Fishery Data Series No. 97-39

Annual Summary of Instream Flow Reservations and Protection in Alaska

by

Christopher C. Estes

December 1997

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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ABSTRACT

This report summarizes instream flow water rights applications and related activities of the Alaska Department of Fish and Game (ADF&G) during the eleventh year of the statewide instream flow program. The status of instream flow applications prepared by other agencies and the private sector in Alaska is also reported. Alaskan legislation, regulations, and other activities that influence instream flow protection are identified and reviewed.

Between July 1, 1996 and June 30, 1997, instream flow analyses were completed by the ADF&G for five river reaches: Copper River (two reaches), Klutina River, Salmon Creek, and Solomon River. Applications to acquire instream flow water rights (reservations) will be submitted to the Alaska Department of Natural Resources (DNR) for adjudication based on these analyses.

Seventy-three applications for reservations of water have been filed by the ADF&G under AS 46.15.145 of the Alaska Water Use Act since 1986. Ten have been granted by the DNR. During 1996 and 1997, DNR initiated adjudication procedures for 17 of the ADF&G's pending applications as part of an 18-month project (January 1996 to June 30, 1997) to eliminate the DNR backlog for all categories of pre-1996 pending water right applications. As of July 1997, the DNR succeeded in reducing a portion of their backlog. The timeline for tackling the remainder of the backlog of pending administrative actions, instream flow and other water rights applications, including completion of the ADF&G's partially adjudicated 17 applications has not been established.

Federal agencies and the private sector have filed 85 applications for reservations of water under AS 46.15.145. Four of these applications were filed by the U.S. Bureau of Land Management (one has been granted), seventy-nine by the U.S. Fish and Wildlife Service, and two by the private sector. With the exception of one of the pending private applications, the adjudication process has not been initiated by the DNR for the remaining eighty-three pending applications.

Two legislatively mandated reservations of water have been granted by the DNR to comply with instream flow protection provisions of the 1992 water sales and export amendments to the Alaska Water Use Act (AS 46.15.035 and AS 46.15.037). The reservations were granted as part of the adjudication process for the Blue Lake water export project in Sitka.

Instream flow protection was also achieved through other state and federal mechanisms, but is not reported in detail.

An evaluation to identify and select options for reducing the state's costs associated with managing water allocation in Alaska was completed by the DNR in 1997. Options ranged from eliminating the Alaska Water Use Act to retaining the status quo. The DNR selected to maintain the status quo for the time being, but, plans to propose regulatory changes in the future.

Key words: instream flow, flow reservation, water rights, adjudication, Alaska Water Use Act, statutes, AS 46.15, Regulations, Tennant Method, Montana Method, flushing flow, Klutina River, Salmon Creek, Copper River, Solomon River, Blue Lake, Sawmill Creek, negotiation, water marketing, water exports, hydropower, National Instream Flow Program Assessment, Public Trust Doctrine, Instream Flow Council, water management, water allocation.

INTRODUCTION

Alaska has abundant and diversified sport fisheries which are of considerable recreational importance to anglers and others (Howe et al. 1997). Approximately 15,000 water bodies in Alaska have been formally identified as supporting anadromous and resident fish species (ADF&G 1994). Many others have yet to be investigated.

Sufficient water of good quality is among the most essential requirements for sustaining fish productivity within Alaska's fish bearing water bodies (e.g. rivers and lakes). Consequently, Alaskans are faced with the challenge of maintaining these conditions while satisfying needs for expanded municipal, community, and individual water supplies. Adding to this challenge are growing demands for water by private, government, and commercial developments, including the sale of water for export to other states and nations. Unless these increasing demands for and uses of Alaska's waters are properly managed, they will harm fish production and other instream uses through unacceptable modifications to flow characteristics in rivers (instream flows) and water volume in lakes.

Fortunately, the Alaska legislature amended the Alaska Water Use Act (AS 46) in 1980 in recognition of the economic and social benefits that would be derived from retaining sufficient water in rivers and lakes. These amendments (AS 46.15.03 and AS 46.15.145) are referred to as the "instream flow law".

The instream flow law provided the opportunity for private individuals; in addition to state, federal, and local government agencies, to legally acquire water rights (appropriations of water) to maintain a specific flow rate in rivers (or level of water in rivers and lakes) for one or a combination of four types of uses:

1) protection of fish and wildlife habitat, migration, and propagation;
2) recreation and parks purposes;
3) navigation and transportation purposes; and
4) sanitary and water quality purposes.

Under Alaskan law (AS 46.15.145) and regulations (11 AAC 93.970), an appropriation of water for these purposes is also defined as a "reservation of water". Reservations of water can be described as the rate or volume of flow in a river, the volume of water in a lake, or a related physical attribute such as water depth. A reservation of water to protect flow related characteristics can also be called an "instream flow reservation".

Subsequent amendments to the Water Use Act related to instream flow protection were approved in 1982 and 1992. The 1982 amendments established formal mechanisms for adjudicating Federal Reserved Water Rights (instream flow and out-of-stream) under the jurisdiction of the Alaska court system. The 1992 amendments provided water export and sales criteria, including mandatory instream flow protection for water bodies used for water export. Regulations to implement the original 1980 instream flow law were adopted by the Alaska Department of Natural Resources (DNR) in September 1983. Additional regulations were promulgated in 1990 (Estes 1992), 1993 (Alaska Administrative Code 1993 a, b, c) and 1996 (Alaska Administrative Code 1996a, b) relating to the instream flow and other water rights application processes, application fees for water rights, conservation fees for water exports, and administrative fees associated with processing new and existing water rights.

To reserve water, an application containing supporting data and analyses that substantiate the need for the amount of water being requested must be submitted to the DNR for adjudication (the administrative determination of the validity and amount of a water right, including the settlement of conflicting claims among competing appropriators). Forms required to apply for reservations of water were first made available by the DNR in November 1983. Further information related to Alaska's instream flow water laws can be found in Curran and Dwight (1979), White (1981), Estes (1984), Estes and Harle (1987), Harle (1988), Estes (1987-1995), and Harle and Estes (1993).

The Fish and Game Act (AS 16) requires the Alaska Department of Fish and Game (ADF&G) to, among other responsibilities, "…manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state"

(AS 16.05.020). AS 16.05.050 enables the ADF&G to acquire water rights to further its objectives or purposes. The Division of Sport Fish of the ADF&G initiated an ongoing program in 1986 to take advantage of the new opportunity to acquire instream flow water rights for sport fishery resources and related instream uses.

This report summarizes the eleventh year of this program (July 1, 1996 to June 30, 1997) in which the primary objective was to estimate seasonal quantities of instream flows necessary to sustain sport fishery resources in four stream reaches. The status of instream flow related activities of other agencies and the private sector is also provided and supplemented by relevant summaries of Alaskan legislation, regulations, and administrative actions.

METHODS

STUDY DESIGN

Procedures for site selection, instream flow analysis, and completing applications for instream flow reservations were selected to comply with requirements established by state law (AS 46.15.145), state regulations (11 AAC 93.141-146), reservation of water application form instructions (Estes 1993), and the *State of Alaska Instream Flow Handbook* (DNR 1985).

SITE SELECTION

Four water bodies (Figure 1; Appendices A1-A3) were selected for instream flow analyses and preparation of instream flow reservations in Fiscal Year 1997 (FY 97, July 1, 1996 to June 30, 1997): Copper River (two reaches), Klutina River, Salmon Creek, and Solomon River.

Water bodies were nominated and selected following procedures in the 1984 Departmental Instream Flow Work Plan (ADF&G 1984, Estes 1985), and as modified in 1986 (Instream Flow Committee 1986).

Final selections of a water body and portions of water bodies to be reserved site were made by the Statewide Instream Flow Coordinator in consultation with Regional Supervisors for each region of the Division of Sport Fish or designees. Selections were based on the importance of a water body to the sport fishery resources, the likelihood for competing out-of-stream uses, whether existing hydrologic and biologic data for a stream reach were adequate for performing an instream flow analysis (including the subsequent preparation and submission of an application), and whether other state and federal statutory mechanisms would provide better or more cost effective protection than an instream flow water right acquired under Alaskan law.

Stream reach boundaries for each FY 97 instream flow application were selected to insure that flow, habitat, and fish periodicity (seasonal use of habitat for passage, spawning, incubation, and rearing) characteristics within the reach were relatively uniform throughout the study reach.

Reaches were defined on U.S. Geological Survey (USGS) topographic maps with the assistance of ADF&G biologists and USGS hydrologists. Topography, watershed, and channel patterns, fish periodicity, USGS gage site descriptions and mean daily flow data were collectively analyzed.

Fish periodicity data for defining stream reaches and flow requirements were obtained and summarized from reviews of scientific literature, interviews with fishery and habitat biologists from the ADF&G and other

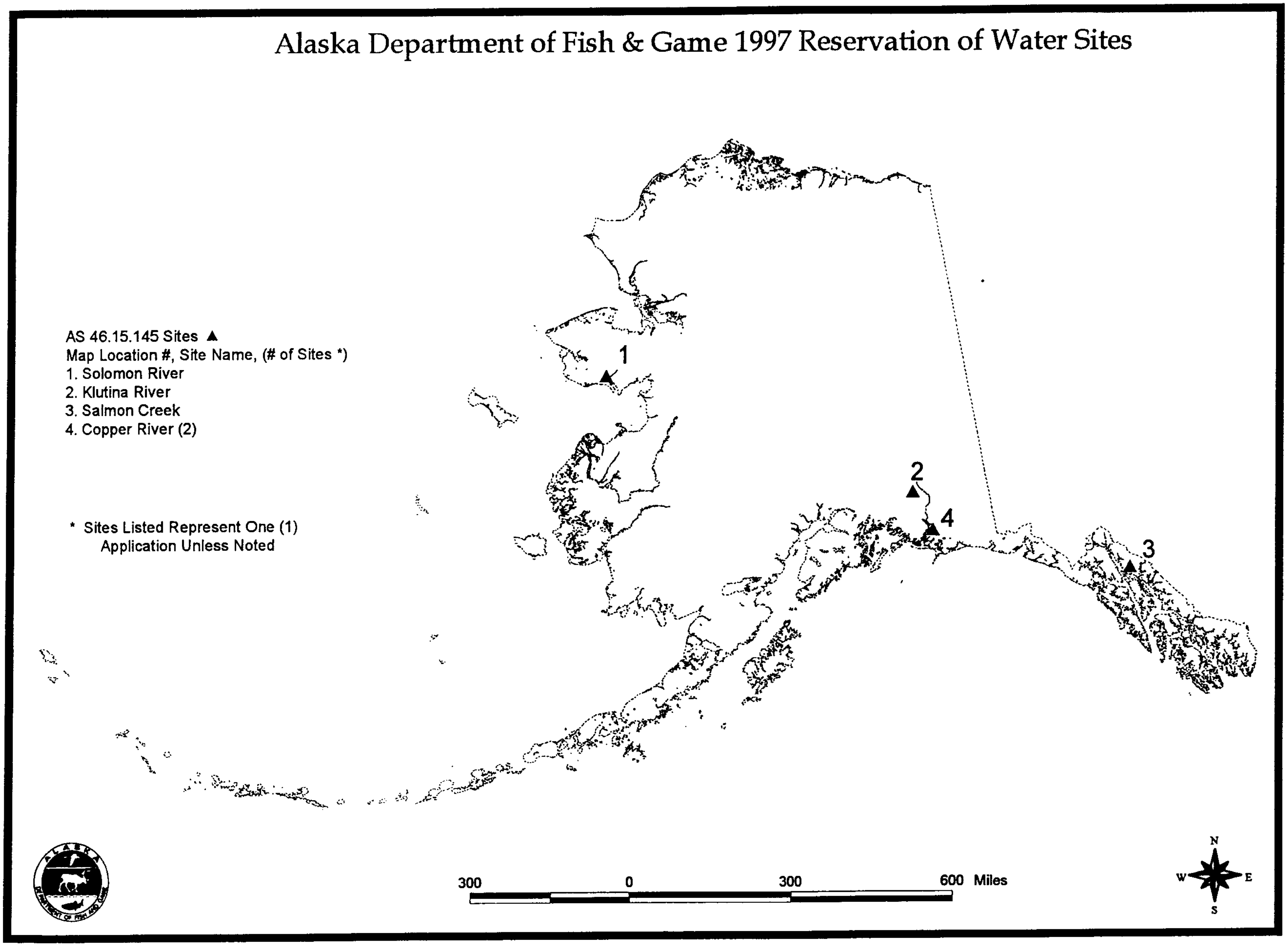

Figure 1.-Locations of July 1, 1996 to June 30, 1997 Alaska Department of Fish and Game reservation of water sites.

agencies, the *Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1994), and *Harvest, catch, and participation in Alaska sport fisheries during 1995* (Howe et al. 1996).

