Fishery Data Series No. 23-12

Hydrologic Investigation in Support of Reservation of Water on Windfall Creek, 2013 to 2018

by

Jarrod J. Sowa

May 2023

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

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

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
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
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
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	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
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.
minute (angular)	′
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
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 23-12

HYDROLOGIC INVESTIGATION IN SUPPORT OF RESERVATION OF WATER ON WINDFALL CREEK, 2013 TO 2018

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ABSTRACT

The Windfall Creek watershed, located 18 miles northwest of Juneau in Southeast Alaska, is an important freshwater sport fishery that provides habitat for many fish species at various life stages. In 2013, ADF&G began a multiyear project to collect the hydrologic data necessary to file a reservation of water application to protect instream flows within one reach of Windfall Creek. To collect the data necessary to file a reservation of water application, a streamgage was operated on Windfall Creek from July 17, 2013, to September 30, 2018. Streamflow data collected at the streamgage was used to prepare a reservation of water application to reserve instream flows in one reach of Windfall Creek. Instream flows were requested to attempt to mimic the natural seasonal patterns of streamflows observed within Windfall Creek. The original application was filed using the first 14 months of streamflow data collected and was accepted by the Alaska Department of Natural Resources on September 2, 2015. After 5 years of streamflow data were collected and analyzed, the original application was amended incorporating the additional data.

Keywords: Windfall Creek, streamgage, discharge, reservation of water, instream flow

INTRODUCTION

Alaska's rivers and lakes support some of North America's most viable and productive salmon fisheries. Over 20,000 streams, rivers, or lakes have been identified throughout the state as being important for spawning, rearing, or migration of anadromous fish (Klein et al. 2022). Fish migration, spawning, rearing, and ultimately, production in these water bodies are dependent upon sufficient seasonal quantities of water. Demand for water to support hydroelectric power generation, petroleum production, mining, water supply (including out-of-state export), residential, forestry, agriculture, and other projects has the potential to modify the naturally occurring instream flows to which fish have adapted and are dependent upon (Poff et al. 1997).

The Fish and Game Act requires the Alaska Department of Fish and Game (ADF&G) to "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" (Alaska Statute [AS] 16.05.020). One mechanism ADF&G uses to fulfill its mandate is to reserve water in rivers and lakes for fish and wildlife (AS 16.05.050). An appropriation of water that remains within a river is legally defined under Alaska law (AS 46.15.145) and regulations (11 AAC 93.970) as a reservation of water. To reserve water, an application with supporting data and analyses must be submitted to the Alaska Department of Natural Resources (DNR). A minimum of 5 years of mean daily flow data is recommended by DNR to quantify instream flow requirements within an application.

Instream flows can be legally reserved by a private individual, group, or government agency in order to maintain specific flow rates in a river or volumes and water levels in a lake during specified time periods for 1 or a combination of 4 types of uses:

- protection of fish and wildlife habitat, migration, and propagation
- recreation and parks
- navigation and transportation
- sanitary and water quality purposes

Priority dates for reservation of water applications are based on the date they are accepted by DNR. Alaska water law is based on the doctrine of prior appropriation, also known as "first in time, first in right." According to the rules of prior appropriation, the right to the requested amount of water is first given to the appropriator who has the earliest priority date to beneficially use the water. Senior water right holders have a legal standing to assert their right against conflicting uses of water from others who do not have a water right or who are junior in priority.

In 2013, ADF&G began a multiyear project to collect the hydrologic data necessary to file a reservation of water application to protect instream flows within one reach of Windfall Creek. Prior to this project, no streamflow data had been measured at Windfall Creek. This report summarizes a 5-year study to collect the streamflow data necessary to file a reservation of water application for one reach of Windfall Creek.

OBJECTIVE

The objective of this project was to collect the hydrological data necessary to file a reservation of water application for the protection of fish habitat, migration, and propagation within one reach (Reach A) of Windfall Creek. Two tasks were necessary to complete this objective:

1. Install and operate a streamgage on Windfall Creek for 5 years to quantify streamflows within Reach A.
2. Complete and file a reservation of water application for Windfall Creek Reach A.

METHODS

STUDY AREA

Windfall Creek is located 18 miles northwest of Juneau (Figure 1). The creek has been catalogued by ADF&G as Anadromous Waters Catalog (AWC) stream number 111-50-10070-2004-3006 (Giefer and Blossom 2021) and has approximately 0.5 miles of anadromous waters. The creek supports populations of coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta),* steelhead (*O. mykiss*), cutthroat trout (*O. clarkii*), and Dolly Varden char (*Salvelinus malma*).

