TYEE LAKE HYDROELECTRIC PROJECT

FERC NO. 3015

EXHIBIT B

PROJECT OPERATION AND RESOURCE UTILIZATION

https://www.ecfr.gov/current/title-18/part-4/subpart-F#p-4.51(c)

Tyee Lake Hydroelectric Project
(FERC No. 3015)

Application For License Amendment
For Major Project – Existing Dam

Exhibit B
Project Operation and Resource Utilization

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1.0 PROJECT OPERATION

1.1 Powerplant Operation

The Tyee Lake Hydroelectric Project (Tyee Lake Project or Project) is a conventional hydroelectric plant owned and operated by the Southeast Alaska Power Agency in conjunction with its Swan-Tyee Intertie (Intertie) and Swan Lake Hydroelectric Project (FERC No. P-2911). The Intertie provides a transmission path that allows for the coordination of generation assets between Petersburg and Wrangell (on the northern end of the distribution system) and Ketchikan (at the southern end of the distribution system).

Operation of the Tyee Lake Project is automatic; however, all equipment is designed for local-manual, local-automatic, and remote operation. The system is manned 7 days per week (1 shift per day) and constantly monitored with staffing on site to tend to any callouts.

Existing and proposed Tyee Lake Project turbines are a Pelton impulse-type designed specifically to operate at net head ranging from 1,163 feet (ft) to 1,384 ft. Due to their design, the turbines at the Tyee Lake Project can operate at below capacity and remain within their efficiency zone. SEAPA uses the automated real-time automation controller – Swan-Tyee Control System (STCS) – to control generation for maximizing efficiency, delivering power, and balancing lake levels (SEAPA 2023).

1.1 Tyee Lake Project Operation During Adverse, Mean, and High-Water Years

Each year SEAPA develops an annual operations plan to forecast reservoir levels and coordinate operation of the Tyee Lake and Swan Lake hydroelectric projects to maximize output from SEAPA facilities, optimize water resources and efficiency of the generating units, and minimize the need for diesel generation. Pursuant to the existing Power Sales Agreement, the operations plan gives priority to the dedicated Firm Power Requirements of Petersburg and Wrangell and optimizes Additional Dedicated Output as a second priority for additional power requirements. Petersburg and Wrangell's Firm Power Requirements are typically provided by SEAPA by using Tyee Lake's Dedicated Output. Ketchikan's Firm Power Requirements are typically provided by SEAPA by using Swan Lake's Dedicated Output and Tyee Lake's Additional Dedicated Output. Swan Lake does not have the capacity to meet the Firm Power Requirements of Ketchikan without Additional Dedicated Output from the Tyee Lake Project.

The Tyee Lake Project can operate with lake elevations ranging from 1,250 ft and 1,396 ft mean lower low water (mllw),[1] but SEAPA typically maintains a draft limit at 1,260 ft mllw. The reservoir is operated to store runoff during the summer months and to release flows for power generation throughout the year. Under normal water years, the reservoir is filled in the summer from snowmelt and precipitation runoff and is generally at its lowest in late spring prior to snowmelt. Because of the generational flexibility required in this closed-loop system, water levels in Tyee Lake vary based on loads and inflow to the system.

As part of the annual operations plan, SEAPA develops a Tyee Lake reservoir model with two case scenarios, a Guide/Curtailment Curve (based on 2018 drought year minus 10 ft and normal loads) and a Sales Curve (SEAPA 2023). If Tyee Lake elevations fall below the Guide/Curtailment Curve, Additional Dedicated Output is considered unavailable and net sales from Tyee Lake to Ketchikan are curtailed until Tyee Lake levels reach the Sales Curve. The area between the Guide/Curtailment Curve and the Sales Curve is considered the Tyee Operations Band. Once the elevation of Tyee Lake has reached the Sales Curve, Additional Dedicated Output is made available to Ketchikan for as long as Tyee Lake levels remain within the Tyee Operations Band.

During normal water years, SEAPA operates to maximize generation and to minimize spill when the reservoirs are refilling. In a typical year, Tyee Lake has the capacity to meet Petersburg and Wrangell's Firm Power Requirements and provide Additional Dedicated Output to Ketchikan. When inflow causes Tyee Lake elevations to exceed 1,396 ft, excess water is spilled over the weir at the natural outlet of Tyee Lake into Tyee Creek. Spill typically occurs in response to precipitation events, the frequency and intensity of which are influenced by the El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), as is the air temperature and demand for power. In an average water year, spill to Tyee Creek may or may not occur. For example, no spill occurred in 2017, and in 2023 spill of less than 1 cubic foot per second (cfs) occurred each day for a total of two days.

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[1] Mean lower low water (mllw) is mean sea level (msl) minus 8, and was the elevation datum used for the original license.

In drought conditions, load demands beyond what can be produced by Tyee Lake and Swan Lake are provided via other sources of generation (i.e., Petersburg and Wrangell Supplemental Diesel Generation or Ketchikan Public Utility (KPU) Supplemental Diesel Generation). As Tyee Lake levels approach the lower elevation limit (typically early spring), SEAPA may curtail or shut off generation at the draft limit to preserve limited available capacity (approximately 10 ft of water or 4,150 megawatt hours [MWh] of available capacity). Petersburg and Wrangell may use supplemental diesel generation to slow the draft rate until the draft limit is reached. Once the draft limit has been reached, Tyee Lake generators may remain off and Petersburg and Wrangell may use full diesel generation to meet Petersburg and Wrangell's Full Power Requirements until Tyee Lake recovers and reaches sufficient capacity (typically around lake elevation 1,265 ft) to meet the Firm Power Requirements of Petersburg and Wrangell (SEAPA 2023). Tyee Lake does not supply Additional Dedicated Output to Ketchikan until the lake elevation reaches the Sales Curve. In low water years, Tyee Lake may not have the capacity to provide Additional Dedicated Output to meet Ketchikan's demand, as occurred in the 2018-2019 drought (SEAPA 2023).

During high water years, SEAPA operates to maximize generation and to minimize spill. More spill occurs during high water years, particularly during the summer and fall months (July through October) during precipitation events when Tyee Lake is generally full. For example, during above-average water years in 2020, 2021, and 2022, spill occurred on 62, 130, and 81 days each year, respectively. The amount of annual energy that could potentially be generated from the amount of spill ranged from 27,755 MWh in 2022 to 67,112 MWh in 2021. The proposed development and installation of a third unit would increase the capacity of the Tyee Lake Project, allow SEAPA to capture water that would have otherwise spilled to provide Additional Dedicated Output to meet Ketchikan's demand, could offset the need to generate power from stored water at Swan Lake, and reduce reliance on diesel generation later in the year.

