluated to determine its effectiveness in providing regional flow characteristics. Principal findings are:

- Arctic, Northwest, and Southwest Alaska lack sufficient hydrologic data to evaluate their respective streamflow-gaging networks. A proposed network for these three regions was designed by using clustering and spatial analysis techniques and by assuming that the drainage area of the proposed sites would be a significant variable. The proposed network would consist of 57 streamflow-gaging stations in the Arctic region, 57 in the Northwest region, and 48 in the Southwest region.
- In Southcentral Alaska, generalized least squares (GLS) procedures were used to develop regional regression equations for the 50-year peak discharge, the average annual discharge, and the 7-day, 10-year low-flow discharge for October 1 to September 30. Network analysis procedures indicated that adding streamflow-gaging stations to the existing network would further decrease the sampling error for the peak-discharge equation by 3 percent, for the average-discharge equation by 10 percent, and for the low-flow equation by 20 percent. The proposed network consists of 41 streamflow-gaging stations.
- Sufficient data were available in Southeast Alaska to utilize GLS procedures to develop regional regression equations for the 50-year peak discharge, average annual discharge, the 7-day, 10-year low-flow discharge for October 1 to March 31, and the 7-day, 10-year low-flow discharge from April 1 to September 30. The network analysis procedure indicated that adding stations to the existing network would further decrease the sampling error for the peak-flow equation by 4 percent, the 7-day 10-year low-flow equation for October 1 to March 31 by 5 percent, and the 7-day, 10-year low-flow equation for April 1 to September 30 by 4 percent. The proposed network consists of 22 streamflow-gaging stations.
- Sufficient data were available to use GLS procedures in Yukon Alaska to develop regional regression equations for the 50-year peak discharge, average annual discharge, and the 7-day, 10-year low-flow discharge for October 1 to September 30. The resulting equations should be used with caution since the data are not spatially distributed. Network analysis procedures indicated that adding streamflow-gaging stations to the existing network would further decrease the sampling error for the peak-discharge equation by 16 percent, for the average-discharge equation by 258 percent, and for the low-flow equation by 30 percent. The proposed network consists of 83 streamflow-gaging stations.
- Several important factors of the proposed network have not been addressed in this study. For example, many of the proposed sites have not been visited and thus it is uncertain whether or not an adequate hydraulic control exists at the sites to develop a relation between water stage and discharge. It is also uncertain whether there is reasonable access to the proposed sites.
- Of the equations developed by GLS methods, most of the error is model error, not sampling error. In addition to more data collection, a better understanding is needed between independent and dependent variables. Other basin characteristics may be significant, and different forms of the regression equations may be more appropriate.
- The proposed network for Alaska consists of 308 streamflow-gaging stations of which 32 are classified as index stations. Although it is unlikely that this number of gaging stations could be added to the network at one time, a possible approach may be to concentrate efforts in one particular area or establish the index stations.

REFERENCES CITED

Benson, M.A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 62 p.

______1964, Factors affecting the occurrence of floods in the Southwest: U.S. Geological Survey Water-Supply Paper 1580-D, 72 p.

Benson, M.A., and Carter, R.W., 1973, A national study of the streamflow data-collection program: U.S. Geological Survey Water-Supply Paper 2028.

Benson, M.A., and Matalas, N.C., 1967, Synthetic hydrology based on regional statistical parameters: Water Resources Research, v. 3, no. 4, p. 931-935.

Childers, J.M., 1970, A proposed streamflow data program in Alaska: U.S. Geological Survey Open-File Report, 55 p.

Childers, J.M., Kernodle, D.R., and Loeffler, R.M., 1979, Hydrologic reconnaissance of western arctic Alaska, 1976 and 1977: U.S. Geological Survey Open-File Report 79-699, 70 p.

Childers, J.M., Sloan, C.E., Meckel, J.P., and Nauman, J.W., 1977, Hydrologic reconnaissance of the eastern north slope, Alaska, 1975: U.S. Geological Survey Open-File Report 77-492, 65 p.

Ferrians, O.J., 1980, Permafrost map of Alaska: U.S. Geological Survey Miscellaneous Investigations Series, Map I-445, 1 sheet.

Jones, S.H., and Fahl, C.B., 1994, Magnitude and frequency of floods in Alaska and conterminous basins of Canada: U.S. Geological Survey Water-Resources Investigations Report 93-4179, 122 p.

Lamke, R.D., 1984, Cost-effectiveness of the stream-gaging program in Alaska: U.S. Geological Survey Water-Resources Investigations Report 84-4096, 100 p.

______1991, Alaska floods and droughts, *in* Paulson, R.W., and others, National water summary, 1988-89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p.171-180.

Moss, M.E., and Gilroy, E.J., 1980, Cost-effective stream-gaging strategies for the lower Colorado River basin, the Blythe field office operations: U.S. Geological Survey Open-File Report 80-1048.

Moss, M.E., Gilroy, E.J., Tasker, G.D., and Karlinger, M.R., 1982, Design of surface-water data networks for regional information: U.S. Geological Survey Water-Supply Paper 2178, 33 p.

Moss, M.E., and Tasker, G.D., 1990, Manual for comparing methods of designing hydrologic-data-collection networks: U.S. Geological Survey Open-File Report 90-389, 103 p.

National Park Service, 1986, Noatak National Preserve, Alaska: General Management Plan, Land Protection Plan, Wilderness Suitability and Review, 228 p.

Parks, Bruce, and Madison, R.J., 1985, Estimation of selected flow and water-quality characteristics of Alaskan streams: U.S. Geological Survey Water-Resources Investigations Report 84-4247, 64 p.

Savard, C.S., and Scully, D.R., 1984, Surface-water quantity and quality in the lower Kenai Peninsula, Alaska: U.S. Geological Survey Water-Resources Investigations Report 84-4161, 62 p.

Stedinger, J.R., and Tasker, G.D., 1985, Regional hydrologic regression 1, ordinary, weighted and generalized least squares compared: Water Resources Research, v. 21, no. 9, p. 1421-1432.

______1986, Regional hydrologic analysis 2: Mean-error estimator, estimation of sigma and log Pearson Type 3 distributions: Water Resources Research, v. 22, no. 10, p. 1487-1499.

Tasker, G.D., 1986, Generating efficient gaging plans for regional information, *in* Integrated design of hydrological networks: International Association of Scientific Hydrology Publication 158, p. 269-281.

Thomas, W.O., 1993, An overview of selected techniques for analyzing surface-water data networks: World Meteorological Organization Operational Hydrology Report, 103 p.

Thomas, W.O., and Benson, M.A., 1970, Generalization of streamflow characteristics from drainage-basin characteristics: U.S. Geological Survey Water-Supply Paper 1975, 55 p.

U.S. Geological Survey, 1987, Hydrologic unit map—1987—State of Alaska: U.S. Geological Survey map, 1 sheet.

Wahrhaftig, Clyde, 1965, Physiographic divisions of Alaska: U.S. Geological Survey Professional Paper 482, 52 p., 6 plates.