Windfall Creek drains from Windfall Lake and flows downstream 0.5 miles to a side channel of the Herbert River. The watershed has a drainage area of approximately 12 square miles. Windfall Creek is located within the temperate coastal rainforest of Southeast Alaska. The climate of this area is characterized by cold, snowy winters and cool wet summers. The Windfall Creek watershed is located wholly within the Tongass National Forest.

The creek is a popular fishery for Juneau area anglers since it is the only Juneau area stream where anglers can catch and retain sockeye salmon. There also is a United States Forest Service public use cabin located on the northeast shore of the lake that can be accessed by a 4.3-mile-long trail.

An ADF&G fish weir operated in the spring of 1997 and counted 616 cutthroat trout, 34,074 Dolly Varden, and 9 steelhead trout out-migrating from Windfall Creek (Jones and Harding 1998). Immigrating sockeye salmon were counted at ADF&G fish weirs in 1989 and 1997 and the total return was estimated to be 4,667 in 1989 and 4,228 in 1997 (Bethers and Glynn 1990; Yanusz 1998). Since 1990, ADF&G has also conducted foot surveys of spawning sockeye salmon in Slate Creek, a tributary to Windfall Creek above Windfall Lake (Figure 2).

STUDY DESIGN

The reach (Reach A) of Windfall Creek selected for instream flow protection extended from the outlet of Windfall Lake to a side channel of the Herbert River (Figure 2). No major tributaries enter Windfall Creek within this reach and the difference in flows (from accretion and reduction) within the reach is minimal. To quantify the streamflows within Reach A, a streamgage station was operated on Windfall Lake from July 17, 2013, to September 30, 2018.

GAGING STATION

The objective of operating a streamgage is to obtain a continuous record of discharge at the site (Carter and Davidian 1968). The collection of stage and direct measurements of discharge are essential components in the operation of a streamgage. A continuous record of stage was obtained by installing a water-level data logger that measured and recorded water surface elevation (WSE) in Windfall Lake. Direct measurements of discharge were taken in Windfall Creek at different times of year and with varying flow rates to define the stage–discharge relationship (rating curve) and to also detect the timing and magnitude of changes to this relationship over time. ADF&G followed United States Geological Survey (USGS) streamgage operation protocols and procedures described in Rantz and others (1982), as well as procedures outlined in ADF&G's Surface-Water Data Manual (Klein 2013).

In July 2017, ADF&G installed a streamgage (13801) on Windfall Creek (Windfall Creek streamgage). Stage and water temperature were measured at Windfall Lake using an In-Situ Level TROLL 500 water level data logger. The data logger cable was housed in 1¼-inch pipe, secured to the lakebed with custom pipe brackets and ⅝-inch rebar. At the time of installation, the data logger was programmed to record WSE and water temperature every 15 minutes on the quarter hour. Three survey reference marks (RMs) were established near the transducer to establish the streamgage datum, monitor possible movement of the streamgage, and to measure the WSE. Differential surveying techniques using an auto level were conducted every field visit to survey WSE (Kenney 2010). An elevation of 10 feet was assigned to RM1, which was designated as the primary reference point. The data logger reading and surveyed WSE were compared at each site visit to check for consistency. Two additional RMs (RM2 and RM3) were established near the streamgage site to monitor possible changes in the elevation of RM1.

DISCHARGE MEASUREMENTS

Streamflow, or discharge, is defined as the volume of water moving downstream per unit of time and is typically reported in cubic feet per second (ft^3/s; Buchanan and Somers 1969). Discharge is determined by measuring the average velocity, depth, and width of subsections across the stream and summing the discharge of each subsection. Discharge measurements for the Windfall Creek streamgage were taken near the downstream end of Windfall Creek, typically in a calm pool or run and in a location not affected by backwater from the Herbert River. A top-set wading rod with a SonTek Flowtracker handheld acoustic doppler velocity (ADV) meter was used to measure depth and velocity. The width of the stream was measured using a fiberglass tape measure that was secured across the measurement transect. Discharge measurements were taken at Windfall Creek periodically throughout the year and during periods of extreme low and high flows following USGS protocols (Rantz and others 1982).

SITE VISITS

Site visits were made approximately 8 times a year during the period of operation of the streamgage. During a typical site visit, data was downloaded from the data logger, stream discharge was measured, the water surface elevation was surveyed, and routine streamgage maintenance was performed. Data were downloaded from the data logger using an In-Situ RuggedReader Handheld PC. Discharge measurement data, differential survey notes, and other site visit notes were recorded in waterproof field notebooks. Photographs of the lake and discharge measurement were typically taken.

After each site visit, discharge measurement data were downloaded from the ADV meter, pictures were downloaded and labeled, and stage and water temperature data were downloaded from the RuggedReader to a desktop computer. Transducer stage, water surface elevations, water temperature, and discharge measurement data were imported into the Water Information System Kisters Incorporated (WISKI) hydrological software database for storage and analysis.