1.2 Tyee Lake Project Operation and Operation During Maintenance Activities

Tyee Lake is a natural lake dependent on inflows from snowmelt and seasonal precipitation. The lake tap intake can only discharge within the limits of the turbines. If a maintenance activity requires a Tyee Lake drawdown, SEAPA may control reservoir levels by limiting summer refill from runoff and otherwise coordinating with Swan Lake operations to lower Tyee Lake levels. The Tyee Lake Project is typically shut down for 10 days each year during summer to perform routine maintenance activities. During this time, 3 cfs is diverted to supply station service at 100 kilowatts (kW).

1.3 Proposed Operational Changes

With the addition of a third generating unit, SEAPA would continue to operate the Tyee Lake Project in coordination with the Swan Lake project to maximize output from SEAPA facilities and optimize water resources and unit efficiency. The third turbine would allow SEAPA to better meet load demand when water for generation is available and reduce reliance on diesel generation.

1.4 Annual Plant Factor

The average annual plant factor is determined using the following equation:

$$\frac{\text{Average Annual Output}}{\text{Licensed Capacity x 8,760 hours/year}} = \text{Average Annual Plant Factor}$$

Average annual power generation at the Tyee Lake Project from 2017 through 2023 was approximately 105,805 MWh. The average annual plant factor is approximately 60 percent based on the current licensed capacity of 20 MW. Actual generation after installation of the third unit would vary based on several variables outside of SEAPA’s control. However, all things being equal, generation would increase with the addition of the third unit and the average annual plant factor is expected to exceed 50 percent.

2.0 DEPENDABLE CAPACITY AND AVERAGE ANNUAL ENERGY PRODUCTION

2.1 Dependable Capacity

The dependable capacity of the Tyee Lake Project is 4,150 MWh. This represents the available capacity when Tyee Lake has 10 ft of usable storage. At this elevation, SEAPA typically ceases generation in favor of other generation sources in the system (e.g., diesel generators). There are no proposed changes to the dependable capacity.

2.2 Average Annual Generation

Average annual power generation at the Tyee Lake Project from 2017 through 2023 was approximately 105,805 MWh. Average monthly energy generation from 2017 through 2023 is provided in Table 2-1.

Table 2-1 Tyee Lake Project Average Generation by Month (MWh) 2017-2023.

Month	Average Monthly Energy Generation (MWh)
January	11,448
February	10,400
March	10,369
April	9,530
May	6,970
June	5,145
July	8,659
August	8,629
September	6,259
October	7,146
November	9,498
December	11,753
Average	**8,817**

2.3 Tyee Lake Project Hydrology

The Tyee Lake Project lies within a temperate rainforest. The watershed varies in elevation from 1,250 to 5,005 ft mean sea level (msl) and is composed primarily of dense coniferous forest below the alpine. There are no glaciers in the watershed and runoff from rainfall is the primary source of water, followed by snowmelt. Mean annual precipitation is 81.5

inches, but can vary widely from year to year as rainfall and snowpack are influenced by the ENSO and the PDO (SEAPA 2023). The watershed has an estimated drainage area of 14.4 square miles (USGS 2016) and the lake receives between 250 and 350 ft of water from precipitation and runoff. Water is diverted to the powerhouse through a lake tap. The normal operating pool ranges in elevation from 1,250 ft mllw to full pool. At 1,398.3 ft elevation North American Vertical Datum of 1988 (NAVD 88) (USGS 2020), water spills over the weir at the natural lake outlet to Tyee Creek which joins Hidden Creek before flowing into Bradfield Canal about a half mile from the tailrace.

There are currently no gages that record inflow into Tyee Lake or the amount of water available for generation. There was a USGS gage (USGS Gage No. 15020100) that operated from August 1, 1963, to September 29, 1969, at the mouth of Hidden Creek near Bradfield Canal, downstream from Tyee Lake and Tyee Creek's confluence with Hidden Creek representing a drainage area of 16.1 square miles. Through correlation with concurrent records available for the Harding River USGS Gage (located about 5 mi west of the mouth of Tyee Creek), records for flow at the mouth of Hidden Creek were expanded to cover water years 1952 through 1978 and inflow from Tyee Lake was then synthesized from drainage area proportioning and adjusted for elevation and runoff differences between the upper and lower portions of the basin (IECO 1982). The synthesized estimates of mean monthly and daily discharge from Tyee Lake across the period of record is presented in Table 2-2 and Figure 2-1.

Approximately 70 percent of the runoff in the Tyee Lake basin occurs from June through October (IECO 1982). Historical mean monthly flows peaked in June, July, September, and October, and were lowest in February and March, highlighting the seasonal variability in water availability. The runoff pattern shows that the highest flows occur during June and July, the magnitude and duration of which depend on the depth of the snow in the basin, the temperatures during the melting season, and the occurrence of rain. Extremely high flows also occur in September and October, and to a lesser extent August, resulting from heavy rain events.

Table 2-2 Synthesized Average Monthly and Daily Discharge at Tyee Lake Outlet (1952-1978).

Month	Average Monthly Discharge (cfs)	Average Daily Discharge (cfs)
January	47	5.8
February	36	1.0
March	28	0.1
April	53	2.2
May	193	66.9
June	350	199.1
July	293	159.4
August	238	98.7
September	218	154.0
October	275	143.1
November	113	40.9
December	76	12.8
Annual	161	**73.8**

Source: IECO 1982.