APPENDIX 1

Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska

[See plate 1 in Jones and Fahl (1994) for locations of gaging stations]

PAGE A1-3 Follows

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15195000	Dick Creek near Cordova AK	60°20'32"	144°18'10"	7.95	0.0	200	890	1971-81	P,M,L
15198500	Station Creek near Mentasta AK	62°55'56"	143°40'06"	15.3	0.0	30	3,370	1970-92	P
15199000	Copper River tributary near Slana AK	62°43'03"	144°14'21"	4.32	0.0	22	3,370	1963-92	P
15200000	Gakona River at Gakona AK	62°18'06"	145°18'20"	620	8.0	25	3,030	1950-74 1992	P,M,L
15200270	Sourdough Creek at Sourdough AK	62°31'46"	145°30'52"	68.0	12.0	20	2,290	1970-81	P
15200280	Gulkana River at Sourdough AK	62°31'15"	145°31'51"	1,770	15.0	18	2,780	1973-78, 1989-92	P,M,L
15201000	Dry Creek near Glennallen AK	62°08'49"	145°28'31"	11.4	1.0	10	1,700	1963-92	P
15201100	Little Nelchina River tributary near Eureka Lodge AK	61°59'17"	147°00'34"	7.81	0.0	15	2,940	1964-92	P
15201900	Moose Creek tributary at Glennallen AK	62°06'32"	145°30'57"	7.11	4.0	10	1,600	1963-74	P
15202000	Tazlina River near Glennallen AK	62°03'20"	145°25'34"	2,670	5.0	30	3,450	1950, 1952-72, 1974	P,M,L
15206000	Klutina River at Copper Center AK	61°57'10"	145°18'20"	880	4.0	30	3,500	1949-66, 1988	P,M,L
15207800	Little Tonsina River near Tonsina AK	61°28'49"	145°09'05"	22.7	1.0	60	3,320	1973-78	P,M,L
15208000	Tonsina River at Tonsina AK	61°39'41"	145°11'02"	420	4.0	30	3,600	1950-54, 1956-82	P,M,L
15208100	Squirrel Creek at Tonsina AK	61°40'05"	145°10'26"	70.5	4.0	15	3,100	1964-82	P,M,L
15208200	Rock Creek near Tonsina AK	61°45'32"	145°09'14"	14.3	1.0	15	2,680	1966-92	P
15209000	Chititu Creek near May Creek AK	61°22'12"	142°40'50"	30.9	0.0	30	4,150	1973-83	P
15209100	May Creek near May Creek AK	61°20'42"	142°41'49"	10.4	0.0	20	2,450	1973-83	P
15211700	Strelna Creek near Chitina AK	61°30'40"	144°04'00"	23.8	0.0	25	3,350	1971-92	P
15211900	O'Brien Creek near Chitina AK	61°28'59"	144°27'23"	44.8	0.0	30	4,120	1970-92	P
15212000	Copper River near Chitina AK	61°27'56"	144°27'21"	20,600	3.0	25	3620	1951-52, 1956-90	P,M,L
15212500	Boulder Creek near Tiekel AK	61°20'08"	145°18'26"	9.80	0.0	40	4,300	1963-92	P
15212600	Tiekel River near Tiekel AK	61°16'56"	145°16'23"	115	1.0	60	3,550	1978-81	P
15212800	Ptarmigan Creek tributary near near Valdez AK	61°08'13"	145°44'30"	0.72	0.0	100	3,290	1965-70	P
15213400	Stuart Creek near Tiekel AK	61°15'32"	145°16'54"	37.4	3.0	80	4,060	1972-81	P
15216000	Power Creek near Cordova AK	60°35'14"	145°37'05"	20.5	0.0	160	2,000	1948-92	P,M,L
15219000	West Fork Olsen Bay Creek near Cordova AK	60°45'41"	146°10'20"	4.78	0.0	120	1,400	1964-80	P,M,L

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15219100	Control Creek near Cordova AK	60°45'00"	146°14'00"	4.22	0.0	120	1,200	1964-74	P
15226000	Solomon Gulch near Valdez AK	61°05'02"	146°18'13"	19.7	2.0	100	2,400	1950-56	P,M,L
15226480	Sheep Creek near Valdez AK	61°06'48"	145°48'34"	31.9	0.0	100	4,060	1977-81	P
15227500	Mineral Creek at Valdez AK	61°08'30"	146°21'42"	44.0	0.0	100	3,270	1976-81 1990-92	P
15236200	Shakespeare Creek at Whittier AK	60°46'35"	148°43'35"	1.61	0.0	180	1,580	1969-80, 1984-92	P
15236900	Wolverine Creek near Lawing AK	60°22'14"	148°53'48"	9.51	0.0	160	3,730	1967-78, 1981	P,M,L
15237000	Nellie Juan River near Hunter AK	60°25'20"	148°43'30"	133	3.0	160	2,740	1961-65	P
15237360	San Juan River near Seward AK	59°49'05"	147°53'00"	12.4	10.0	220	652	1986-92	P,M,L
15237400	Chalmers River near Cordova AK	60°13'10"	147°13'30"	6.32	0.0	200	1,230	1967-80	P
15238000	Lost Creek near Seward AK	60°11'50"	149°22'30"	8.42	7.0	100	2,210	1948-50, 1963-72, 1976, 86	P
15238600	Spruce Creek near Seward AK	60°04'10"	149°27'08"	9.26	0.0	120	1,990	1966-92	P,M,L
15238820	Barbara Creek near Seldovia AK	59°28'50"	151°38'42"	20.7	0.0	70	1,610	1972-92	P,M,L
15239000	Bradley River near Homer AK	59°45'20"	150°51'00"	56.1	6.0	120	2,800	1958-90	P,M,L
15239050	Middle Fork Bradley River near Homer AK	59°46'42"	150°45'15"	9.2	1.0	120	3,920	1979-92	M,L
15239500	Fritz Creek near Homer AK	59°42'30"	151°20'35"	10.4	0.0	25	880	1963-92	P,M,L
15239800	Diamond Creek near Homer AK	59°40'10"	151°40'00"	5.35	0.0	25	890	1963-81	P
15239900	Anchor River near Anchor Point AK	59°44'50"	151°45'11"	137	0.0	25	1,120	1966-74, 1979-87, 1992	P,M,L
15240000	Anchor River at Anchor Point AK	59°46'21"	151°50'05"	224	0.0	25	970	1954-66, 1984-92	P,M,L
15240500	Cook Inlet tributary near Ninilchik AK	59°58'45"	151°43'20"	5.19	0.0	20	175	1966-81	P
15241600	Ninilchik River at Ninilchik AK	60°02'56"	151°39'48"	131	1.0	20	670	1963-85	P,M,L
15242000	Kasilof River near Kasilof AK	60°19'05"	151°15'35"	738	15.0	50	1,810	1950-77	P,M,L
15243950	Porcupine Creek near Primrose AK	60°20'24"	149°22'30"	16.8	0.0	80	2,300	1963-89	P
15244000	Ptarmigan Creek at Lawing AK	60°24'20"	149°21'45"	32.6	6.0	90	2,800	1948-58	P,M,L
15246000	Grant Creek near Moose Pass AK	60°27'25"	149°21'15"	44.2	10.0	90	2,900	1948-58	P,M,L
15248000	Trail River near Lawing AK	60°26'01"	149°22'19"	181	2.0	90	2,470	1948-77, 1986	P,M,L
15250000	Falls Creek near Lawing AK	60°25'50"	149°22'10"	11.8	0.0	80	3,480	1963-70, 1976	P