ADF&G biologists (responsible for the areas encompassing targeted instream flow reaches) reviewed and refined the syntheses of periodicity data. If discrepancies were discovered among data sources for species distribution and life phase occurrence within a reservation reach area, individuals responsible for data sources were consulted to reach a consensus as to which data to use. The final periodicity chart was based on these consultations.

Flow data and gage site descriptions used for delineating reach boundaries were obtained from USGS *Water Resources Data for Alaska* reports; and from interviews with ADF&G biologists, USGS hydrologists, DNR Division of Mining and Water hydrologists and water resource specialists, and other resource specialists that are known to have data pertinent to the reservation.

Alaska water laws and regulations required that stream reach boundaries encompassed a stream reach with homogeneous flow and biologic characteristics. Boundaries were first determined by evaluating watershed and channel characteristics upstream and downstream of a stream gage or discharge site.

Seasonal fish distribution and species periodicity were used to refine reach boundaries that were hydrologically defined. The resulting selection of boundaries were then refined based upon reviews by USGS hydrologic personnel and ADF&G's regional biologists.

INSTREAM FLOW ANALYSIS

An applicant's choice and use of a specific method for quantifying instream flow requirements is not restricted by existing Alaska water laws, regulations, or a set of established standards (DNR 1985, Estes and Harle 1987, Alaska Administrative Code 1993a). However, the rationale for the selection of a method or methods must be documented and include a description of the procedures. This information must accompany the resulting instream flow application.

The Tennant Method, also referred to as the Montana Method (Tennant 1972, 1976), was selected as the primary basis for quantifying instream flow requirements for the FY 97 study sites. The Tennant Method analysis was combined with an evaluation of mean daily flows, mean monthly flows, duration flows, and other hydrologic characteristics (Orsborn and Watts 1980, Estes 1984, Estes and Orsborn 1986, Shaw 1988). The combined analyses were used to determine whether sufficient water could be expected to be within each study reach during the various periods of the year in which the reservation was requested, and to enable a refinement of the instream flow choices derived with these analyses.

USGS surface water flow data, required for performing all of these analyses, were obtained from local USGS computers, USGS annual reports and USGS staff. Each data set was transferred into Statistical Analysis System (SAS) data files (SAS 1990). Summary analysis was used to check the data for simple errors.

After initial error checking was complete, the data were analyzed by a series of SAS programs using the procedures outlined below to estimate the long-term average annual and average monthly mean daily flow values and the monthly (and/or semi-monthly) flow duration parameters.

Descriptive information pertaining to the fishery and hydrologic characteristics of the study sites were acquired through literature review and interviews with ADF&G's biologists, USGS' hydrologists, the DNR's Division of Mining and Water hydrologists, and other state, federal, and private resource specialists that were known to have data pertinent to the reservation analyses.

ADF&G biologists and USGS hydrologists, most familiar with each study site, assisted with the refinement of this information whenever discrepancies occurred.

Tennant Method

The choice of the Tennant Method was based on its acceptance by both the DNR and Alaska courts as a valid instream flow analytical procedure (Supreme Court of Alaska 1995), and the limited availability of data, previous analyses, and financial resources required to prepare instream flow applications.

The first step of the Tennant Method was to calculate the average annual flow, QAA, (arithmetic mean of the annual mean of mean daily flows for all years of record) for each stream reach.

Next, each QAA was multiplied by eight Tennant Method coefficients (percentages) to calculate instream flows for eight habitat categories.

Seven of the Tennant Method habitat categories (ranging from 10% to 100% of the QAA) represent a range of poor to optimum habitat quality conditions for fish and wildlife.

The eighth category (200% of the QAA) represents the short-term flushing flow that Tennant (1972) considers necessary to maintain channel substrate characteristics suitable for fish spawning and egg incubation, and benthic invertebrate production. Research by Estes (1984, Reiser et al. 1985) suggests supplemental analyses are required to modify or substitute for Tennant Method flushing flow calculations.

Next, hydrologic analyses were performed to estimate baseline flow conditions in each stream reach. This involved calculating mean monthly flows (QAM), the arithmetic mean of the monthly mean daily discharge for a given month for the entire period of record, and flow duration estimates (the frequency of occurrence of mean daily flows within a particular month).

Finally, seasonal instream flow requirements for individual life phases of fish for each stream reach were chosen by comparing the eight Tennant Method flows, fish periodicity data, QAM, and flow duration estimates. With the exception of flushing flows, instream flows were selected that corresponded to both fish periodicity and the highest of the other seven Tennant Method habitat categories that did not exceed flow duration estimates during that same period.

During the months when spawning occurs, flows within the highest qualitative instream flow condition were selected from the Tennant analysis output that did not exceed those estimated by other hydrologic analyses (i.e. mean monthly flow or duration analysis values) during that same time period.

During other life phase time periods, the highest of the flows were selected that were expected to occur within the system during that time period that fell within the Tennant ranges of "fair to excellent".

When more than one life phase occurred for the same or different species during the same time period, the life phase for that time period requiring the highest instream flow value were requested for that time period.

A flushing flow calculation was calculated as part of the Tennant Method analyses, but not used to file for a flushing flow water right due to provisions in the Water Use Act (AS 46.15.145) that are interpreted by the DNR to limit reserving this type of flow to water bodies with controlled flows. Resources were unavailable to perform supplemental flushing flow analyses recommended by Estes (1984) for refining and supplementing flushing flow results derived by using the Tennant Method.

Average Annual Flow Procedures

Calculation of QAA, from the existing USGS mean daily flow records for the stream reaches, involved first obtaining the mean of the mean daily flows within each water year (October 1-September 30):

$$qaa_h = \frac{\sum_{i=1}^{d_h} q_{hi}}{d_h}; \qquad (1)$$

where: qaa_h equaled the mean annual daily flow for each year (h) of record; d_h equaled the number of days in each year of record (note that only complete years of record were used in this analysis; d_h varied only between leap and non-leap years); q_{hi} equaled the daily mean flow in cubic feet per second for each day in the record.

Next, QAA was estimated as a mean of the annual mean daily flow values over all complete years of record:

$$Q\hat{A}A = \frac{\sum_{h=1}^{n} qaa_h}{n}; \qquad (2)$$

where: n equaled the years of record (with complete daily flow records for each water year).

Mean Monthly Flow Procedures

The QAM was estimated similarly by first estimating the mean daily discharge for each complete month in the record:

$$qam_{jh} = \frac{\sum_{k=1}^{d_{jh}} q_{jhk}}{d_{jh}}; \qquad (3)$$

where: qam_{jh} equaled the monthly mean daily flow for each month (*j*) for each year of record (*h*); d_{jh} equaled the number of days in each month of record (note that only complete months of record were used in this analysis); q_{jhk} equaled the daily mean flow in cubic feet per second for each day in the record.

Next, QAM was estimated as a mean of the monthly mean daily flow values over all complete years of record:

$$Q\hat{A}M_j = \frac{\sum_{h=1}^{n} qam_{jh}}{n_j}; \qquad (4)$$

where: n_j equaled the years of record with complete daily flow records for each *j*.

Duration Analysis Procedures

Flow duration estimates were calculated as percentiles of the distribution of observed values within the time periods involved over the years of record. For example, flow duration estimates for the month of April were calculated by combining all mean daily flow values for April (for all years having complete April records). Then the empirically defined distribution (observed-combined mean daily flow values) was calculated as follows. If the quantity to be calculated was defined as the "t^{th}" percentile, where p = t / 100, then setting:

$$np = j + g$$

where: n was equal to the number of observed mean daily flow values in the combined group (for example 300 days for a 10 year- record of complete months of April); j was the integer part of n times p; and g was the fractional part of n times p. For example, if n = 300 and we wanted to calculate the 97th percentile, then j = 291 and g = 0; or for the 2.5th percentile, then j = 7 and g = 5.

Then the t^{th} percentile (y) was defined as:

$$y = \left(x_{(j)} + x_{(j+1)}\right) / 2 \qquad \text{if } g = 0; \quad (5a)$$

or

$$= x_{(j+1)} \qquad \text{if } g > 0; \quad (5b)$$

where: $x_{(j)}$ and $x_{(j+1)}$ were the ordered (from smallest to largest) values in the combined group of mean daily flow values.

The above and other legally required information was combined and used for preparation of instream flow applications following procedures defined by state law, state regulations, and other administrative requirements (ADNR 1985, Estes 1993, Harle and Estes 1993).

RESULTS

Analyses were completed and applications prepared to request instream flow protection for fish in five stream reaches in four river systems (Figure 1; Appendices A1-A3; ADF&G 1997a, b, c, d, e): Copper River (Reach A), Copper River (Reach B), Klutina River, and Salmon Creek, and Solomon River.

Four of the applications are undergoing normal review prior to submitting them to the DNR. The fifth, for Salmon Creek, is being processed differently than prior applications. After routine analyses were completed for the Salmon Creek site, it became apparent that supplemental information and analyses were needed prior to approving and filing an application. This was due to potentially conflicting federal and state jurisdictions associated with hydropower production and a variety of existing water rights conflicts and insufficient data that will be impacted by this reservation. Without further analyses, and an assessment of other water rights considerations, this application could harm other instream flow water uses important to sport fisheries in adjacent areas. And, resources for additional analyses were not available.

Although this is the first experience where these complications have impacted the completion of a reservation, similar candidate sites for future reservations have since been identified in Southeast Alaska. These complications primarily result from a mosaic of past water use allocations approved during the early period of statehood, and in some instances, decisions made during territorial days.

Also of special interest, is the Solomon River application. It is based on 1990 regulation changes in 11 AAC 93.142 allowing limited and incomplete data and analyses to be used to obtain a priority date in advance of collecting additional data needed to refine and finalize the reservation request (Estes 1991, Harle and Estes 1993).

The Solomon site had partial flow records (see below) restricting the ability of the ADF&G to request instream flows for the entire year. It is anticipated other resources will soon become available to augment these data for further analyses to refine the initial application.