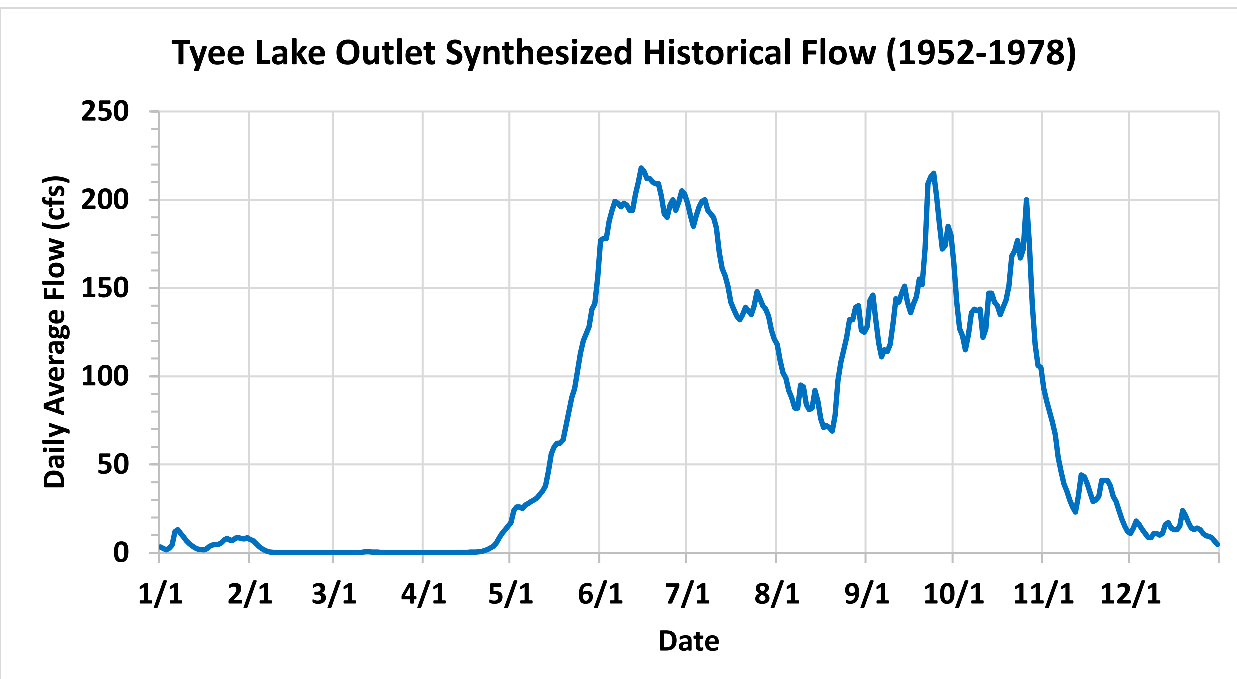

Figure 2-1 Hydrograph at Tyee Lake Outlet Based on Synthesized Average Daily Discharge (1952-1978).

USGS Gage No. 15019990 (Tyee Lake Outlet) is the only active gage in the watershed, and measures river flow at the Tyee Lake outlet. The gage does not account for significant seepage from the natural lake outlet into Tyee Creek that is believed to begin at some point when lake levels exceed approximately 1,360 ft. A concrete weir structure was constructed at the Tyee Lake outlet in 2013 to better measure outflow from Tyee Lake and was further modified in 2015 to reduce leakage around and under the large boulder and rock substrates at the lake outlet. The USGS gage measures water that spills over the weir, but some unquantified seepage continues to flow from the lake into Tyee Creek when the lake level is high.

Monthly minimum, mean, and maximum discharge at the powerhouse and spill data from 2017 through 2023 are provided in Table 2-3. The average annual discharge from the powerhouse was approximately 125 cfs. The average monthly discharge ranged from 74 cfs in June to 162 cfs in December. No spill occurred at any time 2017 through 2019 or from December through May of any year (Table 2-3). When spill occurred, the mean monthly spill ranged from 6 cfs in November to 69 cfs in August. Monthly maximum spill flows ranged from 350 cfs in November to 637 cfs in August.

Table 2-3 Monthly Discharge through Tyee Lake Powerhouse and Spill (2017-2023).

Month	Tyee Plant Use				Spill			
	Min (cfs)	Mean (cfs)	Max (cfs)	Mean (ac-ft)	Min (cfs)	Mean (cfs)	Max (cfs)	Average # Days of Spill
January	47	159	226	9,765	0	0	0	0
February	47	160	212	8,944	0	0	0	0
March	20	147	214	9,047	0	0	0	0
April	41	143	216	8,493	0	0	0	0
May	35	100	176	6,152	0	0	0	0
June	0	74	158	4,419	0	20	514	2
July	0	119	188	7,336	0	36	357	7
August	0	119	196	7,309	0	69	637	10
September	0	89	184	5,295	0	64	571	9
October	0	97	165	5,985	0	50	600	10
November	78	133	196	7,941	0	6	350	2
December	82	162	222	9,921	0	0	0	0
Annual	**-**	**125**	**-**	**90,609**	**-**	**-**	**-**	**-**

Annual and monthly flow duration curves developed from the 7-year record (1963-1969) of daily flows at USGS Gage 15020100 (Tyee Creek at Mouth), which is located downstream of Tyee Lake and confluence with Hidden Creek near Bradfield Canal, are provided in Appendix B-1.

2.4 Area-Capacity Curve

An area-capacity curve for the Tyee Lake Project is shown in Figure 2-2 and a storage-elevation curve is shown in Figure 2-3. Figure 2-4 shows the daily reservoir elevation for the period 2017 through 2023, the minimum and maximum reservoir elevation, and the daily average historical flow data from USGS Gage 15019990 (1952 to 1978). Spill occurred in 2020, 2021, 2022, and 2023.