STREAMFLOW RECORDS COMPUTATION

Streamflow records computation is a step-by-step process in which stream stage measured at the streamgage is converted to discharge using the stage–discharge relationship (rating curve). Before being converted to discharge, the stage record was corrected for transducer movement and drift or fill and scour of the hydraulic control. WISKI was used to develop rating curves; make corrections to the stage record; apply rating curves to corrected stage values to calculate 15-minute discharges; and summarize these discharges to mean daily, mean monthly, and mean annual flow values. Missing or suspect data caused by ice, operator error, or recorder malfunction were estimated by using the hydrographic- and climatic-comparison method (Rantz and others 1982). This included comparison of water temperatures measured by the transducer, nearby weather records, trends of the hydrograph, and instantaneous discharge measurements that were made.

Computed discharge values were typically summarized as mean daily, mean monthly, and mean annual flow values for the water year (October 1–September 30). The procedures used to compute streamflow records coincide with those described in Rantz and others (1982), Kennedy (1983), and Klein (2013).

Mean daily flow records computed for the streamgage were analyzed by a series of SAS programs to estimate the annual, monthly, and mean daily summaries (Table 3) and flow duration values for specified time periods. Mean annual flow was estimated as a mean of the annual mean daily flow values over all complete water years of record. Mean monthly flows were estimated as the mean of monthly mean daily flows for all complete months over the entire period of record. Duration estimates represent the expected frequency of occurrence of mean daily flows within the specified time periods. The durations of daily mean flows were calculated as the percentiles of the empirical distribution of observed values within the specified time periods over the period of record (Table 2). This provided an estimate of the percentage of time a given mean daily flow was equaled or exceeded within the distribution of mean daily flows for each time period analyzed.

RESULTS

HYDROLOGIC DATA

The Windfall Creek streamgage (13801) was operated from July 17, 2013, to September 30, 2018. Thirty-eight measurements of instantaneous discharge, ranging from 6.9 ft^3/s to 248 ft^3/s were taken at the streamgage (Table 1). The highest mean daily flow recorded at the streamgage was 631 ft^3/s on January 20, 2015, and the lowest mean daily flow recorded at the streamgage was 1.1 ft^3/s on August 3 and 4, 2018 (Figure 3). The lowest flows of the year were typically in the winter during dry cold spells and in the summer during dry hot stretches after the winter snowpack had completely melted (Figure 3). Typically, streamflows began to increase in late March due to snowmelt and peaked in early May. Flows then decreased throughout summer before increasing again during autumn precipitation events. A streamgage operated by ADF&G at nearby Peterson Creek (Figure 2) also showed similar streamflow patterns (Figure 5).

RESERVATION OF WATER APPLICATION

The first 14 months of streamflow data collected was used to prepare a reservation of water application for one reach (Reach A) of Windfall Creek. The reservation of water application included the following components: (1) maps and legal descriptions describing the reach boundaries and streamgage location; (2) hydrologic data collected within the reach; (3) description and justification of the method used to quantify instream flow needs; (4) a fish species periodicity chart (Table 3); and (5) the water quantities requested by time period for the reach. The application for Windfall Creek Reach A was accepted by DNR (Land Administration System number 30450) and given a priority date of September 2, 2015. After 5 years of streamflow data were collected and analyzed, the original application was amended incorporating the new data.

DISCUSSION

According to ADF&G's Anadromous Waters Catalog, over 20,000 streams, rivers, and lakes have been determined to support anadromous fish populations in Alaska (Geifer and Blossom 2021). These waterbodies are all potentially subject to water withdrawals and modification of their natural streamflows. Although most water bodies in the state are currently not subject to flow modifications, it is important to reserve these unallocated streamflows before competition over the water arises. Freshwater surface withdrawals in Alaska increased from 393 million gallons per (MGD) day in 2005 (Kenny et al. 2009) to 408 MGD in 2015 (Dieter et al. 2018).

ADF&G has filed reservation of water applications on 358 river reaches and 7 lakes since 1980 and has been granted certificates for 166 river reaches and 1 lake (Klein 2020). One major challenge to filing more applications is the lack of available streamflow data that can be used to quantify streamflows to be reserved. Only 111 continuous streamgages were operated by USGS in 2021 (Klein 2022). Recognizing this data limitation, ADF&G began a program in 2001 to collect streamflow data on rivers, creeks, and lakes supporting important fisheries throughout the state.