The lengths of the five stream reaches, ranged from approximately 1.5 miles (Salmon Creek, Appendix A2) to 40 miles (Copper River-Reach A, Appendix A1).

Fish periodicity for each stream is illustrated in Appendices A4-A8. Salmon Creek (Appendix A7) and had the lowest variety of fish species reported (4) and Klutina River A (Appendix A6) had the most species (12). Appendix A9 lists the common and scientific names of the fish species listed in the periodicity charts (Appendices A4-A8).

Historical records of USGS mean daily flow data varied from less than two years of partial years of record for Solomon River to 37 years for Copper River-Reach B (Appendix A10).

QAA, mean monthly flow, and Tennant Method results are summarized in Appendices A11-A16. QAA values ranged from 41 cubic feet per second (41 cfs) for Salmon Creek (Appendix A14) to 63,620 cfs for the Copper River-Reach A (Appendix A11). Mean monthly flows ranged from 22 cfs in Salmon Creek during March (Appendix A14) to 183,000 cfs in the Copper River-Reach A during July (Appendix A11). Optimum habitat flows ranged from 25-41 cfs for Salmon Creek (Appendix A14) to 38,172-63,620 cfs for Copper River-Reach A (Appendix A11) . Poor habitat flows ranged from 4 cfs for Salmon Creek (Appendix A14) to 6,362 cfs for Copper River-Reach A (Appendix A11). Tennant flushing flow values ranged from 82 cfs for Salmon Creek (Appendix A14) to 127,240 cfs for the Copper River-Reach A (Appendix A11).

Instream flow values requested usually ranged from 60% to 100% of the QAA for the spawning and passage seasons, and 10% to 40% of the QAA for incubation and rearing seasons (ADF&G 1997a, b, c, d, e).

There is presently no legal mechanism for reserving flushing flows in unregulated streams and rivers in Alaska. Research by Estes (1984) suggests flushing flow calculations, using the Tennant Method, require additional analyses that were not funded. Therefore, Tennant values were not modified and used for reserving flushing flows for the five six river reaches.

A flushing flow statement was included in each instream flow application to establish a basis for protecting flushing flows in these unregulated systems (until an acceptable method is developed for use under state law). The statement explained that flushing flows were required to maintain fish habitat and (at a minimum) must be safeguarded whenever significant flow modifications or a structure capable of controlling flows were planned.

Instream flow regimes requested are not included in this report because they are subject to modification both while undergoing departmental review prior to submission to the DNR and during the various stages of the DNR adjudication process. These data will be presented in future reports following the completion of these processes. Past experiences indicate DNR's adjudication of reservation of water applications (filed by the ADF&G and other applicants) is often delayed several years beyond the time of application submittal.

DISCUSSION

RESERVATIONS OF WATER

Status of Applications

Between 1980 and November 1997, the DNR received a combined total of 164 applications for reservations of water (under AS 46.15.145) from the ADF&G, federal agencies, and private sector (Appendix A17, Estes 1987-1996, Harle 1988, Harle and Estes 1993; Keith Bayha, U. S. Fish and Wildlife Service, USFWS, Anchorage, personal communication, Mary Lu Harle, USFWS, Anchorage, personal communication, Bernice Sterin, U. S. Bureau of Land Management, BLM, Anchorage, personal communication).

Not including the 1997 ADF&G applications, 73 instream flow applications have been completed by the ADF&G (72 for rivers and one for a reservation of water in a lake), four by the BLM, 79 (13 rivers and 66 lakes) by the U.S. USFWS, four by the Anchorage Audubon Society, two by private individuals, one by the Arctic Unit of the Alaska Chapter of the American Fisheries Society (AFS), one by the Juneau Chapter of Trout Unlimited (TU), and another six by the private sector.

The 158 ADF&G, BLM, USFWS, TU, and AFS applications met the DNR requirements and were accepted for adjudication. The other six private applications were rejected by the DNR in the early 1980s for a variety of reasons (Estes 1993, Harle and Estes 1993). One of the BLM and 10 of the ADF&G applications for instream flow reservations have been adjudicated and granted by the DNR (Estes 1994).

No ADF&G pending applications for reservations of water have been completely processed and granted since 1990. Adjudications for two of the ADF&G's applications were initiated in 1996 (Estes 1996) and 15 more on June 30, 1997. These 17 adjudications were initiated by the DNR as part of an 18-month project (that began in January 1996) to adjudicate all classes of pre-1996 water rights applications (Estes 1996).

While DNR attempted to reduce its pre-1996 backlog, all water rights applications filed after December 31, 1995 were added to a new backlog unless a special exemption for an expedited review was obtained by an applicant. Although the backlog project was to end on June 30, 1997, an estimated 200 pending pre-1996 water rights applications, (including the 17 ADF&G adjudications in progress) and approximately 1,000 administrative actions remain to be processed and/or completed.

A schedule has not been established by the DNR for addressing the remaining ADF&G applications pending adjudication by the DNR (Estes 1992-1996, Harle and Estes 1993). Some of the pending ADF&G applications were filed nine years ago.

Other Reservation of Water Categories

Two instream flow reservations were granted by the DNR (under AS 46.15.035) in 1996 as part of the adjudication process for a water right application filed by the City and Borough of Sitka to export water from Blue Lake. Water exports require mandatory reservations of water with a 1992 priority date to protect fish resources (Estes 1992, 1996, Harle and Estes 1993) per 1992 amendments to the Alaska Water Use Act (AS 46.15.035 and AS 46.15.037).

Obstacles to Current and Future Protection

More than 15,000 fish bearing freshwater bodies (ADF&G 1994) are potentially subject to water extraction and flow modification in Alaska. Thus, it is not surprising the Alaska Legislature and Governor approved amendments to the Alaska Water Use Act in 1980 to allow for the formal reservation of water (AS 46.15.145) for, among other reasons, to help sustain the production of Alaska's invaluable fishery resources in rivers and lakes. To qualify for water rights protection under AS 46.15.145, many of these 15,000 fish bearing rivers must be subdivided into five or more individual instream flow reservation reaches. Each of these reaches will require a separate instream flow reservation application. Therefore by multiplying the 15,000 anadromous water bodies by a conservative estimate of only four reaches equals 60,000 potential instream flow reaches requiring protection. One may therefore question why less than 100 river reaches and 2 lakes (out of an estimated 60,000 or more fish bearing river reaches and thousands of lakes) have been targeted for formal instream flow and related protection during the past 10 years. And of the applications for reservations of water filed and accepted, why have so few been granted; and, why are the remainder pending adjudication? There are several reasons; among them are: insufficient allocations of personnel and financial resources needed for performing application and adjudication functions related to the reservation of water, insufficient hydrologic data required for defining water availability and instream flow requirements, lengthy administrative processes for preparing and adjudicating applications for water reservations, insufficient public education relating to instream flow and other water reservation protection opportunities, and except for state agencies, reservation of water application fees (Estes 1993, Harle and Estes 1993).

Limited Hydrologic Data

The dearth of hydrologic data in Alaska is perhaps the most limiting factor governing our ability to define instream flow and other water uses. Although Alaska has approximately 40 percent of the nation's surface freshwater supply (Harle and Estes 1993), only 386 USGS continuous flow stream gaging sites have been established in Alaska since 1908 (Meyer 1997). This equates to flow measurements for less than 1 percent of Alaska's water bodies. Seventeen of these Alaskan gage sites have less than 1 year of continuous flow data, 110 have 1 to less than 5 years of continuous flow data (of which 21 have 1 year of data), 79 have 5 to less than 10 years of continuous flow data, 108 have 10 to less than 20 years of continuous flow data, 69 have 20 to less than 50 years of continuous flow data, and 3 sites have 50 or more years of data (Appendix A18). Typically, no more than 20 percent of these Alaskan gages are active in any one year due to funding restrictions (Estes 1991-1996, Brabets and Hawkins 1995, Brabets 1996, Meyer 1997).

Seventy-five USGS gaging stations were operating in Alaska during Water Year 1997, October 1, 1996 to September 30, 1997 (Meyer 1997). This represents an average of approximately one stream gage per 8,400 square miles in Alaska. Alaska’s density of gages contrasts significantly with the lower “48” average of one gage site per 400 square miles.

The stream gaging trend in Alaska is especially alarming, because as of September 30, 1997, only 47 percent (180) of the 386 Alaskan gage sites (Appendix A18) could meet the USGS 10 year-minimum historical data standards for supporting a statistically reliable regional flow analysis. Daily stage and water surface elevation data are non-existent for the majority of Alaskan lakes.

The limited availability of real-time and historical hydrologic data for Alaska has resulted in the majority of requests for withdrawing and impounding water or acquiring instream flows being based on estimates of flows. To estimate flows, one must use regional hydrologic models and/or extend limited data bases through correlation with a limited number of longer-term sites. In the absence of long-term data, it is obvious the USGS databases, from which these models were developed, limit the ability to evaluate naturally occurring hydrologic patterns at ungaged sites (and sites with limited historical flow data) with confidence.

It is more time consuming to estimate flow characteristics for streams having a limited or non-existent database as opposed to summarizing data for a stream having an adequate historical record. Precipitation information also required for these ungaged flow models is also limited, further complicating the process for estimating flow availability. Similar data limitations hamper efforts to quantify water reservations for lakes.

Basic hydrologic data are required by all potential water users (out-of-stream and instream), and water management agencies to enable them to project the reliability and amount of water that might be available, even if there were no other competitors for their targeted water source. Continuous flow and stage data are also necessary to manage and enforce existing water rights.

Limited road systems, extremes in weather conditions, and difficulties such as loss of equipment to bears and other wildlife make data collection difficult and expensive in Alaska.

It should be obvious that additional gaging stations should be added for a minimum of 10- to 20 years to improve the accuracy of the information used to make decisions pertaining to water availability and allocation in Alaska. Unless a commitment is made to close these data gaps in Alaska, we will continue to be limited to making decisions regarding water allocation using these models with little or no hope for improving the precision or accuracy of our flow estimates.

Limited Financial Resources

In an attempt to compensate for limited financial and personnel resources and the above hydrologic conditions, the ADF&G has developed and refined a cost-effective approach to acquire the majority of its instream flow protection for fish by using the Tennant Method as its primary technique for analyzing instream flow needs. When necessary, this method has been modified and new procedures (requiring minimal resource expenditures) were developed (Estes 1989, 1992) to request specialized instream flow and related reservations of water (e.g., flushing flows, and water depth and area in lakes).

As a rule, uses of more sophisticated and expensive methods for reserving water, such as the Instream Flow Incremental Methodology (Bovee 1982) have been limited to situations where competition between out-of-stream uses and instream related requirements was likely to be highly controversial and required an incremental quantitative flow analysis.

Projects under federal jurisdiction (e.g., projects requiring a Federal Energy Regulatory License) have occasionally mandated a specific data collection and analytical procedure. Basin wide adjudications for quantifying Federal Reserved Water Rights may also require the use of more costly data collection and analysis processes.

Unfortunately, supplemental funding, available in the past for projects requiring application of more sophisticated methods, has become increasingly difficult to obtain. Funding has also been unavailable to systematically evaluate whether reservations of water have been providing the desired protection and to monitor whether water uses have been in compliance with governing appropriations.

Insufficient distribution and life history data combined with habitat suitability data are also limiting.