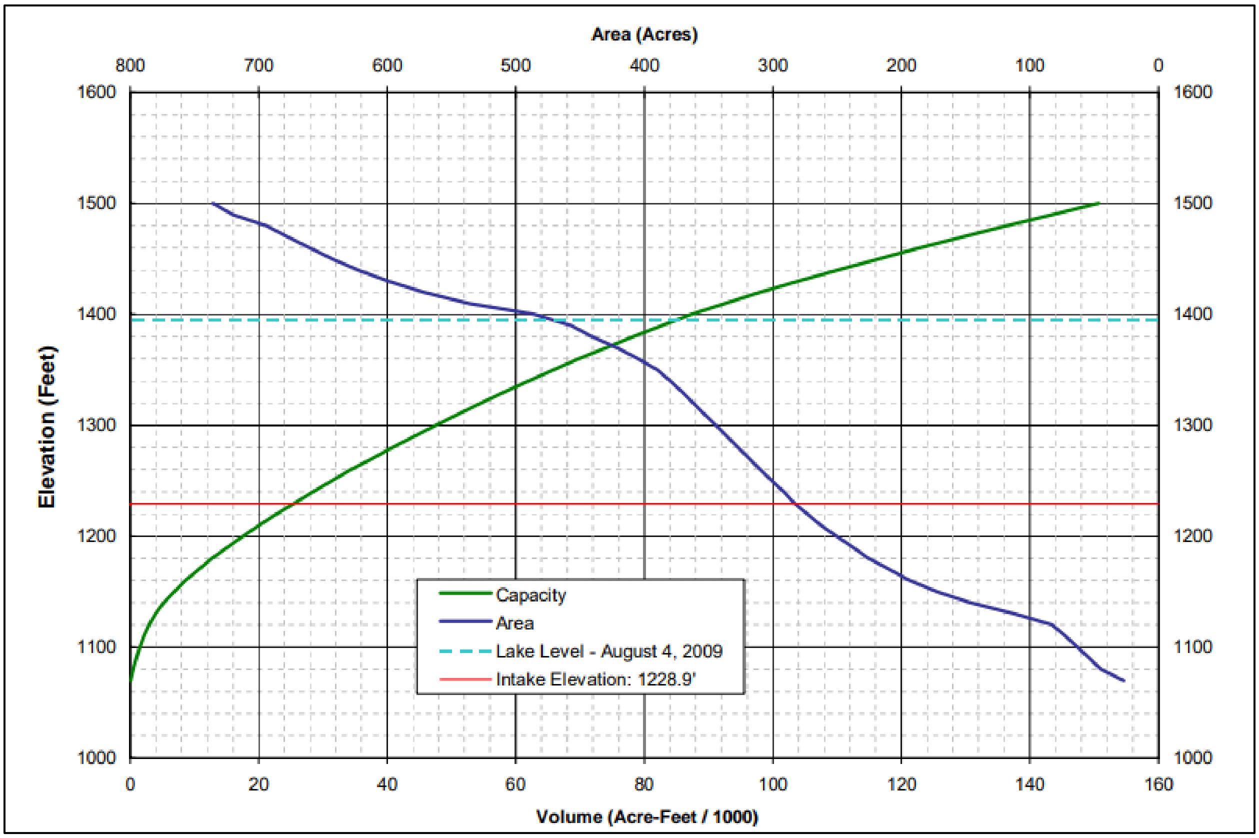

Figure 2-2 Tyee Lake Area-Capacity Curve. Source: TerraSond 2009 (Datum: NAVD 88).

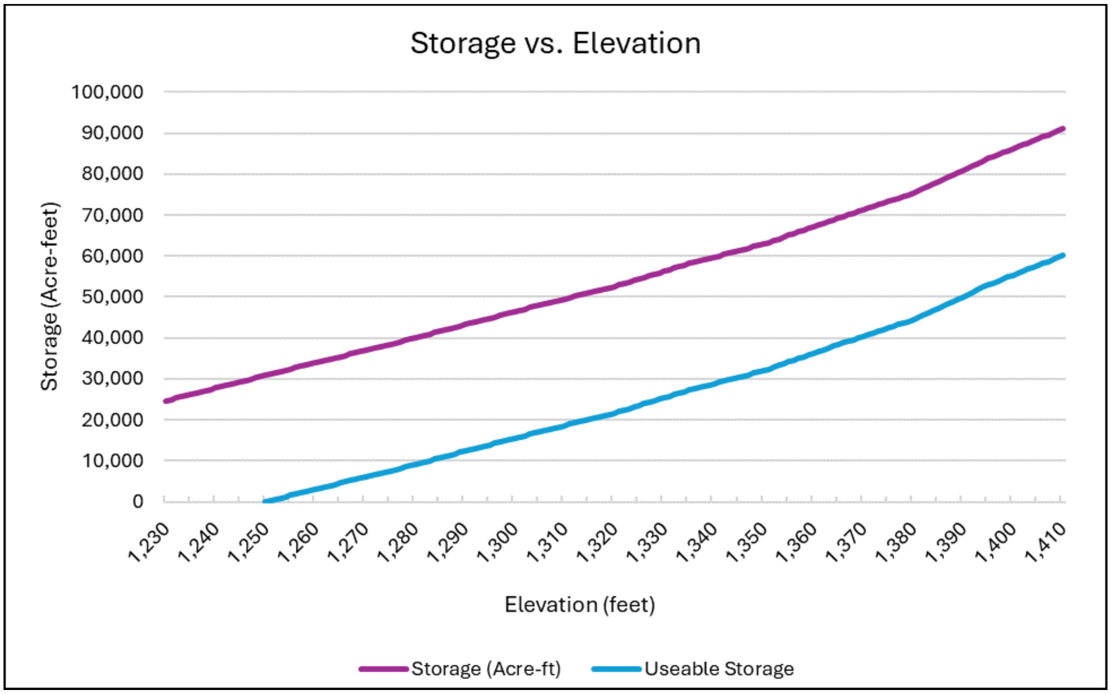

Figure 2-3 Tyee Lake Storage-Elevation Curve. Source: TerraSond 2009. (Datum: NAVD88)