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15251800	Quartz Creek at Gilpatricks AK	60°35'45"	149°32'35"	9.41	0.0	60	3,260	1963-70, 1976, 86	P
15254000	Crescent Creek near Cooper Landing AK	60°29'49"	149°40'38"	31.7	13.0	50	2,700	1949-83, 1986	P,M,L
15258000	Kenai River at Cooper Landing AK	60°29'34"	149°48'28"	634	5.0	70	2,650	1947-92	P,M,L
15260000	Cooper Creek near Cooper Landing AK	60°26'00"	149°49'15"	31.8	16.0	60	2,400	1950-59	P,M,L
15260500	Stetson Creek near Cooper Landing AK	60°26'30"	149°51'05"	8.6	0.0	50	3,200	1958-63	P,M,L
15261000	Cooper Creek at mouth near Cooper Landing AK	60°28'30"	149°52'30"	48.0	10.0	60	2,500	1957-64	P
15264000	Russian River near Cooper Landing AK	60°27'10"	149°59'05"	61.8	4.0	60	2,100	1947-54	P,M,L
15266300	Kenai River at Soldotna AK	60°28'39"	151°04'46"	2,010	5.0	50	1,750	1965-92	P,M,L
15266500	Beaver Creek near Kenai AK	60°33'50"	151°07'03"	51.0	15.0	20	140	1968-92	P,M,L
15267900	Resurrection Creek near Hope AK	60°53'40"	149°38'13"	149	0.0	30	2,750	1967-85	P,M,L
15269500	Granite Creek near Portage AK	60°43'40"	149°17'00"	28.2	0.0	70	2,220	1967-80	P
15270400	Donaldson Creek near Wibel AK	60°45'40"	149°27'20"	4.07	0.0	40	2,580	1963-72	P
15271000	Sixmile Creek near Hope AK	60°49'15"	149°25'31"	234	1.0	60	2,460	1969, 1980-90	P,M,L
15271900	Cub Creek near Hope AK	60°52'12"	149°26'02"	1.80	0.0	40	2,670	1965-79	P
15272280	Portage River at Lake outlet near Whittier AK	60°47'07"	148°50'20"	40.5	5.0	70	2,610	1989-92	M,L
15272530	California Creek at Girdwood AK	60°57'45"	149°08'23"	7.19	0.0	70	2,480	1967-84, 1986-92	P
15272550	Glacier Creek at Girdwood AK	60°56'29"	149°09'44"	58.2	0.0	70	2,610	1966-78	P,M,L
15273095	Little Rabbit Creek above Goldenview Drive at Anchorage AK	61°04'58"	149°45'41"	5.06	0.0	20	1,900	1980-85	P,M,L
15273900	South Fork Campbell Creek at canyon mouth near Anchorage AK	61°08'52"	149°43'12"	25.2	1.0	25	2,760	1967-79, 1981, 89	P,M,L
15274000	South Fork Campbell Creek near Anchorage AK	61°09'57"	149°46'15"	30.4	1.0	22	2,530	1948-72	P,M,L
15274300	North Fork Campbell Creek near Anchorage AK	61°10'10"	149°45'43"	13.4	2.0	22	2,670	1967-84 1989	P,M,L
15275000	Chester Creek at Anchorage AK	61°11'59"	149°50'07"	20.0	1.0	20	800	1958-76	P,M,L
15276000	Ship Creek near Anchorage AK	61°13'32"	149°38'06"	90.5	1.0	30	3,100	1947-92	P,M,L

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15277100	Eagle River at Eagle River AK	61°18'28"	149°33'32"	192	0.5	40	3,120	1966-80	P,M,L
15277200	Meadow Creek at Eagle River AK	61°19'14"	149°32'11"	7.43	0.0	20	2,980	1965-74	P
15277410	Peters Creek near Birchwood AK	61°25'08"	149°29'20"	87.8	0.0	35	3,150	1974-83	P,M,L
15277600	East Fork Eklutna Creek near Palmer AK	61°18'44"	148°57'12"	38.2	0.0	70	3,880	1961-62, 1985-88	P,M,L
15277800	West Fork Eklutna Creek near Palmer AK	61°17'54"	148°58'25"	25.4	0.0	70	4,590	1961-62, 1985-88	P,M,L
15280000	Eklutna Creek near Palmer AK	61°24'15"	149°08'30"	119	3.0	50	3,700	1947-54	P
15281000	Knik River near Palmer AK	61°30'18"	149°01'50"	1,180	4.0	100	4,000	1948-66 1967-89 1992	P,M,L
15281500	Camp Creek near Sheep Mountain Lodge AK	61°50'20"	147°24'31"	1.09	0.0	20.0	4,000	1968-71, 1989-90	P
15282000	Caribou Creek near Sutton AK	61°48'12"	147°40'57"	289	0.0	25	4,190	1955-78	P,M,L
15282400	Purinton Creek near Sutton AK	61°48'42"	148°08'01"	8.51	1.0	25	3,000	1963-81 1988-91	P
15283500	Eska Creek near Sutton AK	61°43'44"	148°54'31"	13.4	0.0	30	2,560	1966, 1971-92	P
15284000	Matanuska River at Palmer AK	61°36'34"	149°04'16"	2,070	0.0	35	4,000	1949-74 1985-86, 1992	P,M,L
15285000	Wasilla Creek near Palmer AK	61°38'47"	149°11'45"	16.8	0.0	25	1,530	1971, 1976-92	P
15286000	Cottonwood Creek near Wasilla AK	61°31'40"	149°31'31"	28.5	11.0	35	400	1949-54	M,L
15290000	Little Susitna River near Palmer AK	61°42'32"	149°13'36"	61.9	0.0	50	3,700	1949-92	P,M,L
15290200	Nancy Lake tributary near Willow AK	61°41'17"	149°57'58"	8.00	2.3	20	550	1980, 1983-92	P
15291000	Susitna River near Denali AK	63°06'14"	147°30'57"	950	1.0	50	4,510	1957-67, 1969-85	P,M,L
15291100	Raft Creek near Denali AK	63°03'04"	147°16'22"	4.33	0.0	30	4,700	1963-92	P
15291200	Maclaren River near Paxson AK	63°07'10"	146°31'45"	280	1.0	50	4,520	1958-85	P,M,L
15291500	Susitna River near Cantwell AK	62°41'55"	147°32'42"	4,140	2.0	30	3,560	1961-72, 1980-85	P,M,L
15292000	Susitna River at Gold Creek AK	62°46'04"	149°41'28"	6,160	1.0	30	3,420	1949-92	P,M,L
15292392	Byers Creek near Talkeetna AK	62°42'33"	150°11'30"	50.2	3.0	38	1,830	1972-81	P

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15292397	Troublesome Creek near Talkeetna AK	62°37'37"	150°13'26"	38.8	2.0	30	1,860	1978-81	P
15292400	Chulitna River near Talkeetna AK	62°33'31"	150°14'02"	2,570	1.0	55	3,760	1958-77, 1979-87	P,M,L
15292700	Talkeetna River near Talkeetna AK	62°20'49"	150°01'01"	2,006	0.0	35	3,630	1964-92	P,M,L
15292780	Susitna River at Sunshine AK	62°10'42"	150°10'30"	11,100	2.0	35	3,480	1971, 1981-87	P
15292800	Montana Creek near Montana AK	62°06'32"	150°03'12"	164	3.0	30	1,930	1963-72, 1986	P
15292900	Goose Creek near Montana AK	62°03'42"	150°03'20"	14.5	1.0	30	500	1963-71, 1984-86	P
15293000	Caswell Creek near Caswell AK	61°56'55"	150°03'14"	19.6	3.0	25	400	1963-87	P
15293700	Little Willow Creek near Kashwitna AK	61°48'37"	150°05'42	155	1.0	30	1,840	1980-87	P
15294005	Willow Creek near Willow AK	61°46'51"	149°53'04"	166	1.0	30	2,890	1979-92	P,M,L
15294010	Deception Creek near Willow AK	61°44'52"	149°56'14"	48.0	2.0	30	1,310	1978-87	P,M,L
15294025	Moose Creek near Talkeetna AK	62°19'00"	150°26'30"	52.3	9.0	35	800	1972-90	P
15294100	Deshka River near Willow AK	61°46'05"	150°20'13"	592	5.0	25	492	1979-87	P,M,L
15294300	Skwentna River near Skwentna AK	61°52'23"	151°22'01"	2,250	5.0	45	2,810	1960-82, 1986	P,M,L
15294345	Yentna River near Susitna Station AK	61°41'55"	150°39'02"	6,180	1.0	50	2,730	1981-86	P,M,L
15294350	Susitna River at Susitna Station AK	61°32'41"	150°30'45"	19,400	2.0	35	3,200	1975-90	P,M,L
15294410	Capps Creek below North Capps Creek near Tyonek AK	61°19'45"	151°39'56"	10.5	2.0	55	1,660	1980-86	P,M,L
15294450	Chuitna River near Tyonek AK	61°06'31"	151°15'07"	131	2.0	45	1,120	1976-86	P,M,L
15294500	Chakachatna River near Tyonek AK	61°12'44"	152°21'26"	1,120	4.0	80	3,900	1959-72	P,M,L
15295600	Terror River near Kodiak AK	57°39'05"	153°01'46"	15.0	3.0	130	2,300	1962-68, 1978-82	P,M,L
15295700	Terror River at mouth near Kodiak AK	57°41'49"	153°09'20"	45.7	1.0	90	1,860	1964-68, 1981-82	P
15296000	Uganik River near Kodiak AK	57°41'06"	153°25'10"	123	2.0	75	1,830	1952-78	P,M,L
15296550	Upper Thumb River near Larsen Bay AK	57°21'03"	153°58'04"	18.8	0.0	50	1,772	1974-82	P,M,L
15296600	Karluk River at outlet near Larsen Bay AK	57°26'37"	154°06'41"	100	16.0	40	1,390	1975-76, 1979-82	P,M,L