Duration of Administrative Processes

Administrative processes can be an added deterrent to potential and existing applicants, for reservations of water, including the ADF&G. Based upon past experiences, an estimated 1- to 3-weeks of an applicant's time may be required to participate in the various phases of the DNR adjudication process for each outstanding instream flow application (Estes 1994).

Adding to an applicant's frustration, is the absence of a fixed timetable for the DNR to adjudicate water rights applications after they are filed. There have been no completed adjudications of the ADF&G's and other applicants' pending applications for reservations of water (filed under AS 46.15.145) since 1991 (Estes 1992-1996, Harle and Estes 1993). However, under AS 46.15.035 and .037, the DNR recently granted two mandatory reservations of water required by 1992 water export amendments to the Water Use Act (Estes 1996). And as noted above, the adjudication of 17 of ADF&G's pending reservation of water applications, as part of the former DNR backlog project, has been initiated by the DNR.

The DNR's variable schedule for processing water rights applications for instream flow and other water reservations, and the overall backlog of water rights actions by the DNR adds another obstacle and level of difficulty. The unscheduled initiation of the adjudication of so many former applications at once cannot be accommodated under the existing ADF&G program.

Prior to 1996, DNR's water rights application backlog was estimated to have been growing at a ratio of approximately one reservation of water application per ten applications for out-of-stream water rights.

Complicating the adjudication of the DNR backlog are water rights for out-of-stream uses that were grandfathered by the DNR in 1966. Many of these water rights were granted without identifying whether the quantity of water claimed by an applicant actually existed, was needed, or used. This may have resulted, or will result, in overappropriations from some of the affected water sources.

DNR's eventual adjudication of its backlog of applications for out-of-stream uses of water (derived from or affecting fish bearing water sources) could provide another type of opportunity for instream flow and related protection if sufficient resources are available to review each water right application and identify instream flow needs.

This is because under AS 46.15.080 (b)(3), the DNR is required to provide the ADF&G the option to review any proposed water use that may affect fish and wildlife production. The ADF&G can, based upon its review, request the DNR to condition (revise or deny) an applicant's proposed out-of-stream water use for the purpose of protecting fish and wildlife.

On the other hand, the timing for adjudicating these out-of-stream water rights has already strained ADF&G's instream flow and other program resources (similar to concerns expressed above associated with reservation of water adjudication processes).

The potential benefit of conditioning a consumptive water use or a water use that modifies flow characteristics must be considered because the unallocated water, resulting from a DNR condition placed on a water right (in consideration of a request from the ADF&G), remains subject to future appropriations. This is because the DNR is only required to consider the input of the ADF&G, and can accept, modify, or ignore the ADF&G's recommendations under this provision.

Findings of Fact and Conclusion of Law Documentation

An absence of standards governing how the DNR documents its rationale for adjudication decisions under AS 46.15.080 further weakens instream flow related considerations under these provisions.

Inadequately documented decisions for denying or reducing the amount of water granted to an applicant for an out-of-stream use (in response to a request from the ADF&G) may result in future DNR adjudicators inadvertently interpreting that the remaining unallocated water in a water body remains subject to allocation, when in fact, a public interest decision had been previously made for purposes of instream protection.

This record keeping problem would be solved if the DNR were to adopt findings of fact and conclusions of law procedures for all water rights applications. Presently, this process is only mandatory for reservation of water adjudication decisions (11 AAC 93.0145).

These were among the reasons AS 46.15.145 provisions were enacted to establish a formal mechanism for allocating water rights for instream flows and other reservations of water (Harle and Estes 1993). Accordingly, it is in the best interests of the ADF&G to closely monitor the DNR's future plans for adjudicating their large backlog of out-of-stream water rights and completing other pending water allocation related administrative actions.

Date of Priority

The growing backlog of the ADF&G's applications for water reservations pending adjudication has, until recently, not been interpreted to pose an immediate threat to desired instream flow and related protection. This is because a priority date was assigned to each application for a reservation of water at the time it was accepted by the DNR.

The priority date establishes the order of priority for the allocation of water within and from the source of water. However, until the adjudication process is completed, the amounts of water requested in applications for water reservations and out-of-stream water uses remain subject to modification or rejection by the DNR.

Until recently, this principle has been applied consistently. Thus, until an instream flow or reservation of water right application has been fully adjudicated, it is assumed 100% of the original amount of water requested in the application will be managed by the DNR on behalf of the applicant.

The ADF&G has become increasingly concerned as more time passes before an application for a reservation of water is adjudicated. This is because it is more likely that those responsible for the original instream flow and water reservation analyses and application preparation, and the DNR staff who completed the initial phases of an adjudication will have changed employment or responsibilities. It is also conceivable that out-of-stream competition for water from sites pending adjudication of previously filed applications for instream flow and other reservations of water will increase over time.

Experiences gained by other states indicate that protection of instream flow and other reservation of water uses is often judged to be less important than allocating water to competing out-of-stream water uses when competition for water allocation is keen.

Accordingly, there is a danger that lengthy delays in adjudicating applications for reservation of water uses may result in less than desired protection than would otherwise be granted today (while competition from other out-of-stream water uses remains minimal).

DNR Water Diversion Policy

Another limitation of existing water management practices, is the DNR policy of not managing water diversions when water is not used. For example, this applies to a water body that has been diverted but no use has been made of the water, and the water is returned to the original water source at the same or different location from the point of diversion.

The DNR claims they have no water management authority for this type of diversion unless someone possesses a prior water right for instream flows or water extraction within the river reach that was diverted. The DNR bases its position on the belief that they cannot manage the water unless it is put to a beneficial use (even if fish were identified as using the reach from where the water was diverted).

This DNR policy could result in the dewatering of portions of fish bearing waters, unless the ADF&G were notified of the water diversion and exercised its AS 16.05.840 and 870 authorities.

Fees

Fees charged by the DNR for filing instream flow and other reservation of water applications are another deterrent for applicants. With the exception of state agencies, all applicants seeking to acquire a reservation of water are charged $500 per application (Alaska Administrative Code 1993b). There is no charge to state agencies.

The $500 fee is expensive relative to application fees charged by the DNR for most other water rights and (unlike other water rights) is not based on the amount of water requested.

An additional regulatory fee was adopted by the DNR in 1993 (Alaska Administrative Code 1993c). It enables the DNR to charge for the cost of staff time expended on the adjudication of water rights that exceeds the application fee. This supplemental fee is discretionary and serves as another obstacle for filing instream flow and other reservation of water applications by the private sector, and perhaps federal agencies.

Applications Summary

The above factors, and the complexity of water law and regulations, all contribute to the low number of applications filed for reservations of water.

THE FUTURE

Some of the above and related concerns have been addressed by the Alaska Legislature (Estes 1992-1996, Harle and Estes 1993, Estes 1996), the Interagency Hydrology Committee for Alaska (IHCA), and the Alaska Water Management Council (AWMC). It is likely some of these issues will be addressed again in the future.

Alaska Water Management Council

The AWMC was established in 1992 to improve water management through better interagency state and federal coordination and cooperation. One of the products produced by council participants details water data issues for Alaska (Munter 1992) and is a good reference.

The Governor of Alaska signed an Administrative Order formalizing the activities of the AWMC in 1993 (Hickel 1993). Federal agencies challenged the language and requested modifications. The order was voided. The revisions requested by federal agencies were never formalized.

The AWMC has not met since the Fall of 1993. It is unlikely the AWMC will be reinstated by the current administration of Governor Knowles, the current Governor of Alaska.

Interagency Hydrology Committee for Alaska

The IHCA was formed in the early 1970s to coordinate technical concerns relating to the collection, analysis, and reporting of Alaskan hydrologic and climatologic data by state, federal and local agencies. In 1993, the IHCA accepted a request from the AWMC to serve as their technical advisor.

The IHCA continues to meet twice a year despite the demise of the AWMC.

Water Exports

Alaska legislation enacted in 1992 (AS 46.15.020 -.037), relating to the export and marketing of water (House Bill 596), has the potential to affect the protection of instream flows and other water reservations on a large scale (Estes 1992-1996, Harle and Estes 1993).

Regulations for conservation fees, required by the legislation, were promulgated in early 1996 (Alaska Administrative Code 1996a, b).

However, regulations defining how to execute the provisions were never completed and unavailable for guiding the first export under the law.

This uncertainty created confusion during the adjudication of the first water export application under this 1992 water export legislation. The application was filed by the City and Borough of Sitka to acquire a water right to annually withdraw fourteen thousand acre-feet of water from Blue Lake for export and sale.

Global Water, Inc., a Canadian firm, has a contract with the City and Borough of Sitka to purchase and ship the water by tanker to China and the Far East. The City and Borough of Sitka may earn between $30 million to $80 million per year if the full amount of water appropriated is exported annually. The State of Alaska is limited to earning a maximum of $80 thousand per year based on water export conservation fee regulations promulgated this year.

Two instream flows were granted for this system as mandated by the Water Use Act. Reservations of water were granted establishing protection for fish in Blue Lake, and to protect instream flow needs of fish in Sawmill Creek.

There was a tremendous push by the City and Borough of Sitka to adjudicate the Blue Lake water export appropriation in a timely manner. A year has passed since the approval of the appropriation by the DNR. Ironically, the infrastructure is incomplete and schedule for initiating water exports unknown.

Interest for exporting water from Alaska to other states and countries appears to be increasing. Two water use applications to export water from Alaska were filed by Sun Belt, a California based company, prior to the passage of HB 596. The applications were closed due to incomplete information. If these water rights had been granted by the DNR, Sun Belt would have withdrawn water from Orchard Lake in Ketchikan and the tailrace of the Snettisham Hydroelectric Project in Juneau.

Water has been purchased from the Municipality of Anchorage water supply for export to Seattle, and eventually Saudi Arabia, by Alaska Glacier Fresh. The company hopes to eventually export 14 million gallons of water per tanker load using a Saudi Arabian ocean vessel (Estes 1995).

The Municipality of Anchorage sold 1.7 million gallons of water to an unspecified industrial plant in Japan during 1994 (Blumberg 1994). The water was sold for $3.14 per 1,000 gallons, for a total sale of $5,338. The water was transported to Japan by an industrial ocean tanker.

A Washington state based firm is exploring water export sites on Prince of Wales Island and other development plans for water export operations in Alaska are increasing (Estes 1996). A special interagency task force has been formed related to labeling and packaging of bottled water slated for intra state and out of state water exports.

The effects of water exports and sales will undoubtedly increase as time passes, placing a greater emphasis on the laws passed to regulate these activities. Accordingly, the impact of this law cannot be fully assessed at this time.

Hydropower Development and Hatchery Water Rights

The development of small and medium sized hydropower operations in Alaska is on the rise and adding to increased competition for water needed instream and within lakes for fish production. Currently, Alaska has more new hydroelectric development underway than other states. Unfortunately, resources to keep up with the demands of project reviews related to instream flow and other impacts are insufficient for adequate oversight.

In 1997, Senator Murkowski introduced Senate Bill 439 in the U.S. Senate to exempt Alaska from jurisdiction by the Federal Energy Regulatory Commission for hydropower projects that are 5 megawatts or less. The bill is still under consideration.

Transfers of hatcheries to the Division of Sport Fish by other divisions of the ADF&G have resulted in the identification of inadequate water rights needed for hatchery operations and instream flow water rights required for fish production in waters impacted by these hatchery operations.