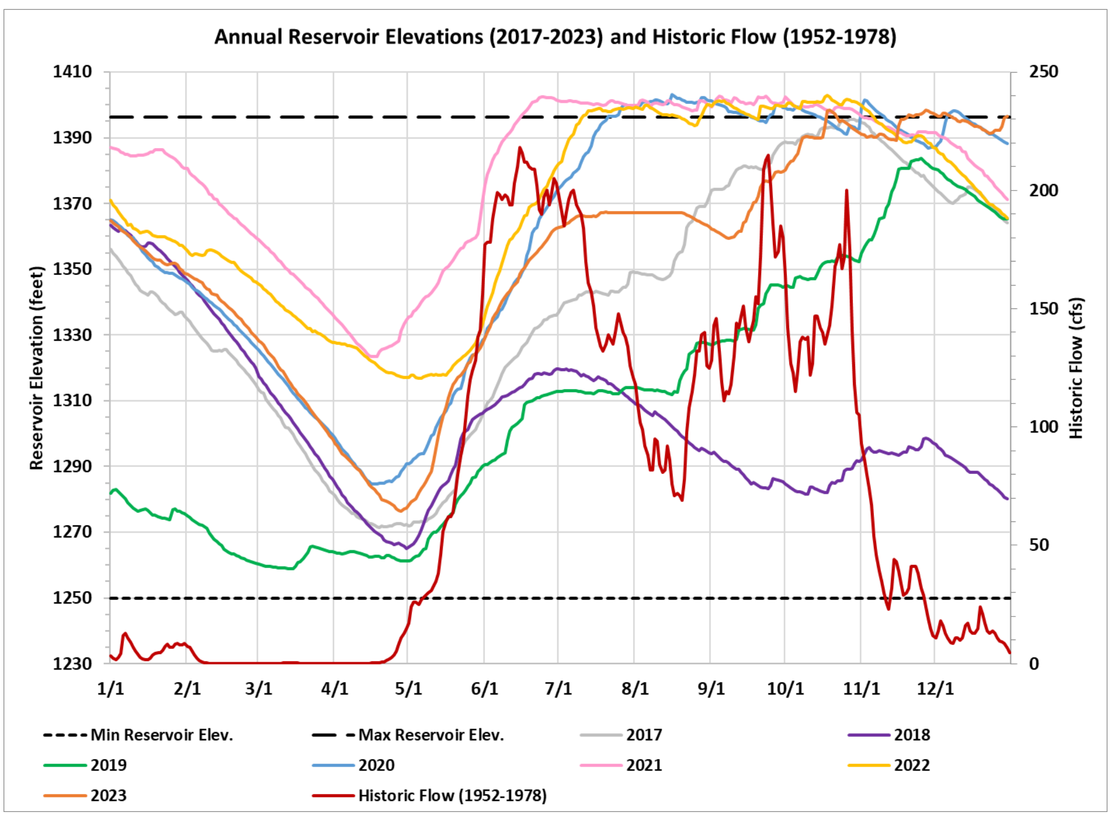

Figure 2-4 Tyee Lake Elevation in MLLW (2017 to 2023) and Synthesized Historical Flow Data from Tyee Lake Outlet (1952-1978).

2.5 Estimated Hydraulic Capacity

The maximum hydraulic capacity of the two installed turbines and the proposed third turbine is 117 cfs each and the existing power tunnel, penstock, and tailrace are sized to accommodate a flow corresponding to 30 MW (36 MVA) of capacity. The minimum hydraulic capacity is 3 cfs to maintain station service (100 kW).

2.6 Tailwater Rating Curve

The Tyee Lake Project uses Pelton turbines, which are not dependent on tailwater elevation. Therefore, a tailwater rating curve is not applicable.

2.7 Power Plant Capability Versus Head

The Tyee Lake Project turbines have a rated speed of 720 revolutions per minute at an effective head of 1,275 ft with a rated output of no less than 12,190 kW. The weighted average efficiency is 91.53 percent. Tyee Lake can operate between elevation 1,250 ft and 1,396 ft MLLW, but typically maintains a draft limit at 1,260 ft mllw. The turbine performances at a head of 1,300 ft, 1,275 ft, and 1,250 ft mllw are presented in Figure 2-5, Figure 2-6, and Figure 2-7.

Table 2-4 Tyee Lake Project Turbine Performance and Characteristics

Flow (cfs)	Net Head (ft)	Theoretical Power (MW)	Guaranteed Efficiency (%)	Turbine Power (MW)	Weighting Factor	Incremental Efficiency (%)
84	1,300	9.24	91.52%	8.46	0.15	13.73%
75	1,300	8.25	91.58%	7.56	0.07	6.41%
67	1,300	7.37	91.49%	6.74	0.16	14.64%
117	1,275	12.62	90.29%	11.39	0.01	0.90%
84	1,275	9.06	91.60%	8.30	0.01	0.92%
75	1,275	8.09	91.66%	7.42	0.33	30.25%
117	1,250	12.37	90.29%	11.17	0.05	4.51%
75	1,250	7.93	91.71%	7.27	0.15	13.76%
67	1,250	7.09	91.64%	6.50	0.07	6.41%

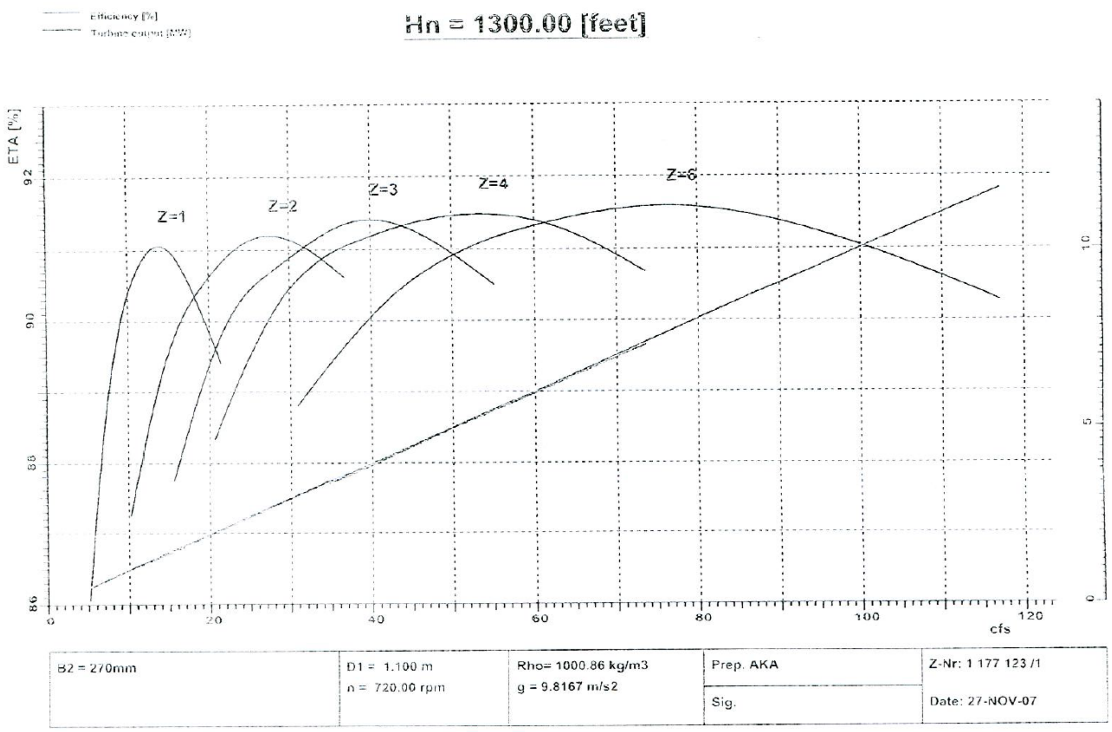

Figure 2-5 Tyee Lake Project Turbine Performance at a Head of 1,300 ft.