Appendix 1. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southcentral Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude						
15297200	Myrtle Creek near Kodiak AK	57°36'12"	152°24'12"	4.74	0.0	130	700	1963-92	P,M,L
15297300	Kalsin Bay tributary near Kodiak AK	57°35'25"	152°25'55"	2.35	0.0	120	530	1963-69	P
15297475	Red Cloud Creek tributary near Kodiak AK	57°49'00"	152°37'20"	1.51	0.0	120	720	1963-90	P

APPENDIX 2

Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska

[See plate 1 in Jones and Fahl (1994) for locations of gaging stations]

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Appendix 2. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska

[Analysis type: P, station used in peak flow analysis, M, station used in average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes & ponds (%)	Mean annual precip-itation (inches)	Mean minimum January temp-erature (°F)	Area of glaciers (%)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude								
15008000	Salmon River near Hyder AK	56°01'34"	130°03'55"	94.0	5.0	150	32	32	3,900	1963-73	M,L
15010000	Davis River near Hyder AK	55°45'00"	130°12'00"	80.0	0.0	175	27	11	3,400	1930-40	P,M,L
15010500	Halibut Bay tributary near Hyder AK	55°15'00"	130°06'00"	8.58	0.0	175	27	0	2,140	1963-70	P
15011500	Red River near Metlakatla AK	55°08'29"	130°31'50"	45.3	1.0	200	28	0	1,700	1963-78	P,M,L
15011870	White Creek near Ketchikan AK	55°24'51"	130°27'38"	2.70	0.0	200	27	0	2,440	1977-84	P,M,L
15011880	Keta River near Ketchikan AK	55°21'13"	130°26'56"	74.2	1.0	200	27	1	2,500	1977-84	P,M,L
15011900	Cabin Creek near Ketchikan AK	55°19'19"	130°47'00"	8.80	3.0	160	28	0	1,650	1964-71	P
15012000	Winstanley Creek near Ketchikan AK	55°24'59"	130°52'03"	15.5	5.0	160	28	0	1,730	1936-38, 1948-75	P,M,L
15014000	Punchbowl Lake outlet near Ketchikan AK	55°31'00"	130°44'00"	12.0	27.0	190	27	0	1,300	1923-30	M,L
15015600	Klahini River near Bell Island AK	56°03'15"	131°02'55"	58.0	0.0	180	26	5	2,790	1967-73	P,M,L
15018000	Shelokum Lake outlet near Bell Island AK	55°59'00"	131°39'00"	15.6	8.0	165	27	0	1,700	1915-21	P,M,L
15019000	Black Bear Creek near Meyers Chuck AK	55°43'30"	132°09'48"	16.5	1.0	100	28	0	1,070	1963-70	P
15020100	Tyee Creek at mouth near Wrangell AK	56°12'54"	131°30'25"	16.1	4.0	175	26	2	2,620	1927, 1963-69	P,M,L
15022000	Harding River near Wrangell AK	56°12'48"	131°38'12"	67.4	1.0	175	26	9	2,400	1951-92	P,M,L
15024750	Goat Creek near Wrangell AK	56°39'40"	131°58'14"	17.3	6.0	175	25	5	2,560	1976-86	P,M,L
15024800	Stikine River near Wrangell AK	56°42'29"	132°07'49"	19,920	1.0	40	14	10	4,310	1977-92	P,M,L
15026000	Cascade Creek near Petersburg AK	57°00'21"	132°46'45"	23.0	4.0	175	24	13	3,160	1917-20, 1923-28, 1946-73	P,M,L
15028300	Farragut River near Petersburg AK	57°10'24"	133°06'36"	151	5.0	175	24	26	2,540	1977-92	P,M,L
15030000	Sweetheart Falls Creek near Juneau AK	57°56'35"	133°40'55"	36.3	6.0	150	18	9	2,110	1915-17, 1918-27	M,L
15031000	Long River above Long Lake near Juneau AK	58°10'56"	133°53'06"	8.29	0.0	175	20	39	3,020	1965-75	P,M,L
15034000	Long River near Juneau AK	58°10'00"	133°41'50"	32.5	9.0	180	20	22	2,400	1916-22, 1927-31, 1952-73	P,M,L
15036000	Speel River near Juneau AK	58°12'10"	133°36'40"	226	1.0	175	20	25	3,100	1917-18, 1961-75	P,M,L

Appendix 2. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used in average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes & ponds (%)	Mean annual precip-itation (inches)	Mean minimum January temp-erature (°F)	Area of glaciers (%)	Mean basin elevation (feet)	Period of record	Analysis type
		Latitude	Longitude								
15038000	Crater Creek near Juneau AK	58°08'15"	133°46'15"	11.4	7.0	175	20	28	2,590	1915, 1917-18, 1920, 1927-32	P,M,L
15039900	Dorothy Lake outlet near Juneau AK	58°14'56"	133°58'54"	11.0	13.0	160	20	35	3,450	1986-92	P,M,L
15040000	Dorothy Creek near Juneau AK	58°13'40"	134°02'25"	15.2	12.0	150	20	16	3,100	1930-67	P,M,L
15041200	Taku River near Juneau	58°32'19"	132°42'00"	6,600	1.0	35.0	6.0	8.0	3,790	1987-92	M,L
15042000	Carlson Creek at Sunny Cove near Juneau AK	58°19'00"	134°11'00"	22.3	0.0	200	22	11	2,300	1916-20	P
15044000	Carlson Creek near Juneau AK	58°19'00"	134°10'15"	24.3	0.0	200	22	10	2,200	1951-61	P,M,L
15048000	Sheep Creek near Juneau AK	58°16'30"	134°18'50"	4.57	0.0	150	22	2	1,900	1918-20, 1947-73	P,M,L
15049900	Gold Creek near Juneau AK	58°18'26"	134°23'12"	8.41	0.0	140	22	6	2,280	1984-92	P,M,L
15050000	Gold Creek at Juneau AK	58°18'25"	134°24'05"	9.76	0.0	150	22	8	2,400	1917-20, 1947-48, 1949-82	P,M,L
15052000	Lemon Creek near Juneau AK	58°23'30"	134°25'15"	12.1	0.0	180	22	67	3,430	1952-73	P,M,L
15052500	Mendenhall River near Auke Bay AK	58°25'47"	134°34'22"	85.1	3.0	180	22	66	3,260	1966-92	P,M,L
15052800	Montana Creek near Auke Bay AK	58°23'53"	134°36'34"	15.5	0.0	100	22	3	1,500	1966-75, 1983-87	P,M,L
15053800	Lake Creek at Auke Bay AK	58°23'40"	134°37'50"	2.50	0.0	80	22	0	1,170	1964-73	P,M,L
15054000	Auke Creek at Auke Bay AK	58°22'56"	134°38'10"	3.96	8.0	80	22	0	1,160	1948-50, 1964-75	P,M,L
15054500	Bessie Creek near Auke Bay AK	58°35'30"	134°54'00"	1.35	0.0	80	22	0	1,100	1967-79	P
15056100	Skagway River at Skagway AK	59°28'02"	135°17'00"	145	0.0	100	0	17	3,900	1964-86	P,M,L
15056200	West Creek near Skagway AK	59°31'35"	135°21'10"	43.2	0.0	100	0	26	3,400	1962-77	P,M,L
15056210	Taiya River near Skagway AK	59°30'43"	135°20'40"	179	0.0	90	0	33	3,400	1967-77	P,M,L
15056400	Chilkat River at gorge near Klukwan AK	59°37'40"	135°55'55"	190	1.0	90	-6	36	4,820	1962-68	P,M,L
15056560	Klehini River near Klukwan AK	59°24'50"	136°00'07"	284	0.0	80	0	15	3,480	1981-92	P,M,L
15057500	William Henry Creek near Auke Bay AK	58°44'46"	135°14'25"	1.58	0.0	110	21	0	1,720	1967-76	P
15058000	Purple Lake outlet near Metlakatla AK	55°06'00"	131°26'00"	6.67	20.0	150	30	0	860	1947-56	P,M,L
15059500	Whipple Creek near Ward Cove AK	55°26'30"	131°47'38"	5.29	0.0	125	29	0	880	1968-80	P,M,L