Elimination of the Water Use Act

Perhaps, the most significant and immediate threats to future instream flow protection in Alaska were cost savings options being considered by the DNR. These ranged from elimination of the Alaska Water Use Act and the DNR Water Management Section within the Division of Mining and Water to retaining the status quo (Estes 1995, 1996). Based on an evaluation of a DNR survey regarding these options, the DNR has selected to maintain the status quo until it proposes regulatory modifications in the future. Correspondence regarding these options and other concerns discussed above are included in Appendix B1 of Estes (1996).

Summary of Other Demands for Instream Flow Protection

In addition to filing for reservations of water with limited resources, the ADF&G's instream flow protection program has become increasingly burdened with an annual increase in the number of requests for instream flow and related technical support by other ADF&G staff, agencies, and the private sector.

Without additional staffing and financial resources, the limitations above, combined with the growth in demands for assistance to others, will increasingly hamper, if not prevent, the ability of the ADF&G to maintain its average production rate of seven applications per year (Estes 1987-1996).

RECOMMENDATIONS

Based upon the experiences of the ADF&G, the following recommendations are provided to improve instream flow protection.

1) Pending requests for additional ADF&G staff (fishery biologists and hydrologists) and financial resources should be allocated to the instream flow program to allow for a greater number of applications to be processed for reservations of water on an annual basis. Staff should also be provided to perform adjudication activities without impeding the completion of new applications.

2) Pending requests for additional staff (fishery biologists, hydrologists/hydraulic engineers) and financial resources should be approved for instream flow related protection to allow the ADF&G to provide better and more technical reviews of AS 46.15 water rights applications filed for water withdrawals, diversions, and impoundments. These resources are necessary to avoid impeding other efforts to acquire instream flows under AS 46.15.145. The DNR submits copies of applications (received for out-of-stream and other water rights) to the ADF&G to provide the Department an opportunity to express its instream flow and other fish and wildlife concerns pertaining to the proposed water uses.

3) A pending request for hydropower coordination and data collection and analysis should be approved to insure instream flow and other impacts are coordinated and will be adequately addressed under Federal Energy

Regulatory Commission processes without impeding other instream flow protection functions performed by the Department.

4) Legislation should be enacted annually to continue funding additional stream gage data collection stations based upon the recommendations of the USGS network evaluation. The stations are required to improve flow projection models and estimates and to determine the availability of water for out-of-stream, instream and related uses. They are also required to predict and monitor floods.

5) Out-of-stream appropriations of water should be automatically reviewed by the DNR once every 10 years, as are reservations of water.

6) The DNR water rights database should be fully automated and easily accessible to other agencies and the public.

7) All water rights acquired under grandfather provisions in 1966 should be evaluated to determine their accuracy based on hydrologic analyses of water availability. If analyses of flow data indicate water is overappropriated and public interest criteria were not addressed adequately, corrective adjustments should be made to the affected certificate of appropriation.

8) The ADF&G should review the status and adequacy of all water rights held by the department. The department should also evaluate whether all water uses comply with state statutory and regulatory requirements.

9) The Instream Flow Incremental Methodology or other equivalent methods should be used to reanalyze the adequacy of instream flow reservations obtained using the Tennant Method for the most important sport fisheries. If results indicate additional water should be reserved, a supplemental instream flow reservation application should be completed and filed. This may also include monitoring of fish population dynamics.

10) All DNR water rights decisions and the rationale for granting, conditionally granting, or denying diversionary, withdrawal, and impoundment water rights (i.e. findings of fact and conclusion of law) should be documented in writing. This requirement is mandatory for instream flow water rights, but only optional for out-of-stream water rights. Decisions to condition a water right for fish and wildlife purposes should be incorporated into final certificates of appropriation to insure the record is clear why a water allocation has been conditioned.

11) Legislation should be enacted or regulations established that will guarantee a base level of instream flow protection for all fish bearing waters..

12) A formal instream flow educational program should be funded to encourage public participation in the instream flow reservation process.

13) An instream flow methods and application handbook should be prepared to provide sufficient guidance for the public and other interested parties to file for instream flow reservations.

14) Private sector instream flow applicants should be exempt from optional administrative fees that can presently be assessed by DNR to pay for DNR staff adjudication time and resources.

15) The DNR should provide the ADF&G a 60-day written warning prior to beginning the adjudication of a pending instream flow application filed by the ADF&G.

16) The validity of statutory provisions, that can be interpreted to automatically grant instream flow water rights for water bodies within Alaska State Parks, should be established.

17) The Alaska Water Use Act should be amended for consistency with the Alaska Constitution and Alaska Water Management regulations to clarify that priority of use for instream flow water rights is on equal footing with priority of use for other water allocation purposes.

18) Regulations for implementing all of the provisions of House Bill 596 should be completed. (Estes 1993-1996)

19) The DNR should reevaluate the validity of earlier policies preventing management of water that is diverted from a water body and not used.

20) The ADF&G's recommendations relating to the DNR evaluation of cost savings options in Appendix B1 of Estes (1996) should be implemented.

CONCLUSIONS

The ability of the ADF&G and others to complete instream flow reservation applications and acquire instream flow water rights is becoming increasingly difficult. Competing uses of and demands for water are increasing. At the same time, data requirements and delayed adjudication processes will continue to limit the number of reservations completed, submitted, and granted. This will unfortunately widen the gap between the number of applications filed for water withdrawals versus reservations of water.

Needed are a combination of improved laws and regulations governing the processes to reserve water in addition to increased resources that can be used to support data collection and analyses, and the preparation and defense of applications to counter these limitations.

It is better to reserve water today as opposed to attempting to restore a fraction of whatever water is remaining in the future. The latter is a losing proposition and, more often than not, irreversible.

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LITERATURE CITED

Alaska Administrative Code. 1993a. 11 AAC 93.141 - 144.

Alaska Administrative Code. 1993b. 11 AAC 05.010(a)(8)(viii)(B).

Alaska Administrative Code. 1993c. 11 AAC 05.010(a)(8)(O).

Alaska Administrative Code. 1996a. 11 AAC 05.010(a)(8)(P). Effective February 16, 1996.

Alaska Administrative Code. 1996b. 11 AAC 05.010(a)(8)(Q). Effective February 16, 1996.

ADF&G (Alaska Department of Fish and Game). 1984. Instream flow work plan. Alaska Department of Fish and Game, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1994. An atlas to the catalog of waters important for spawning, rearing or migration of anadromous fishes. Alaska Department of Fish and Game, Division of Habitat, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1997a. *In Prep*. Application for reservation of water Copper River-Reach A. Sport Fish RTS No. I.700.300.0790. Located at the Alaska Department of Fish and Game, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1997b. *In Prep*. Application for reservation of water, Copper River-Reach B. Sport Fish RTS No. I.700.300.0790. Located at the Alaska Department of Fish and Game, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1997c. *In Prep*. Application for reservation of water. Klutina River. Sport Fish RTS No. I.700.300.3830. Located at the Alaska Department of Fish and Game, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1997d. *In Prep*. Application for reservation of water. Salmon Creek. Sport Fish RTS No. I.700.300.7450. Located at the Alaska Department of Fish and Game, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1997e. *In Prep*. Application for reservation of water. Solomon River. Sport Fish RTS No. I.700.300.8260. Located at the Alaska Department of Fish and Game, Anchorage.

Blumberg, P. 1994. Japan buys water. Anchorage Daily News. August 23, 1994. Pages B1-2. Anchorage.

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Flow methodology. Instream Flow Information Paper No. 122. FWS/OBS/82/26. U.S. Fish and Wildlife Service. Ft. Collins, Colorado.

Brabets, T. 1996. Unpublished data provided to Christopher Estes, Alaska Department of Fish and Game, in response to a data inquiry regarding U.S. Geological stream gaging historical database. U.S. Geological Survey, Water Resources Division, Anchorage.

Brabets. T. P. and D. B. Hawkins. 1995. Evaluation of the streamflow-gaging network in Alaska. Water Resources Investigation Report 95. U. S. Geological Survey. Anchorage

Curran, H. and L. Dwight. 1979. Analysis of Alaska Water Use Act and its interaction with Federal Reserved Water Rights. Institute of Water Resources. University of Alaska, Fairbanks.

DNR (Alaska Department of Natural Resources). 1985. State of Alaska instream flow handbook. Alaska Department of Natural Resources, Anchorage.

Estes, C. C. 1984. Evaluation of methods for recommending instream flows to support spawning by salmon. Master's thesis, Washington State University, Pullman.

Estes, C. C. 1985. Organization of departmental instream flow program. Memorandum to Richard Logan, September 12, 1985. Alaska Department of Fish and Game, Anchorage.

Estes, C. C. 1985. Organization of departmental instream flow program. Memorandum to Richard Logan, September 12, 1985. Alaska Department of Fish and Game, Anchorage.

Estes, C. C. 1987. Instream flow. Alaska Department of Fish and Game, Fishery Data Series No. 23, Juneau.

Estes, C. C. 1988. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 55, Juneau.

Estes, C. C. 1989. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 121, Juneau.

Estes, C. C. 1990. Annual summary of statewide instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 90-43, Anchorage.

Estes, C. C. 1991. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 91-65, Anchorage.

Estes, C. C. 1992. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 92-45, Anchorage.

Estes, C. C. 1993. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 93-43, Anchorage.

Estes, C. C. 1994. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 94-37, Anchorage.

Estes, C. C. 1995. Annual summary of Alaska Department of Fish and Game instream flow reservation applications. Alaska Department of Fish and Game, Fishery Data Series No. 95-39, Anchorage.

Estes, C. C. 1996. Annual summary of instream flow reservations and protection in Alaska. Alaska Department of Fish and Game, Fishery Data Series No. 96-45, Anchorage.

Estes, C. C. and M. L. Harle. 1987. Alaska's instream flow program. Instream Flow Chronicle. Colorado State University. Ft. Collins. IV(1):1-2.

Estes, C. C. and J. F. Orsborn. 1986. Review and analysis of methods for quantifying instream flow requirements. Water Resources Bulletin. 22(3):389-398.

Harle, M. L. 1988. Private appropriations of instream flows in Alaska. In: Instream Flow Protection in the Western United States: A Practical Symposium. Natural Resources Law Center. March 31 - April 1, 1988. Edited by L. J. MacDonnell and T. A. Rice. First Edition. University of Colorado School of Law. Boulder.

Harle, M. L. and C. C. Estes. 1993. An assessment of instream flow protection in Alaska. In: Instream Flow Protection in the Western United States. Edited by L. J. MacDonnell and T. A. Rice. Natural Resources Law Center. Revised Edition. University of Colorado School of Law. Boulder.

Hickel, W. J. 1993. Administrative order number 133. State of Alaska, Office of the Governor, Juneau.

Howe, A. L., G. Fidler, and M. J. Mills. 1995. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 95-24, Anchorage.

Howe, A. L., G. Fidler, A. E. Bingham, and M. J. Mills. 1996. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-32, Anchorage.

Howe, A. L., G. Fidler, C. Olnes, A. E. Bingham, and M. J. Mills. 1997. Harvest, catch, and participation in Alaska sport fisheries during 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-29, Anchorage.

Instream Flow Committee. 1986. Memorandum to directors, October 1, 1986. Alaska Department of Fish and Game, Anchorage.

Meyer, D. 1997. Unpublished data provided to Christopher Estes, Alaska Department of Fish and Game, in response to a data inquiry regarding U.S. Geological stream gaging historical database. U.S. Geological Survey, Water Resources Division, Anchorage.