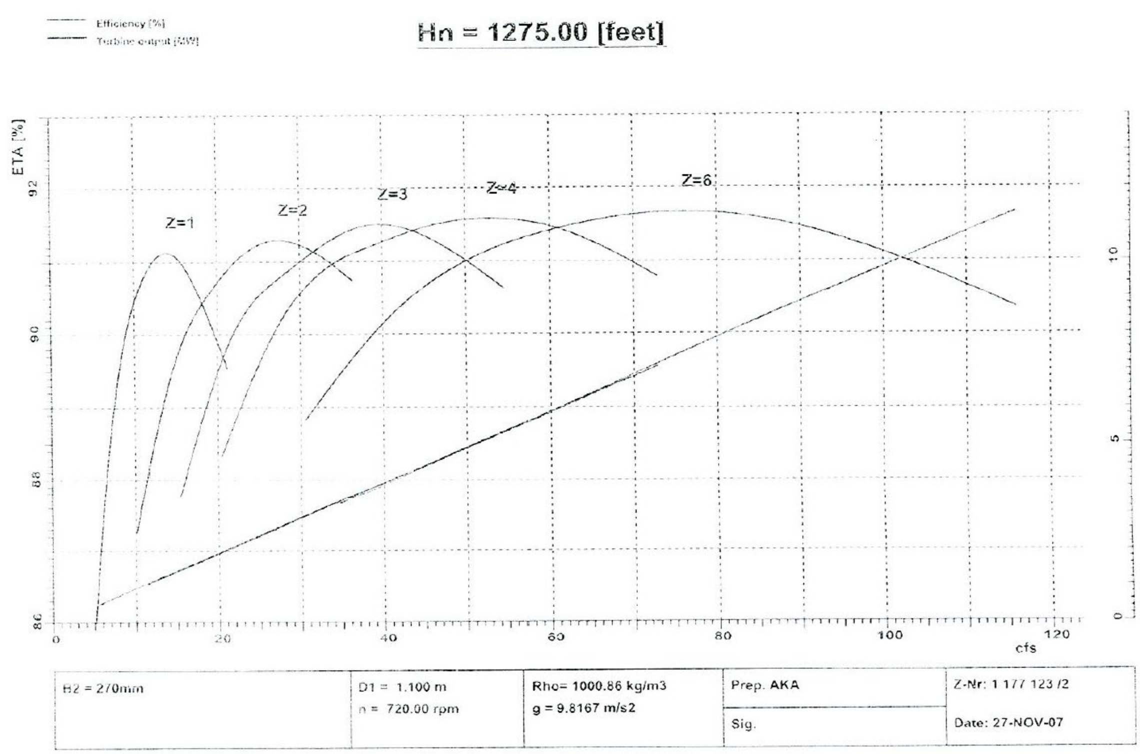

Figure 2-6 Tyee Lake Project Turbine Performance at a Head of 1,275 ft.

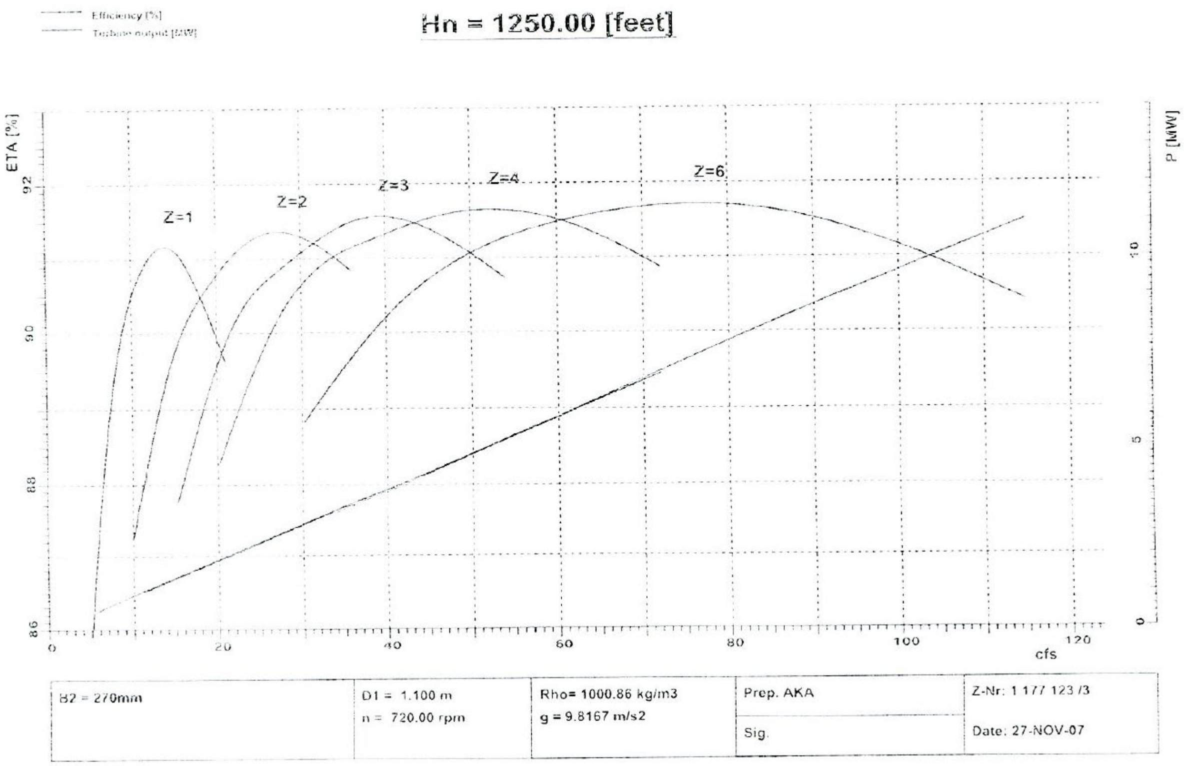

Figure 2-7 Tyee Lake Project Turbine Performance at a Head of 1,250 ft.

3.0 USE OF PROJECT POWER

The power used on-site is not metered. However, during routine annual maintenance 100 kW capacity is maintained to provide station service. Aside from limited power used on-site, all power generated by the Tyee Lake Project is subject to a Power Sales Agreement with Petersburg Municipal Power and Light, Wrangell Municipal Power and Light, and Ketchikan Public Utility. Tyee Lake provides Dedicated Output to first meet Petersburg and Wrangell's Firm Power Requirements. If Tyee Lake has capacity to meet those Firm Power Requirements, it can sell power to KPU as Additional Dedicated Output. As part of its annual operations plan, SEAPA forecasts firm power requirements for each of the utilities and expected generation. For 2024, SEAPA estimated that Tyee Lake would generate 108,533 MWh and Petersburg and Wrangell's Firm Power Requirements would be 81,421 MWh (SEAPA 2023). The remaining power generated by Tyee Lake would be sold to KPU to meet its load requirements. There are no other power purchasers.