Appendix 2. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used in average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location: Latitude	Location: Longitude	Drainage area (square miles)	Area of lakes & ponds (%)	Mean annual precip-itation (inches)	Mean minimum January temp-erature (°F)	Area of glaciers (%)	Mean basin elevation (feet)	Period of record	Analysis type
15060000	Perseverance Creek near Wacker AK	55°24'40"	131°40'05"	2.81	11.0	190	29	0	1,340	1932, 1938-39, 1946-69	P,M,L
15062000	Ward Creek near Wacker AK	55°25'50"	131°40'00"	14.0	7.0	180	28	0	1,040	1948-58	M,L
15064000	Ketchikan Creek at Ketchikan AK	55°20'40"	131°38'05"	13.5	8.0	180	28	0	1,280	1911-12, 1916-19, 1964-67	P,M,L
15066000	Beaver Falls Creek near Ketchikan AK	55°22'55"	131°28'25"	5.80	9.0	190	29	0	1,630	1928-32	P,M,L
15067900	Upper Mahoney Lake outlet near Ketchikan AK	55°24'50"	131°33'16"	2.03	6.0	200	29	0	2,500	1977-89	P,M,L
15068000	Mahoney Creek near Ketchikan AK	55°25'34"	131°30'40"	5.70	8.0	200	29	0	1,680	1923, 1927-33, 1948-58, 1980-81	P,M,L
1507000	Falls Creek near Ketchikan AK	55°36'54"	131°20'14"	36.5	5.0	200	28	0.0	1,800	1916-26, 1927-33, 1946-59	M,L
15072000	Fish Creek near Ketchikan AK	55°23'31"	131°11'38"	32.1	14.0	180	28	0	1,300	1915-35, 1939-92	P,M,L
15072200	Sea Level Creek near Ketchikan AK	55°22'05"	131°11'03"	18.6	8.0	180	28	0	720	1963-71	P
15074000	Ella Creek near Ketchikan AK	55°30'20"	131°01'25"	19.7	16.0	175	28	0	900	1928-38, 1947-58	P,M,L
15076000	Manzanita Creek near Ketchikan AK	55°36'00"	130°59'00"	33.9	9.0	200	27	0	1,300	1927-37, 1948-67	P,M,L
15078000	Grace Creek near Ketchikan AK	55°39'28"	130°58'14"	30.2	9.0	200	27	0	1,500	1927-36, 1963-68	P,M,L
15079800	Klu Creek near Bell Island AK	55°50'30"	131°25'20"	5.97	1.0	150	28	0	1,400	1963-68	P
15080000	Orchard Creek near Bell Island AK	55°50'00"	131°27'00"	59.0	3.0	150	27	0	1,600	1915-26	P,M,L
15081490	Yatuk Creek near Klawock AK	55°53'57"	133°08'42"	5.80	2.0	100	29	0	390	1971-79	P
15081500	Staney Creek near Craig AK	55°48'57"	133°07'58"	51.6	0.0	100	29	0	850	1964-81	P,M,L
15081580	Black Bear Lake outlet near Klawock AK	55°33'25"	132°52'33"	1.82	17.0	100	30	0	2,300	1980-91	P,M,L
15081800	North Branch Trocadero Creek near Hydaburg AK	55°21'41"	132°52'20"	17.4	0.0	140	31	0	1,050	1967-73	P,M,L
15081890	Natzuhini Creek near Hydaburg AK	55°17'18"	132°49'18"	9.10	0.0	140	31	0	1,030	1971-79	P

Appendix 2. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used in average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location: Latitude	Location: Longitude	Drainage area (square miles)	Area of lakes & ponds (%)	Mean annual precip-itation (inches)	Mean minimum January temp-erature (°F)	Area of glaciers (%)	Mean basin elevation (feet)	Period of record	Analysis type
15082000	Reynolds Creek near Hydaburg AK	55°12'50"	132°36'10"	5.70	16.0	175	31	0	1,600	1951-56	P
15083500	Perkins Creek near Metlakatla AK	54°56'48"	132°10'15"	3.38	0.0	150	32	0	730	1976-92	P,M,L
15085100	Old Tom Creek near Kasaan AK	55°23'44"	132°24'25"	5.90	4.0	100	30	0	1,000	1949-92	P,M,L
15085200	Dog Salmon Creek near Hollis AK	55°20'42"	132°30'24"	16.8	1.0	150	30	0	1,200	1963-70	P
15085600	Indian Creek near Hollis AK	55°26'58"	132°41'41"	8.82	0.0	100	30	0	1,000	1949-63	P,M,L
15085700	Harris Creek near Hollis AK	55°27'47"	132°42'11"	28.7	0.0	120	30	0	1,400	1949-64	P,M,L
15085800	Maybeso Creek at Hollis AK	55°29'26"	132°40'31"	15.1	0.0	120	30	0	1,120	1949-62	P,M,L
15086000	Karta River near Kasaan AK	55°33'50"	132°35'00"	49.5	6.0	100	29	0	1,000	1915-22	P,M,L
15086500	Neck Creek near Point Baker AK	56°05'55"	133°08'20"	17.0	9.0	110	29	0	500	1960-67	P,M,L
15086600	Big Creek near Point Baker AK	56°07'54"	133°08'56"	11.2	5.0	110	28	0	680	1963-81	P,M,L
15086900	Red Creek near Point Baker AK	56°15'36"	133°19'34"	11.2	6.0	125	28	0	980	1971-80	P
15087250	Twin Creek near Petersburg AK	56°43'13"	132°55'33"	3.01	0.0	100	25	0	1,110	1966-80	P
15087545	Municipal Watershed Creek near Petersburg AK	56°46'40"	132°55'07"	2.20	0.0	100	26	0	1,400	1978-88	P,M,L
15087570	Hamilton Creeek near Kake AK	56°52'21"	133°40'30"	65.0	0.0	70	26	0	493	1971-86 1989-92	P,M,L
15087585	Twelvemile Creek near Petersburg AK	56°58'07"	133°04'05"	9.39	1.0	120	25	1	960	1973-82	P
15087590	Rocky Pass Creek near Point Baker AK	56°37'10"	133°44'10"	2.72	2.0	100	27	0	358	1976-88	P,M,L
15087595	Kadake Creek near Kake AK	56°46'45"	134°00'42"	43.6	0.0	80	26	0	725	1972-82	P
15087610	Nakwasina River near Sitka AK	57°15'37"	135°19'54"	31.9	2.0	160	28	1	2,080	1976-82	P,M,L
15087690	Indian River near Sitka AK	57°04'01"	135°17'42"	10.1	0.0	140	28	0	1,340	1980-92	P,M,L
15088000	Sawmill Creek near Sitka AK	57°03'05"	135°13'40"	39.0	3.0	150	28	3	2,400	1928-42, 1945-57	P,M,L
15090000	Green Lake outlet near Sitka AK	56°59'14"	135°06'40"	28.8	1.0	160	28	7.0	2,100	1915-25	M,L
15092000	Maksoutof River near Port Alexander AK	56°30'00"	134°58'00"	26.0	12.0	200	29	1	1,500	1951-56	P
15093400	Sashin Creek near Big Port Walter AK	56°22'32"	134°39'40"	3.72	7.0	300	30	0	1,130	1965-80	P,M,L
15094000	Deer Lake outlet near Port Alexander AK	56°31'10"	134°40'10"	7.41	26.0	300	28	1	1,300	1951-67	P,M,L
15098000	Baranof River at Baranof AK	57°05'15"	134°50'30"	32.0	9.0	180	27	14	2,000	1915-27, 1958-74	P,M,L
15100000	Takatz Creek near Baranof AK	57°08'35"	134°51'50"	17.5	5.0	180	27	13	2,300	1951-69	P,M,L
15101500	Greens Creek near Juneau AK	58°05'18"	134°44'49"	22.8	1.0	80	22	0	1,880	1978-92	P,M,L