Windfall Creek is an important freshwater sport fishery that provides habitat for many fish species at various life stages. Prior to this project, no known streamflow data had been collected within the creek. This project collected the 5 years of streamflow data needed to support a reservation of water application for Windfall Creek. Mean daily streamflows measured at the streamgage ranged from a low of 1.1 ft^3/s to a high of 631 ft^3/s. Instream flows requested in the reservation application attempted to mimic the natural seasonal patterns of streamflows observed within Windfall Creek. All requested flows were at the median daily flow for the requested time periods (Table 2 and Figure 4). Although not requested, research has shown that flows near bankfull are needed to maintain the channel's sediment, riparian vegetation, and floodplain habitat (Leopold et al. 1964; Reiser et al. 1985; Schmidt and Potyondy 2004). Changes in the magnitude, frequency, timing, and duration of these flows could directly lead to biological and geomorphic changes (Whiting 2002).

The application was filed using the first 14 months of streamflow data and was accepted by the DNR and given a priority date of September 2, 2015. After 5 years of streamflow data were collected and analyzed, the original application was amended incorporating the additional data. Currently, no water withdrawals or impoundments occur within the Windfall Creek watershed.

ACKNOWLEDGEMENTS

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TABLES AND FIGURES

Table 1.–Summary of instantaneous discharge measurements taken at ADF&G's Windfall Creek streamgage 13801.

Data record number	Date	Start time	End time	Width (ft)	Area (ft^2)	Mean velocity (ft/s)	Flow (ft^3/s)
1	09/20/2013	11:41	12:44	89	141	1.4	191
2	10/21/2013	12:40	13:40	90	135	1.3	173
3	12/19/2013	13:12	13:49	19	18	1.4	25
4	02/14/2014	13:19	13:55	16	11	0.94	10
5	05/15/2014	11:45	12:22	43	50	1.8	87
6	06/25/2014	11:45	13:00	87	174	1.4	248
7	08/22/2014	11:33	12:04	43	60	0.59	35
8	09/10/2014	11:31	12:04	43	57	0.64	37
9	10/29/2014	11:23	11:52	25	18	1.6	28
10	12/23/2014	11:34	12:09	25	22	1.5	34
11	02/19/2015	12:20	12:57	32	53	1.3	68
12	04/23/2015	11:41	12:14	29	27	2.8	78
13	05/15/2015	12:28	1:12	53	27	1.1	32
14	07/22/2015	11:48	12:20	51	53	0.55	29
15	08/26/2015	11:44	12:18	55	65	0.89	54
16	10/02/2015	12:32	13:06	56	67	0.90	60
17	12/10/2015	11:37	12:07	32	40	1.5	61
18	01/20/2016	11:40	12:07	19	14	1.6	22
19	02/11/2016	11:43	12:15	37	40	2.2	89
20	03/22/2016	12:55	13:25	24	19	0.78	16
21	05/05/2016	11:06	12:00	99	189	0.57	108
22	07/07/2016	10:13	10:49	49	45	0.37	17
23	09/29/2016	11:58	12:28	33	33	0.84	29
24	11/22/2016	11:35	12:08	18	8.7	1.3	12
25	01/12/2017	11:43	12:13	14	7.3	0.93	6.9
26	04/13/2017	11:55	12:26	32	40	1.9	78
27	05/01/2017	12:43	14:15	32	36	1.8	67
28	07/14/2017	11:25	12:14	93	148	0.79	118
29	09/13/2017	11:25	11:56	56	67	0.70	50
30	10/12/2017	12:07	12:42	26	21	1.8	40
31	12/27/2017	11:45	12:14	25	17	0.63	11
32	03/14/2018	12:02	12:24	19	22	1.2	27
33	04/11/2018	11:03	11:33	27	27	2.4	68
34	05/24/2018	11:01	11:37	63	72	0.88	64
35	06/27/2018	12:14	13:04	48	44	0.16	7.3
36	07/26/2018	11:02	11:39	61	68	0.20	14
37	08/27/2018	12:18	12:58	52	54	0.41	22
38	09/13/2018	12:05	12:39	25	15	0.35	5.3

Table 2.–Monthly exceedance flows (ft^3/s) for the ADF&G's Windfall Creek streamgage 13801. The period of record is from July 17, 2013, to September 30, 2018.

% Time exceeded	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	631	300	150	211	407	249	363	478	436	439	363	459
5	254	122	61	136	180	104	186	233	260	204	175	190
10	209	77	48	101	115	73	150	188	203	165	123	112
15	180	66	40	96	101	60	116	142	149	148	100	77
20	145	49	34	87	91	49	98	113	133	122	90	61
25	111	36	29	79	84	41	82	88	119	100	73	48
30	85	26	24	75	75	37	70	73	105	95	61	37
35	74	22	20	71	71	35	60	60	86	83	51	32
40	62	17	18	67	67	31	49	53	71	76	43	28
45	54	14	17	62	61	30	40	49	63	71	38	25
50	44	12	15	59	50	27	36	42	55	62	33	23
55	39	11	14	55	41	25	32	35	49	58	28	21
60	35	10	11	52	38	23	29	31	43	55	26	20
65	27	9.2	9.2	48	34	21	26	27	37	45	22	18
70	21	8.9	7.9	44	30	19	24	25	34	40	19	17
75	19	8.2	6.4	38	28	19	22	21	31	34	17	15
80	15	8	5.8	35	25	17	19	18	28	29	16	14
85	14	7.5	5.4	30	23	14	19	14	25	21	13	13
90	11	7	5	24	18	10	14	10	20	16	12	12
95	9.3	6.4	4.7	9	15	8.7	9.4	7.7	13	12	11	11
100	6.8	4.5	2.8	7.6	9.6	3.4	7.6	1.1	11	8.6	10	8.9
Mean	83	32	23	63	66	37	62	71	86	80	56	49