Munter, J. A. 1992. Interagency water data issues group: work session report. Public Data File 92-10. Alaska Department of Natural Resources, Fairbanks.

Orsborn, J. F. and F. J. Watts. 1980. Hydraulics and hydrology for fisheries biologists. U.S. Fish and Wildlife Service, Fisheries Academy, Kearneysville, Virginia.

Reiser, D. W., M. P. Ramey, and T. R. Lambert. 1985. Review of flushing flow requirements in regulated streams. Pacific Gas and Electric Company, San Ramon, California.

SAS (SAS Institute Incorporated). 1990. SAS procedures guide, version 6, third Edition. SAS Institute Incorporated, Cary, North Carolina.Shaw, E. M., editor. 1988. Hydrology in practice. Van Nostrand Reinhold Co. Ltd., London.

Supreme Court of Alaska. 1995. Opinion No. 4232-July 28, 1995. Supreme Court No. S-5711. Superior Court No. 2AN-91-8627 CI. Appeal from the Superior Court of the State of Alaska, Third Judicial District, Anchorage, Dana Fabe, Judge. Tulkisarmute Native Community Council; People of the Village of Tuluksak, Appellants v. Harold Heinze, Commissioner, Department of Natural Resources; Ric Davidge, Director, Division of Water, Appellees, Calista Corporation; Tuluksak Dredging, Intervenors-Appellees. Anchorage.

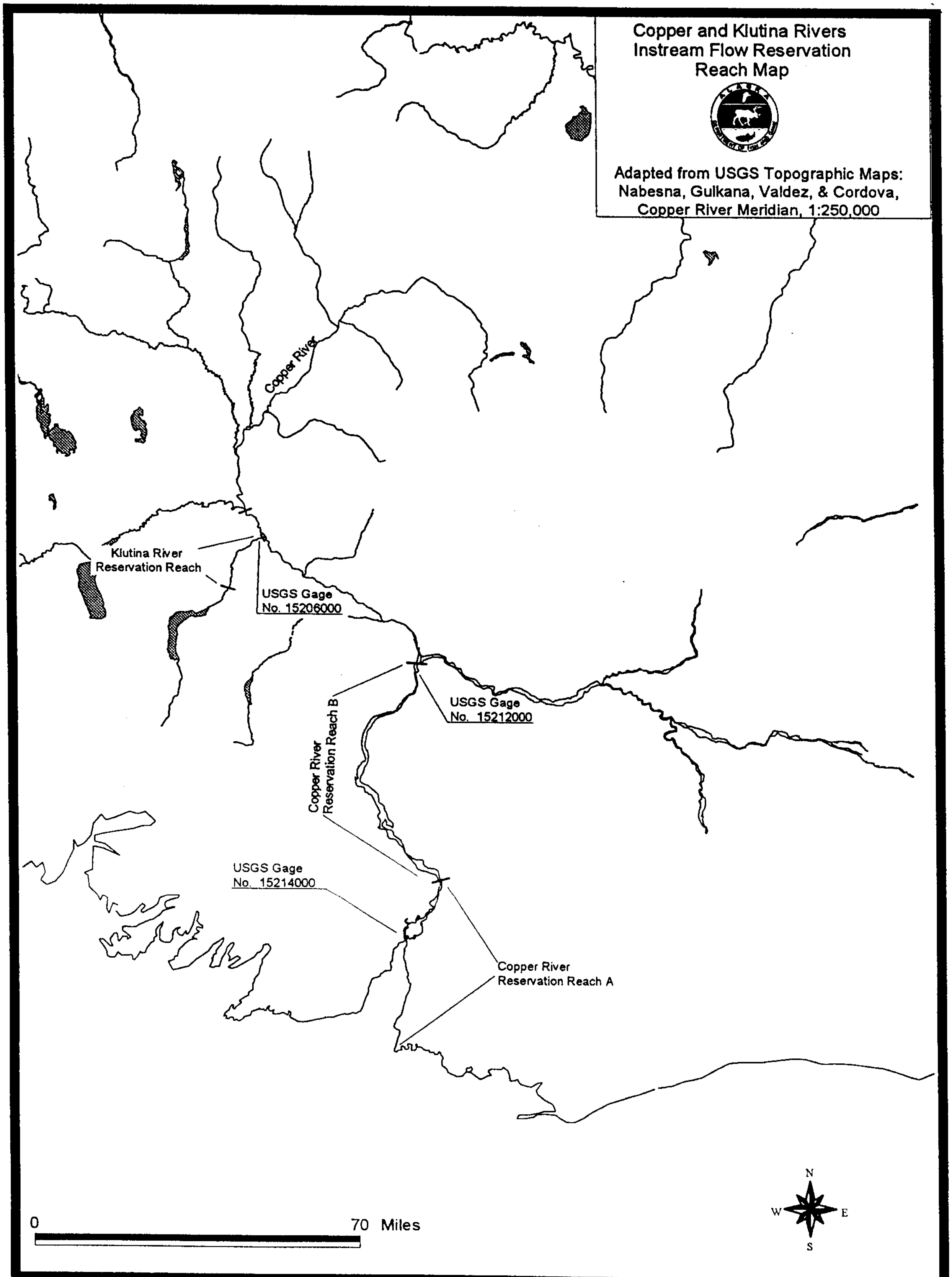
Tennant, D. L. 1972. A method for determining instream flow requirements for fish, wildlife and aquatic environment. Pages 3-11 *in* Pacific Northwest River Basin Commission Transcript of Proceedings of Instream Flow Requirements Workshop, March 15-16, 1972. Pacific Northwest River Basin Commission, Portland, Oregon.

Tennant, D. L. 1976. Instream flow regimes for fish, wildlife, recreation, and related environmental resources. Pages 359-373 *in* J. F. Orsborn and C. H. Allman, editors. Instream Flow Needs, Volume II, American Fisheries Society, Bethesda, Maryland.

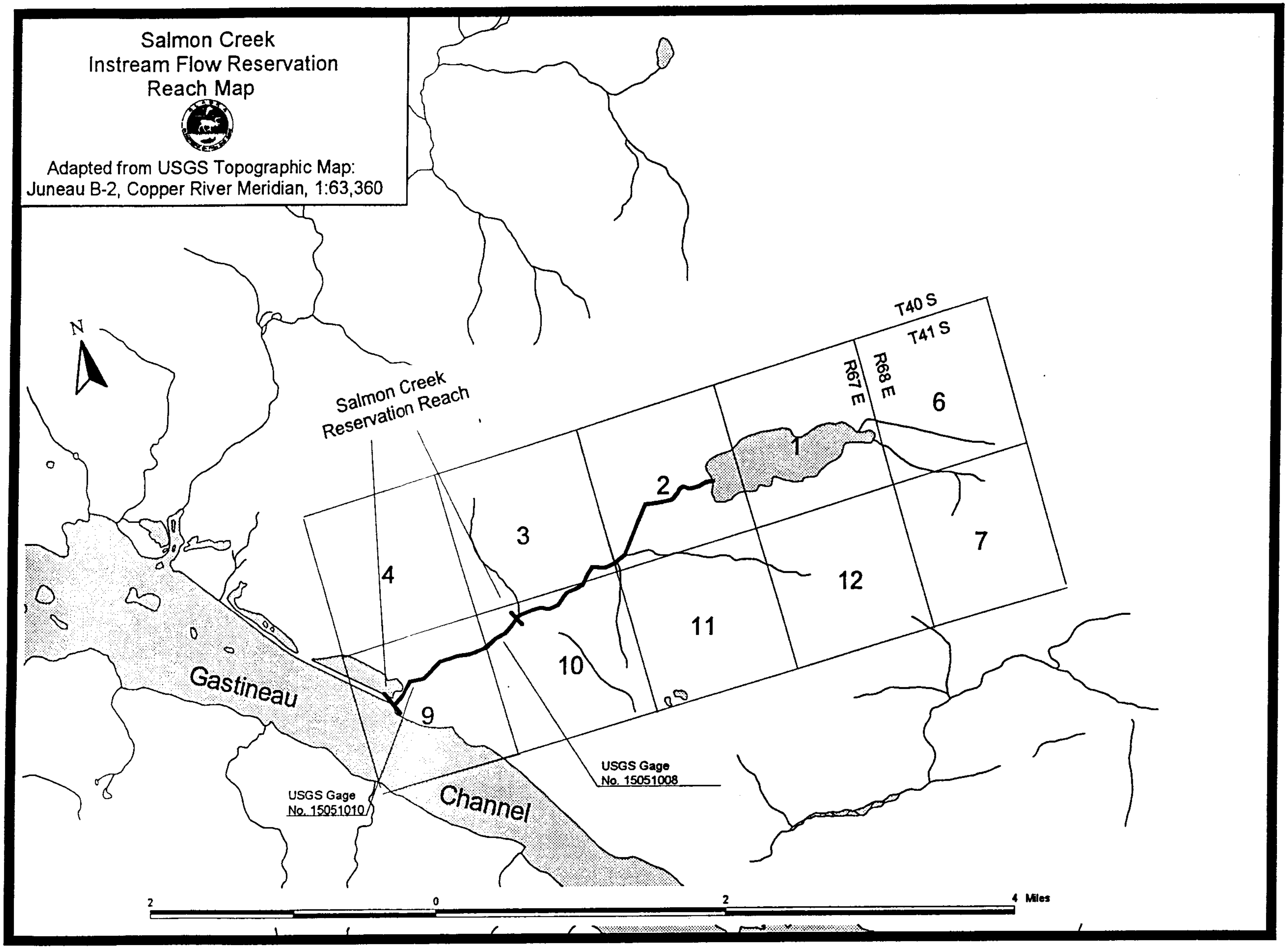
Thompson, K. 1996. Unpublished data provided to Christopher Estes regarding the status of U.S. Geological Survey stream gages in Alaska. U.S. Geological Survey, Water Resources Division, Anchorage.

White, M. R. 1981. Opportunities to protect instream flows in Alaska. U.S. Fish and Wildlife Service, Office of Biological Surveys, Washington, D.C.