Appendix 2. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Southeast Alaska--Continued

[Analysis type: P, station used in peak flow analysis, M, station used in average flow analysis, L, station used in low-flow analysis]

Station number	Stream	Location: Latitude	Location: Longitude	Drainage area (square miles)	Area of lakes & ponds (%)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Area of glaciers (%)	Mean basin elevation (feet)	Period of record	Analysis type
15101600	Wheeler Creek near Douglas AK	58°01'49"	134°46'08"	57.1	0.0	80	24	0	1,710	1971-77	P
15101800	Fishery Creek near Angoon AK	57°45'45"	134°42'21"	54.3	0.0	80	24	0	1,300	1967-78	P
15102000	Hasselborg Creek near Angoon AK	57°39'40"	134°14'55"	56.2	11.0	100	24	1	1,200	1952-68	P,M,L
15102350	North Arm Creek near Angoon AK	57°23'48"	134°19'24"	8.64	0.0	75	24	0	1,020	1970-78	P
15106100	Black River near Pelican AK	57°42'19"	136°05'34"	24.7	1.0	140	28	0	930	1977-82	P
15106920	Kadashan River above Hook Creek near Tenakee AK	57°39'46"	135°11'06"	10.2	0.0	100	26	0	1,020	1968-92	P,M,L
15106940	Hook Creek above tributary near Tenakee AK	57°40'39"	135°07'42"	4.48	0.0	100	26	0	1,260	1968-80	P,M,L
15106960	Hook Creek near Tenakee AK	57°40'22"	135°10'40"	8.00	0.0	100	26	0	1,160	1968-80	P,M,L
15106980	Tonalite Creek near Tenakee AK	57°40'42"	135°13'17"	14.5	0.0	100	26	0	950	1968-88	P,M,L
15107000	Kadashan River near Tenakee AK	57°41'43"	135°12'59"	37.7	0.0	100	26	0	970	1964-80	P,M,L
15107920	Indian River near Tenakee AK	57°49'50"	135°16'00"	12.9	0.0	100	25	0	1,360	1976-82	P,M,L
15108000	Pavlof River near Tenakee AK	57°50'30"	135°02'09"	24.3	1.0	100	24	0	920	1957-81	P,M,L
15108250	Game Creek near Hoonah AK	58°03'02"	135°29'21"	42.8	0.0	80	24	0	1,100	1970-80	P
15108290	Gos Creek near Elfin Cove AK	58°11'49"	136°03'07"	16.7	1.0	100	26	0	1,360	1973-80	P
15108800	Lawson Creek at Douglas AK	58°17'05"	134°24'40"	2.98	0.0	100	22	0	1,600	1966-71	P
15109000	Fish Creek near Auke Bay AK	58°19'50"	134°35'20"	13.6	0.0	80	24	0	1,600	1958-78	P,M,L

APPENDIX 3

Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon Alaska

[See plate 1 in Jones and Fahl (1994) for locations of gaging stations]

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Appendix 3. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon, Alaska

[Analysis type: P, station used in peak flow analysis, A, station used in average flow analysis, L, station used in low-flow analysis

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record	Analysis type
		Latitude	Longitude						
15305900	Dennison Fork near Tetlin Junction AK	63°25'24"	142°29'00"	2.93				1964-92	P
15305920	West Fork tributary near Tetlin Junction AK	63°40'03"	142°16'00"	1.02	0.0	15	-22	1967-84 1990-92	P
15305950	Taylor Creek near Chicken AK	63°54'27"	142°12'58"	38.4	0.0	15	-22	1967-91	P
15344000	King Creek near Dome Creek AK	64°23'38"	141°24'43"	5.87	0.0	15	-22	1975-92	P,M
15348000	Fortymile River near Steele Creek AK	64°18'33"	141°24'08"	5,880	4.0	15	-22	1911-12, 1964, 1976-82	P,M
15356000	Yukon River at Eagle AK	64°47'22"	141°11'52"	113,500	1.0	12	-19	1911-12, 1950-92	P,M,L
15365000	Discovery Fork American Creek near Eagle AK	64°39'40"	141°18'00"	5.53	0.0	15	-22	1963-73	P
15367500	Bluff Creek near Eagle AK	64°45'08"	141°13'41"	3.38	0.0	15	-21	1963-72	P
15389000	Porcupine River near Fort Yukon AK	66°59'26"	143°08'16"	29,500	2.0	10	-29	1965-79	P,M,L
15389500	Chandalar River near Venetie AK	67°05'49"	147°11'04"	9,330	2.0	10	-18	1964-74	P,M
15438500	Bedrock Creek near Central AK	65°33'28"	145°05'26"	9.94	0.0	15	-24	1964-74 1989	P
15439800	Boulder Creek near Central AK	65°34'05"	144°53'13"	31.3	0.0	15	-24	1963-92	P,M
15442500	Quartz Creek near Central AK	65°37'09"	144°28'55"	17.2	0.0	15	-24	1967, 1969-79 1989-92	P
15453481	West Fork Dall River tributary near Stevens Village AK	66°17'53"	150°23'10"	4.18	0.0	15	-16	1982-92	P
15453500	Yukon River near Stevens Village AK	65°52'32"	149°43'04"	196,300	3.0	15	-21	1976-92	P,M,L
15453610	Ray River tributary near Stevens Village AK	65°56'57"	150°55'00"	8.00	0.0	10	-16	1977-92	P
15457700	Erickson Creek near Livengood AK	65°34'30"	148°56'18"	26.3	0.0	15	-16	1973-92	P
15457800	Hess Creek near Livengood AK	65°39'55"	149°05'47"	662	0.0	15	-16	1971-78, 1983-86	P,M
15468000	Yukon River at Rampart AK	65°30'25"	150°10'15"	199,400	3.0	15	-21	1956-67	P,M,L
15469900	Silver Creek near Northway Junction AK	62°59'01"	141°40'07"	11.7	1.0	10	-24	1963-72	P
15470000	Chisana River at Northway Junction AK	63°00'23"	141°48'17"	3,280	2.0	20	-23	1950-71	P,M,L

Appendix 3. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon, Alaska--Continued

[Analysis type: P, station used in peak flow analysis, A, station used in average flow analysis, L, station used in low-flow analysis