Table 3.–Fish species periodicity for Windfall Creek.

Coho salmon												
Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt passage			XX	XXXX	XXXX	XX						
Adult passage								XXXX	XXXX	XXXX	XX	
Spawning								XX	XXXX	XXXX	XXXX	XX
Incubation	XXXX	XXXX	XXXX	XXXX				XX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Pink salmon												
Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry passage			XX	XXXX	XXXX	XX						
Adult passage							XXXX	XXXX	XXXX			
Spawning							XX	XXXX	XXXX	XX		
Incubation	XXXX	XXXX	XXXX	XXXX	XX		XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing				XXXX	XX							

Chum salmon												
Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry passage			XX	XXXX	XXXX	XX						
Adult passage							X	XXXX	XXXX	XX		
Spawning								XXXX	XXXX	XXX		
Incubation	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX	XXXX	XXXX	XXXX
Rearing				XXXX	XX							

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Table 3.–Page 2 of 3.

Sockeye salmon

Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt passage				XXXX	XXXX	XX						
Adult passage					X	XXXX	XXXX	XXXX	XX			
Spawning							XX	XXXX	XX			
Incubation	XXXX	XXXX	XXXX	XXXX			XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Cutthroat trout

Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt passage			XXXX	XXXX	XXXX							
Adult passage			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Spawning				XXX	XXXX	XX						
Incubation				XXX	XXXX	XXXX	XXXX	XX				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Steelhead

Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt passage				XX	XXXX	XXXX						
Adult passage: Up				XXXX	XXXX	XXXX						
Adult passage: Down					XXXX	XXXX	X					
Spawning				XXX	XXXX	XXXX						
Incubation				XXX	XXXX	XXXX	XXXX	XXXX				
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

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Table 3.–Page 3 of 3.

Dolly Varden

Life stage:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt passage			XXXX	XXXX	XXXX							
Adult passage			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
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

Notes: Life stage assessment is based on the professional judgment of ADF&G biologists. Smolt passage is for juvenile emigration to estuarine/marine environment. Adult passage for salmon is immigration. Adult passage for trout, char, and other species, is immigration and emigration. Incubation life stage includes time of egg deposition to fry emergence. Each "X" designates the week of the month the fish species life stage occurs. Blank cells indicate the fish species life stage does not occur during that month.

Figure 1.–Map of Windfall Creek near Juneau, Alaska.