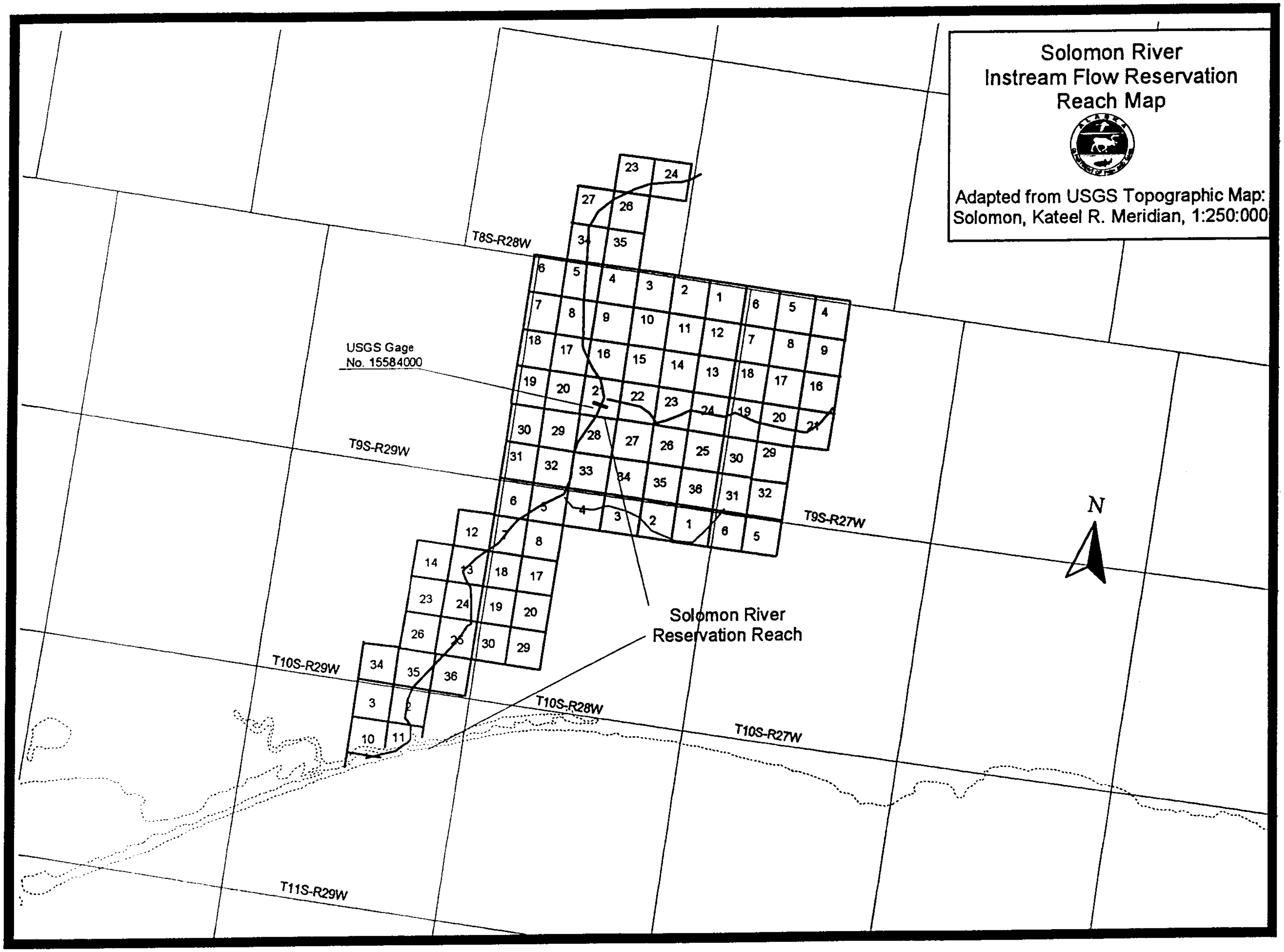
APPENDIX A. FIGURES AND TABLES



Appendix A1.-Reservation reach boundaries, Copper River-Reach A, Copper River-Reach B, and Klutina River.



Appendix A2.-Reservation reach boundaries, Salmon Creek.



Appendix A3.-Reservation reach boundaries, Solomon River.

Appendix A4.-Species periodicity chart for Copper River-Reach A.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage						XXXX	XXXX	XXXX	XXXX	XXXX	????	
Spawning												
Incubation												
Rearing												

Chinook Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				??	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XX??				
Spawning ?							??	????				
Incubation ?												
Rearing												

Sockeye Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					??	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XXXX	????			
Spawning ?												
Incubation ?												
Rearing ?												

Chum Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	????	????	????	????					
Adult Passage					????	????	????					
Spawning												
Incubation												
Rearing												

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Pink Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	????	????	????	????					
Adult Passage					????	????	????					
Spawning												
Incubation												
Rearing												

Steelhead Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage					????	XXXX	XXXX	XXXX	XXXX	XXXX	????	
Spawning												
Incubation												
Rearing												

Cutthroat Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				????	????	????	????					
Adult Passage				????	????	????	????					
Spawning												
Incubation												
Rearing												

Round Whitefish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage												
Adult Passage						??	????	????	????			
Spawning ?												
Incubation ?												
Rearing												

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

Pacific Lamprey	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage												
Adult Passage			????	????	????	????	????	????	????			
Spawning ?												
Incubation ?												
Rearing ?												

Green Sturgeon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage	????	????	????	????	????	????	????	????	????	????	????	????
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning		????	????	????								
Incubation			????	????	????	????	????					
Rearing								????	????	????	????	????

White Sturgeon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage	????	????	????	????	????	????	????	????	????	????	????	????
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning		????	????	????								
Incubation			????	????	????	????	????					
Rearing								????	????	????	????	????

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

Appendix A5.-Species periodicity chart for Copper River-Reach B.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage						XXXX	XXXX	XXXX	XXXX	XXXX	????	
Spawning												
Incubation												
Rearing												

Chinook Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				??	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XX??				
Spawning ?							??	????				
Incubation ?												
Rearing												

Sockeye Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					??	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XXXX	????			
Spawning ?												
Incubation ?												
Rearing ?												

Rainbow Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage					????	????	????					
Spawning												
Incubation												
Rearing												

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Arctic Grayling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage								????	????	????		
Spawning												
Incubation												
Rearing												

Pacific Lamprey	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage												
Adult Passage			????	????	????	????	????	????	????			
Spawning ?												
Incubation ?												
Rearing ?												

Steelhead Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage					????	XXXX	XXXX	XXXX	XXXX	XXXX	????	
Spawning												
Incubation												
Rearing												

Round Whitefish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage						??	????	????	????			
Spawning ?												
Incubation ?												
Rearing												

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Burbot	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage					????	????	????	????	????	????	????	
Spawning		????										
Incubation ?												
Rearing	????	????	????	????	????	????	????	????	????	????	????	????

Longnose Sucker	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning		????	????	????								
Incubation			????	????	????	????	????					
Rearing								????	????	????	????	????

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

Appendix A6.-Species periodicity chart for Klutina River.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage	????					XXXX	XXXX	XXXX	XXXX	XXXX	????	????
Spawning	????	????							????	XXXX	XXXX	????
Incubation	XXXX	XXXX	XXXX	????						????	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Chinook Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			??	??	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XX??	??			
Spawning ?							XXXX	XXXX	XXXX			
Incubation ?	XXXX								XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Sockeye Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	????	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage				??	XXXX	XXXX	XXXX	XXXX	????	????	????	
Spawning							XXXX	XXXX	XXXX	????	????	
Incubation								XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Rainbow Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage					????	XXXX	XXXX	XXXX	XXXX	XXXX		
Spawning			XXXX	XXXX	XXXX	????						
Incubation				XXXX	XXXX	XXXX	XXXX	????				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Arctic Grayling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage				????	XXXX	XXXX	XXXX	XXXX	XXXX	????		
Spawning				????	????							
Incubation				????	????	????						
Rearing	????	????	????	????	????	????	????	????	????	????	????	????

Dolly Varden	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	????	????	????	????					
Adult Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning ?									????	XXXX	XXXX	
Incubation ?	XXXX	XXXX	XXXX	XXXX	????					????	XXXX	XXXX
Rearing ?	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Steelhead Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			????	XXXX	XXXX	XXXX	XXXX	XXXX	????			
Adult Passage	????	????	????	????	????	XXXX	XXXX	XXXX	XXXX	XXXX	????	????
Spawning			XXXX	XXXX	XXXX	????						
Incubation				XXXX	XXXX	XXXX	XXXX	????				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Round Whitefish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	??	??	??	??	??	XXXX	XXXX	XXXX	XXXX	????	????	????
Spawning ?	??	??	??	??	??	??	??	??	??	??	??	??
Incubation ?	??	??	??	??	??	??	??	??	??	??	??	??
Rearing	??	??	??	??	??	??	??	??	??	??	??	??

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Burbot	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning	????	????	????	????	????	????	????	????	????	????	????	????
Incubation ?	????	????	????	????	????	????	????	????	????	????	????	????
Rearing	????	????	????	????	????	????	????	????	????	????	????	????

Longnose Sucker	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning	????	????	????	????	????	????	????	????	????	????	????	????
Incubation	????	????	????	????	????	????	????	????	????	????	????	????
Rearing	????	????	????	????	????	????	????	????	????	????	????	????

Pacific Lamprey	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage	????	????	????	????	????	????	????	????	????	????	????	????
Adult Passage	????	????	????	????	????	????	????	????	????	????	????	????
Spawning ?	????	????	????	????	????	????	????	????	????	????	????	????
Incubation ?	????	????	????	????	????	????	????	????	????	????	????	????
Rearing ?	????	????	????	????	????	????	????	????	????	????	????	????

Lake Trout	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage						XXXX	XXXX	XXXX	XXXX	????	????	????
Spawning		????	????	????					????	????		
Incubation	????	????	????	????	????					????	????	????
Rearing	????	????	????	????	????	????	????	????	????	????	????	????

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for trout, char, and other species, immigration and emigration.
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Appendix A7.-Species periodicity chart for Salmon Creek.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XX	XXXX	XX						
Adult Passage									XXXX	XXXX	X	
Spawning										XXXX	XXXX	X
Incubation	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Chum Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry Passage			XX	XXXX	XX							
Adult Passage								X	XXXX	XX		
Spawning									XXXX	XXXX	XX	
Incubation	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX	XXXX
Rearing			XX	XX								

Pink Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry Passage			XX	XXXX	X							
Adult Passage							XXX	XXX				
Spawning							XX	XXXX	X			
Incubation	XXXX	XXXX	XXXX				XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing			X	X								

Dolly Varden	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			XX	XXXX	XXXX	XX						
Adult Passage							XXX	XXXX	XXXX	XXXX	XX	
Spawning									XX	XXXX	XX	
Incubation	XXXX	XXXX	XXXX	XXXX	XX				XX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for steelhead and resident fish species, immigration and emigration
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

Appendix A8.-Species periodicity chart for Solomon River.

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					XXXX	XXXX						
Adult Passage								XXXX	XXXX	XXXX	XX	
Spawning								XX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XX				X	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Chum Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					XXXX	XXXX						
Adult Passage							XXXX	XXXX	XXXX			
Spawning							XX	XXXX	XXXX	XXXX		
Incubation	XXXX	XXXX	XXXX	XX			XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing			XX	XXXX	XX							

Arctic Grayling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage												
Adult Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning					XX	XX						
Incubation					X	XXXX	X					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Dolly Varden	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					XX	XXX						
Adult Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning								XX	XXXX	XXX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX				XXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for other species, immigration and emigration unless noted
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

-continued-

Appendix A8.-Page 2 of 2.

Slimy Sculpin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning					????	????						
Incubation					????	????	?					
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Round Whitefish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Passage	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Spawning									XX	XXXX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX				X	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Chinook Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					??	XXXX	??					
Adult Passage						????	XXXX	?				
Spawning							?XX	???				
Incubation	XXXX	XXXX	XXXX	XX??			??	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Pink Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage					??	XXXX	?					
Adult Passage							?XXX	XX?				
Spawning							?XXX	XXX?				
Incubation	XXXX	XXXX	XXXX	XX??			?XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing												

Based upon professional judgment of ADF&G biologists
Smolt passage is for juvenile emigration to estuarine/marine environment
Adult passage: for salmon is immigration: for other species, immigration and emigration unless noted
Incubation life phase includes time of egg deposition to fry emergence
? = Data not available or timing is incomplete

Appendix A9.-Common and scientific names of fishes identified in periodicity charts (Appendices A4-A8).