4.0 PLANS FOR FUTURE DEVELOPMENT

Aside from the proposed modifications associated with this application, SEAPA does not currently have any additional plans for future development of the Tyee Lake Project during the current license term.

5.0 REFERENCES

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USGS. 2024b. USGS 15020100 TYEE C AT MOUTH NR WRANGELL AK. Available Online: https://waterdata.usgs.gov/nwis/inventory/?site_no=15020100. Accessed August 2024.

APPENDIX B-1

MONTHLY FLOW DURATION CURVES DEVELOPED FROM USGS GAGE NO. 15020100 (TYEE CREEK AT MOUTH) FOR THE 7-YEAR PERIOD OF RECORD (1963-1969)

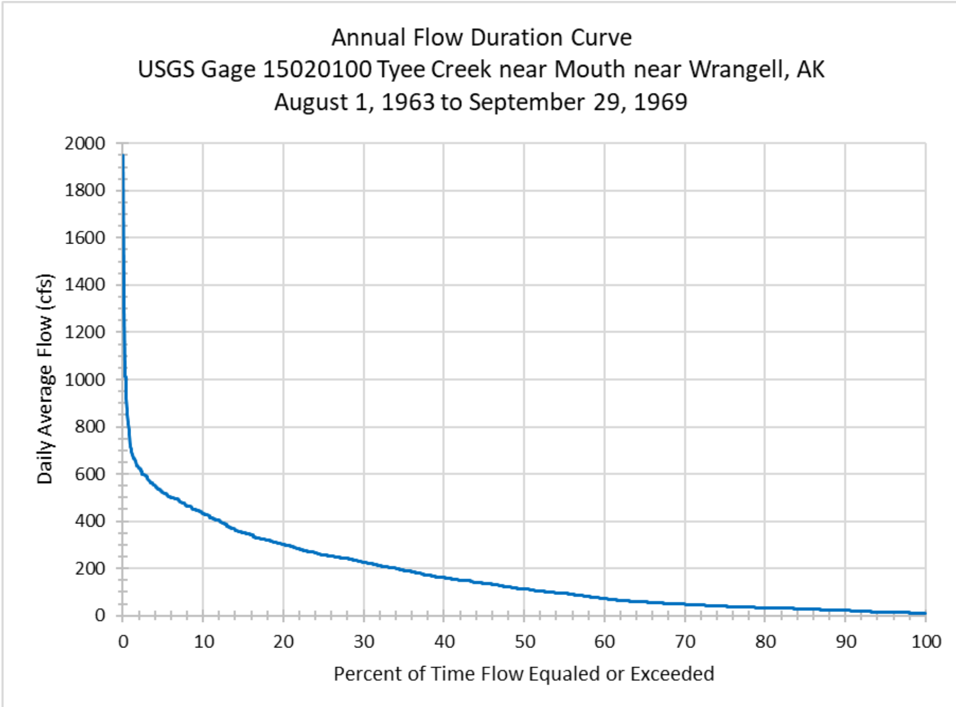

Figure B1-1 Annual Flow Duration Curve at Mouth of Tyee Creek USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