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record	Analysis type
		Latitude	Longitude						
15470300	Little Jack Creek near Nabesna AK	62°32'47"	143°19'30"	6.73	1.0	30	-20	1975-92	P
15470330	Chalk Creek near Nabesna AK	62°30'19"	143°09'24"	14.8	3.0	30	-20	1975-92	P
15470340	Jack Creek near Nabesna AK	62°27'52"	143°06'18"	115	1.0	30	-20	1975-83 1992	P
15471000	Bitters Creek near Northway Junction AK	63°09'38"	142°05'20"	15.4	0.0	10	-24	1964-86, 1989-90	P
15471500	Tanana River tributary near Tetlin Junction AK	63°16'45"	142°30'27"	2.43	0.0	10	-24	1965-90	P
15473600	Log Cabin Creek near Log Cabin Inn AK	63°01'48"	143°20'36"	10.7	0.0	20	-16	1965-91	P
15473950	Clearwater Creek near Tok AK	63°10'19"	143°12'03"	36.4	0.0	20	-20	1964-80 1985	P
15476000	Tanana River near Tanacross AK	63°23'18"	143°44'47"	8,550	2.0	18	-22	1953-90	P,M,L
15476049	Tanana River tributary near Cathedral Rapids AK	63°24'24"	143°48'28"	3.09	0.0	15	-15	1970, 1973-92	P
15476050	Tanana River tributary near Tanacross AK	63°24'27"	143°47'54"	3.32	0.0	15	-15	1964-72	P
15476200	Tanana River tributary near Dot Lake AK	63°41'40"	144°17'40"	11.0	1.0	15	-15	1964-80	P
15476300	Berry Creek near Dot Lake AK	63°41'23"	144°21'47"	65.1	1.0	18	-14	1964-92	P,M,L
15476400	Dry Creek near Dot Lake AK	63°41'32"	144°34'16"	57.6	1.0	18	-13	1964-90	P,M
15478000	Tanana River at Big Delta AK	64°09'20"	145°51'00"	13,500	2.0	22	-14	1949-57	P,M,L
15478010	Rock Creek near Paxson AK	63°04'16"	146°06'17"	50.3	7.0	30	-6	1963-87	P
15478040	Phelan Creek near Paxson AK	63°14'27"	145°28'03"	12.2	0.0	80	-7	1967-78, 1984-85 1990-92	P,M,L
15478050	McCallum Creek near Paxson AK	63°13'27"	145°38'56"	15.5	0.0	60	-7	1967-91	P
15478499	Ruby Creek above Richardson Highway near Donnelly AK	63°37'54"	145°52'14"	4.89	0.0	30	-8	1987-92	P
15480000	Banner Creek at Richardson AK	64°17'24"	146°20'56"	20.2	0.0	10	-16	1964-92	P
15484000	Salcha River near Salchaket AK	64°28'22"	146°55'26"	2,170	0.0	15	-19	1909-10, 1949-92	P,M,L
15490000	Monument Creek at Chena Hot Springs AK	65°03'17"	146°03'05"	26.7	0.0	16	-20	1967, 1970-92	P
15493000	Chena River near Two Rivers AK	64°53'55"	146°24'42"	941	0.0	16	-19	1967-92	P,M,L
15493500	Chena River near North Pole AK	64°47'47"	147°11'56"	1,440	0.0	15	-20	1972-80	P,M,L
15493700	Chena River below Moose Creek Dam	64°48'03"	147°13'40"	1,460	0.0	16	-20	1979-92	M,L

Appendix 3. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon, Alaska--Continued

[Analysis type: P, station used in peak flow analysis, A, station used in average flow analysis, L, station used in low-flow analysis

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record	Analysis type
		Latitude	Longitude						
15511000	Little Chena River near Fairbanks AK	64°53'10"	147°14'50"	372	0.0	15	-18	1967-92	P,M,L
15514000	Chena River at Fairbanks AK	64°50'45"	147°42'04"	1,980	2.0	15	-18	1947-92	P,M,L
15514500	Wood River near Fairbanks AK	64°26'06"	148°12'46"	855	0.0	15	-12	1969-78	P,M,L
15515500	Tanana River at Nenana AK	64°33'55"	149°05'30"	25,600	4.0	16	-15	1948, 1962-92	P,M,L
15515800	Seattle Creek near Cantwell AK	63°19'32"	148°14'49"	36.2	2.0	20	-6	1964-89	P,M,L
15515900	Lily Creek near Cantwell AK	63°19'54"	148°16'16"	5.63	0.0	20	-6	1966-81	P
15516000	Nenana River near Windy AK	63°27'28"	148°48'11"	710	2.0	30	-7	1951-56, 1959-81	P,M,L
15516050	Jack River near Cantwell AK	63°23'41"	148°55'13"	325	1.0	30	-5	1973-81	P
15516200	Slime Creek near Cantwell AK	63°30'34"	148°48'39"	6.90	0.0	30	-8	1966-91	P
15518000	Nenana River near Healy AK	63°50'43"	148°56'37"	1,910	1.0	25	-8	1951-79	P,M,L
15518080	Lignite Creek above mouth near Healy AK	63°54'17"	148°59'01"	48.1	0.0	25	-10	1986-92	P,M,L
15518200	Rock Creek near Ferry AK	64°01'56"	149°08'40"	8.17	0.0	25	-12	1965-80	P
15518250	Birch Creek near Rex AK	64°10'35"	149°17'26"	4.10	0.0	20	-14	1965-91	P
15518350	Teklanika River near Lignite AK	63°55'14"	149°29'51"	0.0	25	-8		1965-74	P,M,L
15519000	Bridge Creek near Livengood AK	65°27'52"	148°15'13"	12.6	0.0	15	-16	1963-72	P
15519200	Brooks Creek tributary near Livengood AK	65°23'02"	148°56'12"	7.81	0.0	10	-16	1964-90	P
15520000	Idaho Creek near Miller House AK	65°21'13"	146°09'33"	5.31	0.0	18	-20	1963-90	P
15530000	Faith Creek near Chena Hot Springs AK	65°17'32"	146°22'48	61.1	0.0	18	-20	1963-72	P
15534900	Poker Creek near Chatanika AK	65°09'32"	147°28'49"	23.1	0.0	15	-18	1971-78	M,L
15535000	Caribou Creek near Chatanika AK	65°09'00"	147°33'05"	9.19	0.0	15	-18	1970-86	P,M,L
15540070	Little Goldstream Creek near Nenana AK	64°39'52"	148°56'17"	41.8	1.0	15	-16	1967 1974-81	P
15541600	Globe Creek near Livengood AK	65°17'08"	148°07'56"	23.0	0.0	15	-16	1964-92	P
15541650	Globe Creek tributary near Livengood AK	65°16'31"	148°06'58"	9.01	0.0	15	-16	1963-72	P
15541800	Washington Creek near Fox AK	65°09'04"	147°55'22"	46.7	0.0	15	-16	1963-72	P
15564600	Melozitna River near Ruby AK	64°47'34"	155°33'39"	2,693	2.0	15	-17	1962-73	P,M,L
15564800	Yukon River at Ruby AK	64°44'28"	155°29'22"	259,000	4.0	15	-19	1957-78	P,M,L

Appendix 3. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon, Alaska--Continued

[Analysis type: P, station used in peak flow analysis, A, station used in average flow analysis, L, station used in low-flow analysis

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record	Analysis type
		Latitude	Longitude						
15564866	Nutirwik Creek near Wiseman AK	67°56'05"	149°49'00"	29.2	0.0	35	-16	1988-92	P
15564868	Snowden Creek near Wiseman AK	67°44'16"	149°45'10"	16.7	0.0	28	-18	1977-92	P
15564872	Nugget Creek near Wiseman AK	67°29'25"	149°52'20"	9.47	0.0	25	-18	1975-92	P
15564875	Middle Fork Koyukuk River near Wiseman AK	67°26'18"	150°04'30"	1,200	1.0	25	-16	Max. evident 1968, 1971-80, 1984-87	P,M
15564877	Wiseman Creek at Wiseman AK	67°24'38"	150°06'21"	49.2	0.0	25	-17	1971-79 1992	P,M
15564879	Slate Creek at Coldfoot AK	67°15'17"	150°10'24"	73.4	0.0	20	-18	1981-92	P
15564884	Prospect Creek near Prospect Camp AK	66°46'56"	150°41'06"	110	0.0	18	-18	1968, 1975-92	P
15564885	Jim River near Bettles AK	66°47'10"	150°52'23	465	0.0	18	-16	Max. evident 1971-77	P,M,L
15564887	Bonanza Creek tributary near Prospect Camp AK	66°36'52"	150°41'24"	11.7	0.0	20	-18	1975-92	P
15564900	Koyukuk River at Hughes AK	66°02'51"	154°15'30"	18,700	1.0	16	-17	1961-82	P,M,L
15565200	Yukon River near Kaltag AK	64°19'40"	158°43'10"	296,000	4.0	15	-18	1957-66	P,M,L
15565235	Ophir Creek near Takotna AK	63°08'42"	156°31'15"	6.19	0.0	20	-14	1976-80	P,M
15565447	Yukon River at Pilot Station AK	61°56'04"	162°52'50"	321,000	4.0	16	-17	1976-92	P,M,L