Common Name	Scientific Name
Arctic grayling	*Thymallus arcticus*
Burbot	*Lota lota*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Cutthroat trout	*Oncorhynchus clarki*
Dolly Varden	*Salvelinus malma*
Green Sturgeon	*Acipenser medirostris*
Lake trout	*Salvelinus namaycush*
Least cisco	*Coregonus sardinella*
Longnose sucker	*Catostomus catostomus*
Pacific lamprey	*Entosphenus tridentatus*
Pink salmon	*Oncorhynchus gorbuscha*
Rainbow trout	*Oncorhynchus mykiss*
Round whitefish	*Prosopium cylindraceum*
Sheefish	*Stenodus leucichthys*
Slimy sculpin	*Cottus cognatus*
Sockeye salmon	*Oncorhynchus nerka*
Steelhead trout	*Oncorhynchus mykiss*
White Sturgeon	*Acipenser transmontanus*

Appendix A10.-Summary of U.S. Geological Survey (USGS) hydrologic data for instream flow reservation application reaches (Appendices A1-A3).

Stream/Reach	USGS Site Number	Years of Daily Flow Record
Copper River at Million Dollar Bridge near Cordova	15214000	1988-1995
Copper River near Chitina	15212000	1950, 1952 1955-1990
Klutina River at Copper Center	15206000	1908,1913 1949-1967, 1970
Salmon Creek near Juneau	15051010	1990-present
Salmon Creek above canyon mouth near Juneau	15051008	1982-1990
Solomon River at East Fork	15584000	1908, 1909 (partial records)

Appendix A11.-Tennant Method analysis for Copper River-Reach A.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Copper River-Reach A

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	FLOW (cfs)
QAA	100	63620
Flushing or Maximum	200	127240
Optimum Range	60-100	38172-63620
Outstanding	40	25448
Excellent	30	19086
Good	20	12724
Fair or Degrading	10	6362
Poor or Minimum	10	6362
Severe Degredation	<10	<6362
	MAY-OCT	
QAA	100	63620
Flushing or Maximum	200	127240
Optimum Range	60-100	38172-63620
Outstanding	60	38172
Excellent	50	31810
Good	40	25448
Fair or Degrading	30	19086
Poor or Minimum	10	6362
Severe Degredation	<10	<6362

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	9812
Feb	8704
Mar	8882
Apr	12500
May	49760
Jun	135400
Jul	183000
Aug	162400
Sep	108200
Oct	41140
Nov	18250
Dec	11920

Appendix A12.-Tennant Method analysis for Copper River-Reach B.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Copper River-Reach B

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	FLOW (cfs)
QAA	100	38215
Flushing or Maximum	200	76430
Optimum Range	60-100	19108-38215
Outstanding	40	15286
Excellent	30	11465
Good	20	7643
Fair or Degrading	10	3822
Poor or Minimum	10	3822
Severe Degredation	<10	<3822
	MAY-OCT	
QAA	100	38215
Flushing or Maximum	200	76430
Optimum Range	60-100	19108-38215
Outstanding	60	22929
Excellent	50	19108
Good	40	15286
Fair or Degrading	30	11465
Poor or Minimum	10	3822
Severe Degredation	<10	<3822

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	6599
Feb	5772
Mar	5406
Apr	6758
May	29027
Jun	79415
Jul	122346
Aug	107069
Sep	51211
Oct	21362
Nov	10857
Dec	7736

Appendix A13.-Tennant Method analysis for Klutina River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Klutina River

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	FLOW (cfs)
QAA	100	1686
Flushing or Maximum	200	3372
Optimum Range	60-100	1012-1686
Outstanding	40	674
Excellent	30	506
Good	20	337
Fair or Degrading	10	169
Poor or Minimum	10	169
Severe Degredation	<10	<169
	MAY-OCT	
QAA	100	1686
Flushing or Maximum	200	3372
Optimum Range	60-100	1012-1686
Outstanding	60	1012
Excellent	50	843
Good	40	674
Fair or Degrading	30	506
Poor or Minimum	10	169
Severe Degredation	<10	<169

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	273
Feb	230
Mar	211
Apr	213
May	830
Jun	3679
Jul	5086
Aug	4517
Sep	2774
Oct	1214
Nov	547
Dec	352

Appendix A14.-Tennant Method analysis for Salmon Creek (15051010).

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Salmon Creek Gage 15051010 (replaced 15051008)

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	FLOW (cfs)
QAA	100	41
Flushing or Maximum	200	82
Optimum Range	60-100	25-41
Outstanding	40	16
Excellent	30	12
Good	20	8
Fair or Degrading	10	4
Poor or Minimum	10	4
Severe Degredation	<10	<4
	MAY-OCT	
QAA	100	41
Flushing or Maximum	200	82
Optimum Range	60-100	25-41
Outstanding	60	25
Excellent	50	21
Good	40	16
Fair or Degrading	30	12
Poor or Minimum	10	4
Severe Degredation	<10	<4

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	35
Feb	37
Mar	22
Apr	28
May	55
Jun	57
Jul	40
Aug	36
Sep	64
Oct	57
Nov	34
Dec	23

Appendix A15.-Tennant Method analysis for Salmon Creek (15051008).

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Salmon Creek Gage 15051008 (replaced by 15051010)

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	FLOW (cfs)
QAA	100	52
Flushing or Maximum	200	104
Optimum Range	60-100	31-52
Outstanding	40	21
Excellent	30	16
Good	20	10
Fair or Degrading	10	5
Poor or Minimum	10	5
Severe Degredation	<10	<5
	MAY-OCT	
QAA	100	52
Flushing or Maximum	200	104
Optimum Range	60-100	31-52
Outstanding	60	31
Excellent	50	26
Good	40	21
Fair or Degrading	30	16
Poor or Minimum	10	5
Severe Degredation	<10	<5

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	31
Feb	29
Mar	29
Apr	35
May	62
Jun	81
Jul	69
Aug	63
Sep	69
Oct	89
Nov	39
Dec	35

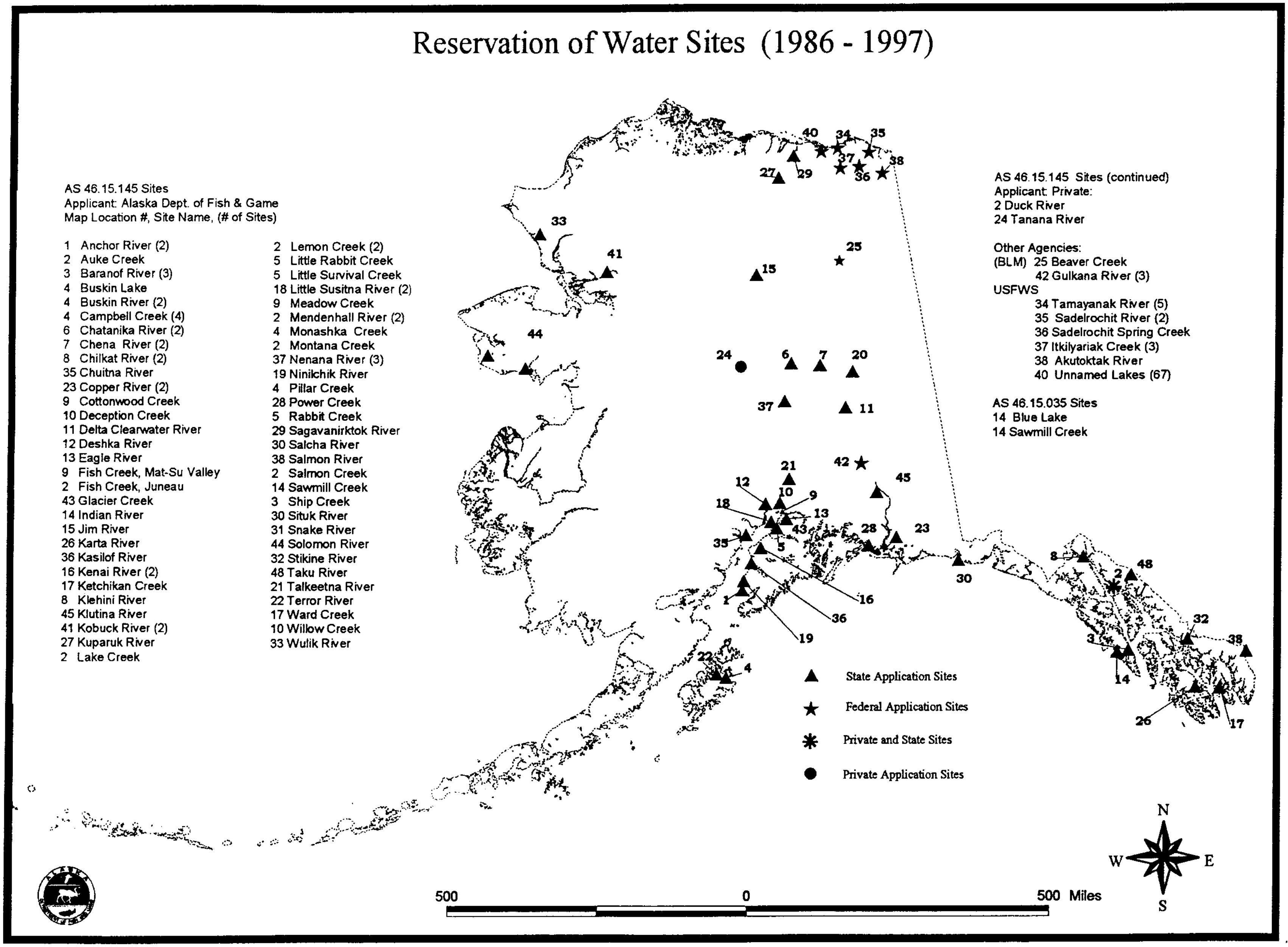
Appendix A16.-Tennant Method analysis for Solomon River.

Tennant Method Flow Classifications (adapted from Tennant 1975)

Seasonal Base Flow (Q) Regimens as Percentages (%) of Average Annual Flow (QAA) for Solomon River

SEASONAL FLOW DESCRIPTIONS	% OF QAA NOV-APR	ESTIMATED FLOW (cfs)
QAA	100	95
Flushing or Maximum	200	190
Optimum Range	60-100	57-95
Outstanding	40	38
Excellent	30	29
Good	20	19
Fair or Degrading	10	10
Poor or Minimum	10	10
Severe Degredation	<10	<10
	MAY-OCT	
QAA	100	95
Flushing or Maximum	200	190
Optimum Range	60-100	57-95
Outstanding	60	57
Excellent	50	48
Good	40	38
Fair or Degrading	30	29
Poor or Minimum	10	10
Severe Degredation	<10	<10

MONTH	LONG-TERM MEAN MONTHLY FLOW
Jan	n/a
Feb	n/a
Mar	n/a
Apr	n/a
May	n/a
Jun	n/a
Jul	85
Aug	207
Sep	41
Oct	n/a
Nov	n/a
Dec	n/a



Appendix A17.-Locations of 1986 to 1997 reservation of water sites (per AS 46.15.035 and AS 46.15.145) in Alaska.

Appendix A18.-Historical data summary for U.S. Geological Survey continuous streamflow gage sites in Alaska, 1908 to September 1997 including estimated number of active gages for water year 1997, October 1, 1996 to September 30, 1997.

Number of Gage Sites	Period of Record (Years)
17	0 to < 1
21	1
110	1 to < 5
79	5 to < 10
108	10 to < 20
69	20 to < 50
3	≥50
75	Estimated number of active gages for the period October 1, 1996 to September 30, 1997

Data from Meyer (1997).