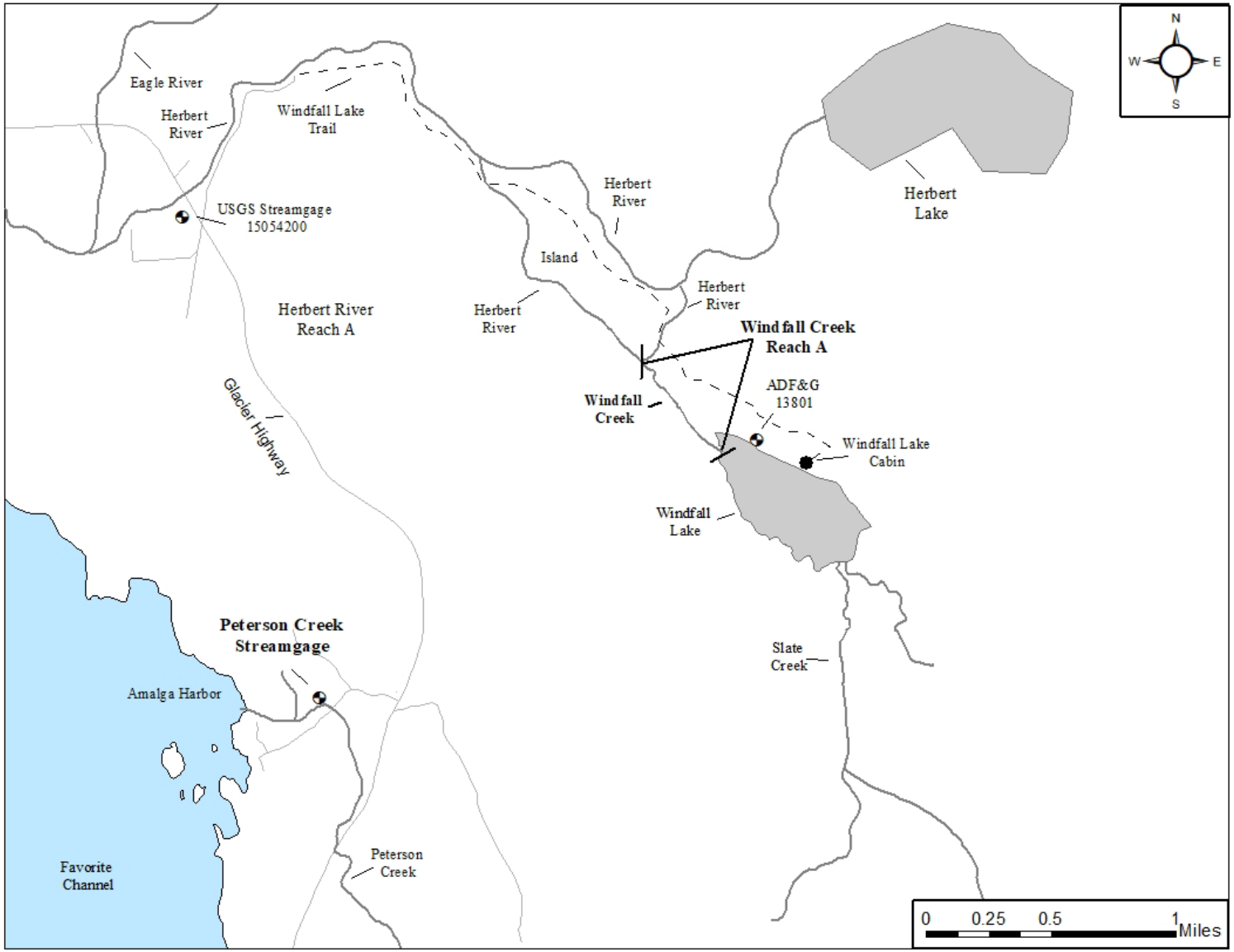

Figure 2.–Location of Windfall Creek Reach A boundaries, ADF&G's Windfall Creek streamgage 13801, and the nearby Peterson Creek streamgage.