APPENDIX 4

Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon River Basin of Canada

[See plate 1 in Jones and Fahl (1994) for locations of gaging stations]

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Appendix 4. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon River Basin of Canada
[All stations used in peak flow analysis only]

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record
		Latitude	Longitude					
15304520	Lubbock River near Atlin BC	60°04'52"	133°51'30"	683	6.0	11	-14	1960-92
15304600	Atlin River near Atlin BC	59°35'57"	133°48'48"	2,630	9.0	12	-8	1950-84
15304650	Wann River near Atlin BC	59°25'55"	134°12'20"	104	4.0	32	0	1958-92
15304700	Fantail River at outlet of Fantail Lake near Atlin BC	59°35'40"	134°23'26"	277	2.0	32	-6	1957-92
15304750	Tutshi River at outlet of Tutshi Lake near Atlin BC	59°56'48"	134°19'29"	320	7.0	24	-9	1958-92
15304800	Lindeman River near Bennett BC	59°50'12"	135°00'44"	92.7	2.0	52	-5	1955-92
15304850	Wheaton River near Carcross YT	60°08'05"	134°53'45"	338	2.0	12	-10	1958-92
15304855	Watson River near Carcross YT	60°13'00"	134°43'50"	444	2.0	12	-12	1966-73
15304920	Tagish Creek near Carcross YT	60°17'32"	134°18'00"	29.7	1.0	12	-4	1957-70
15304950	Maclintock River near Whitehorse YT	60°36'45"	134°27'27"	656	1.0	12	-17	1956-92
15305000	Yukon River at Whitehorse YT	60°42'50"	135°02'35"	7,490	8.0	15	-10	c1944-92
15305030	Takhini River at Kusawa Lake at Whitehorse YT	60°36'46"	136°07'26"	1,570	5.0	16	-11	1953-86
15305040	Mendenhall River near Champagne YT	60°47'00"	136°17'00"	297	4.0	12	-18	1976-84
15305050	Takhini River near Whitehorse YT	60°51'08"	135°44'21"	2,700	4.0	14	-13	c1949-92
15305100	Yukon River above Frank Creek YT	61°26'04"	135°11'18"	11,900	6.0	14	-12	1953, 1955-92
15305150	Swift River near Swift River BC	59°55'50"	131°46'04"	1,280	1.0	18	-16	1958-92
15305200	Gladys River at outlet of Gladys Lake near Atlin BC	59°54'20"	132°54'50"	737	5.0	12	-12	1958-92
15305250	Teslin River near Teslin YT	60°29'07"	133°18'04"	11,700	3.0	13	-16	1944, 1948-92
15305260	Teslin River near Whitehorse YT	60°29'25"	134°46'35"	14,100	3.0	12	-17	1956-73
15305300	Big Salmon River near Carmacks YT	61°52'22"	134°50'00"	2,610	1.0	13	-20	1953, 1955-92
15305350	Yukon River at Carmacks YT	62°05'45"	136°16'18"	31,600	4.0	12	-16	1952-92
15305360	Big Creek near mouth near Minto YT	62°34'07"	137°00'58"	676	0.0	12	-12	1976-92
15305380	Riddell Creek near Ross River YT	62°41'00"	131°07'00"	21.0	0.0	24	-28	1975-82
15305385	180 Mile Creek near Ross River YT	62°18'00"	131°41'00"	32.1	0.0	20	-28	1975-84
15305390	Ross River at Ross River YT	61°59'40"	132°22'40"	2,800	3.0	12	-30	1962-92

Appendix 4. Basin characteristics of streamflow-gaging stations and crest-stage gages located in Yukon River Basin of Canada--

Station number	Stream	Location		Drainage area (square miles)	Area of lakes and ponds (percent)	Mean annual precipitation (inches)	Mean minimum January temperature (°F)	Period of record
		Latitude	Longitude					
15305400	Pelly River at Ross River YT	61°59'12"	132°26'54"	7,100	2.0	12	-26	1955-74
15305405	Vangorda Creek at Faro YT	62°14'00"	133°23'00"	35.2	0.0	15	-8	1977-84
15305406	Pelly River at Faro YT	62°13'20"	133°22'40"	8,530	1.0	12	-24	1973-92
15305411	South MacMillan River near Ross River YT	63°06'00"	130°12'00"	70.5	0.0	24	-21	1975-84
15305412	South MacMillan River at Canol Road near Ross River YT	62°55'20"	130°32'00"	385	1.0	24	-21	1975-92
15305420	Pelly River at Pelly Crossing YT	62°49'47"	136°34'50"	18,900	2.0	20	-20	1953-92
15305450	Yukon River above White River near Dawson YT	63°05'02"	139°29'40"	57,900	4.0	10	-18	1957-92
15305500	Kluane River at outlet of Kluane Lake YT	61°25'37"	139°02'56"	1,910	8.0	20	-20	1953-92
15305540	White River at Alaska Highway near Koidern YT	61°58'41"	140°33'10"	2,410	0.0	22	-18	1975-92
15305545	Dry Creek No. 2 near Beaver Creek YT	62°10'00"	140°40'00"	59.0	3.0	16	-30	1976-84
15305582	Stewart River above Fraser Falls near Mayo YT	63o29'17"	135o08'06"	11,810	2.0	15	-12	1980-92
15305590	Stewart River at Mayo YT	63°35'26"	135°53'48"	12,200	2.0	15	-12	1949-79
15305620	Stewart River at Stewart Crossing YT	63°22'56"	136°40'59"	13,500	2.0	15	-12	1961-73
15305650	Stewart River at mouth YT	63°16'55"	139°14'56"	19,700	1.0	12	-13	1964-92
15305670	Yukon River at Stewart YT	63°18'42"	139°25'43"	96,900	3.0	12	-18	1957-65
15305673	Sixty Mile River near Dawson YT	63°59'00"	140°48'00"	174	0.0	22	-24	1977-84
15305692	Grizzly Creek near Dawson YT	64°24'00"	138°18'00"	13.2	1.0	16	-19	1975-82
15305693	Wolf Creek near Dawson YT	64°22'00"	138°23'00"	22.4	3.0	16	-20	1975-82
15305695	North Klondike River near mouth near Dawson YT	64°01'16"	138°34'58"	425	0.0	16	-22	1975-92
15305698	Klondike River above Bonanza Creek near Dawson YT	64°02'34"	139°24'28"	3,010	0.0	16	-24	1966-92
15305700	Yukon River at Dawson YT	64°04'12"	139°25'30"	102,000	3.0	10	-18	1945-80
15388944	Porcupine River below Bell River YT	67°26'25"	137°47'01"	13,900	3.0	10	-30	1975-92
15388948	Old Crow River near mouth near Old Crow YT	67°38'04"	139°41'47"	5,370	30	10	-21	1976-89
15388950	Porcupine River at Old Crow YT	67°33'50"	139°53'00"	21,400	3.0	10	-30	1962-89
15388960	Porcupine River near International Boundary YT	67°25'27"	140°53'28"	23,100	3.0	10	-30	1988-92