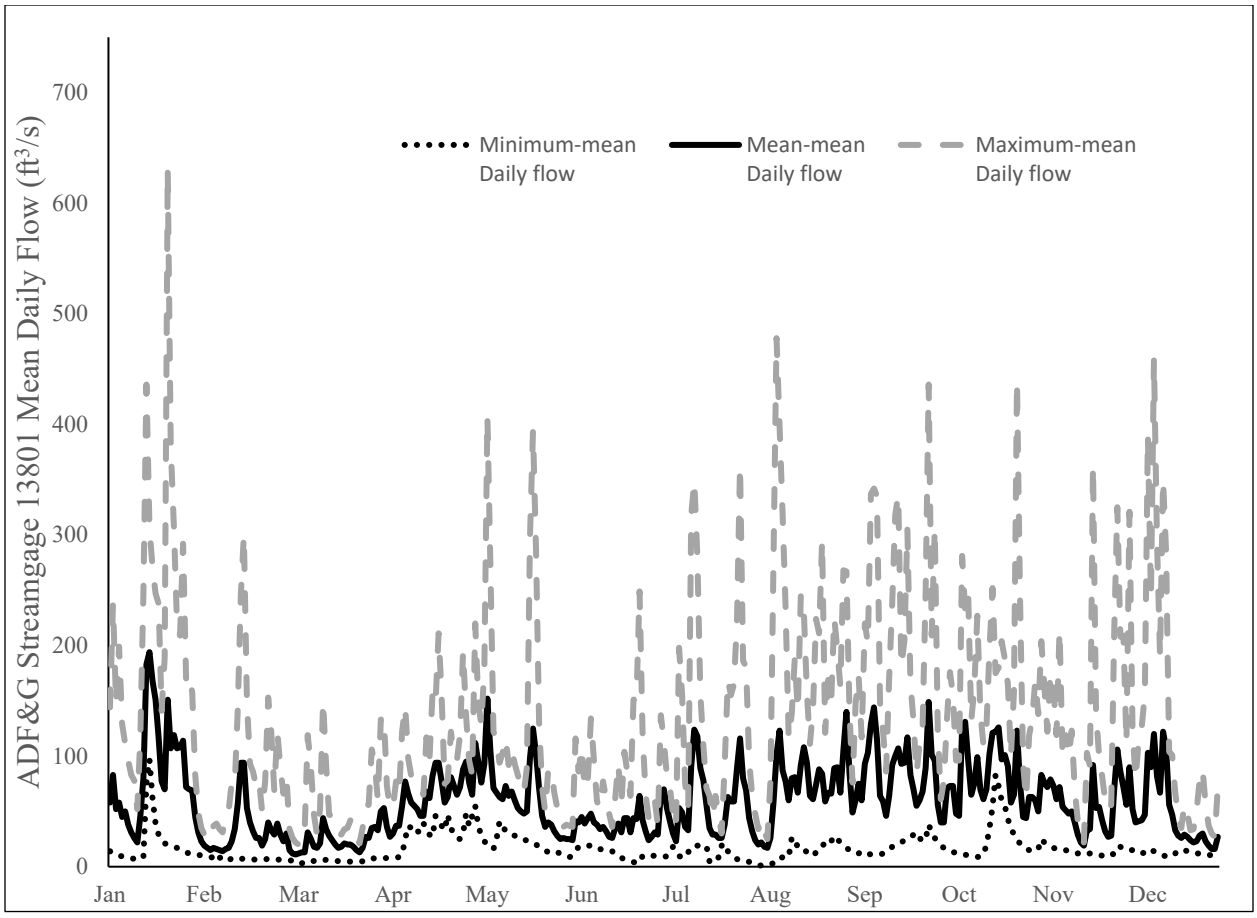

Figure 3.–Hydrograph of mean daily flows for ADF&G's Windfall Creek Streamgage 13801. The period of record is from July 17, 2013, to September 30, 2018.

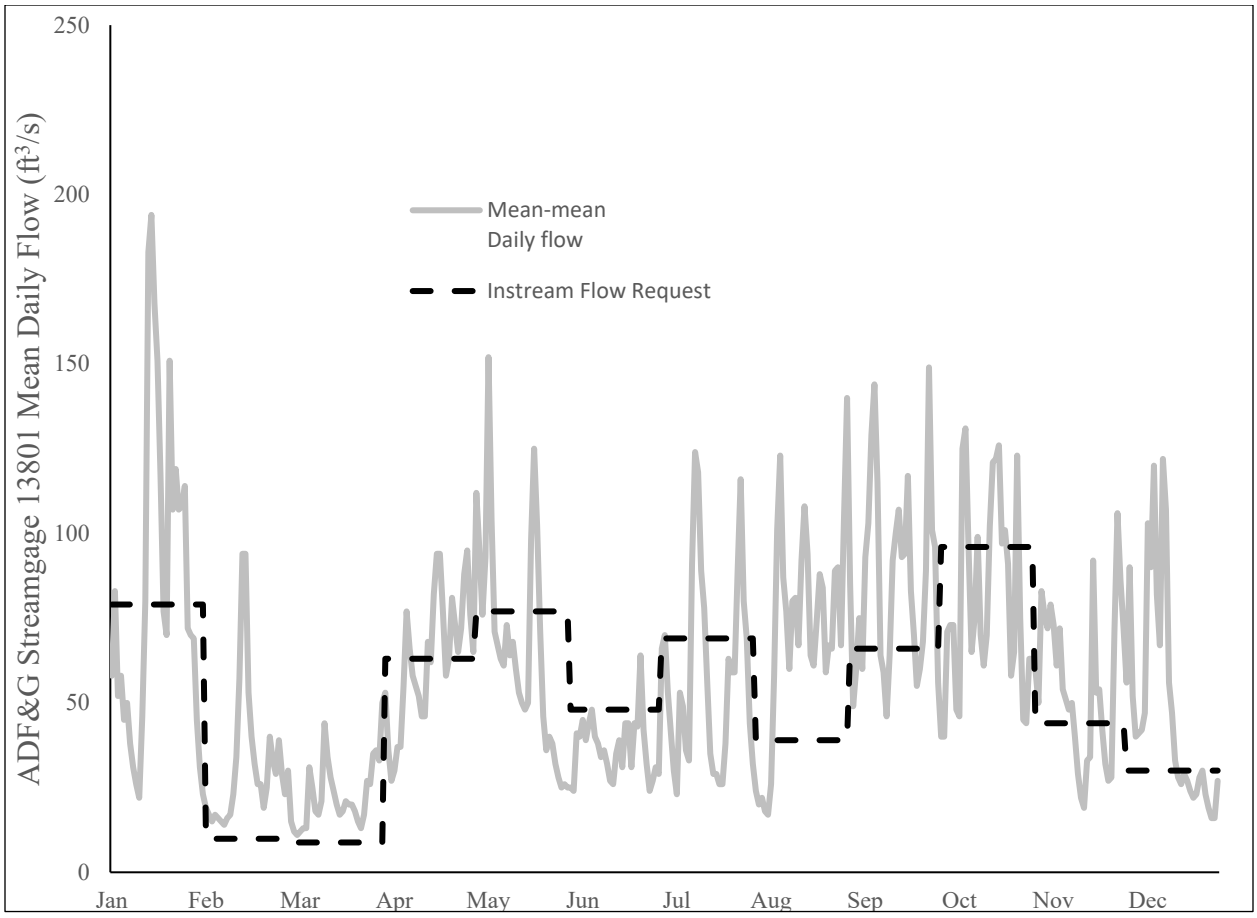

Figure 4.–Mean daily flows from ADF&G's Windfall Creek streamgage 13801 compared to instream flow requests. The period of record is from July 17, 2013, to September 30, 2018.

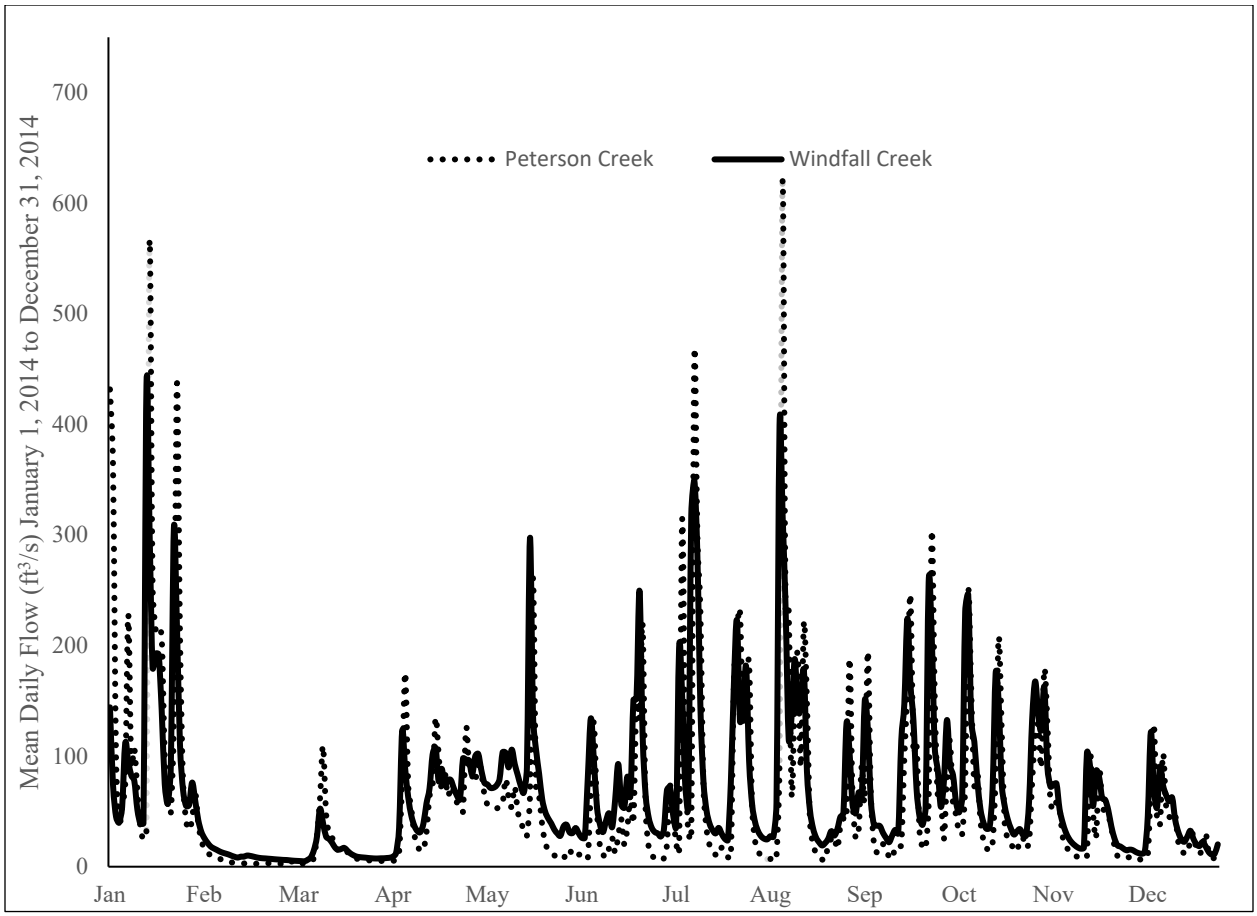

Figure 5.–Mean daily flows from Windfall Creek and Peterson Creek streamgages. The period of record is from January 1, 2014 to December 31, 2014.

APPENDIX A: PHOTOS

Appendix A1.–Looking downstream at Windfall Creek on December 19, 2013, at a discharge of 25 ft^3/s.

Appendix A2.–Looking downstream at the confluence of Windfall Creek and the Herbert River on October 29, 2014, at a discharge of 28 ft^3/s.