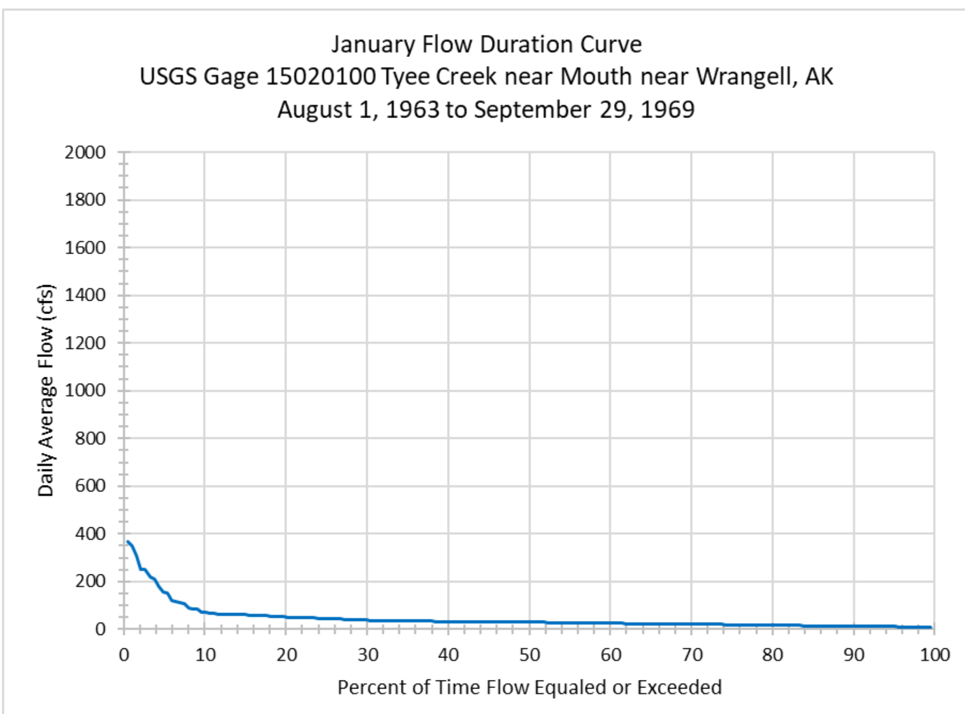

Figure B1-2 January Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

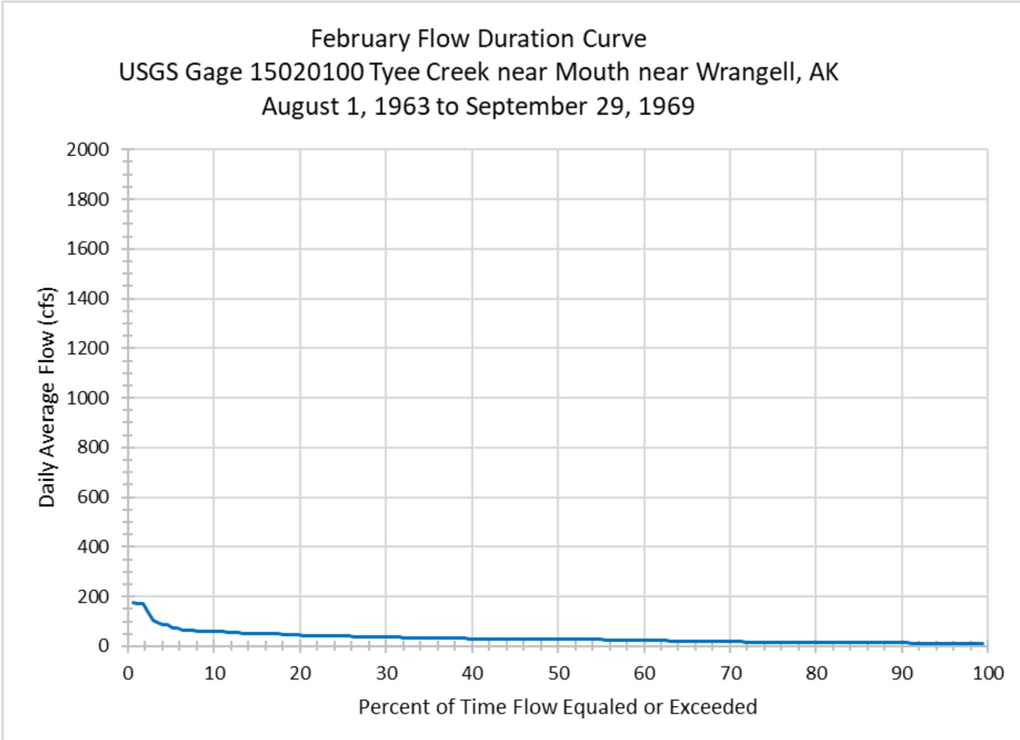

Figure B1-3 February Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

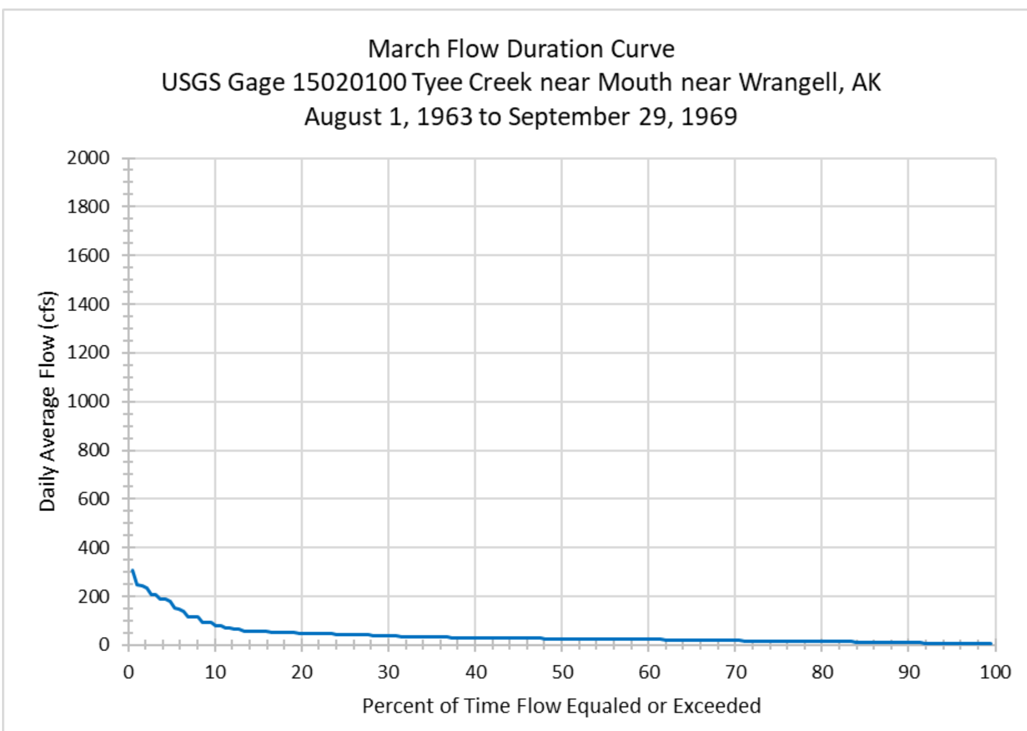

Figure B1-4 March Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

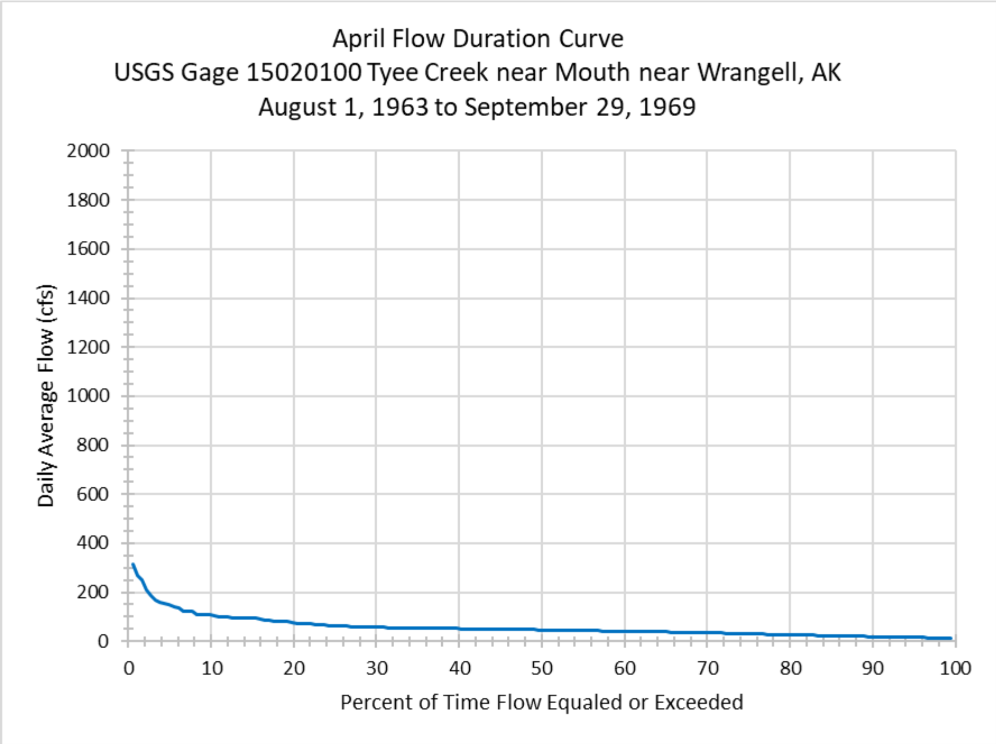

Figure B1-5 April Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

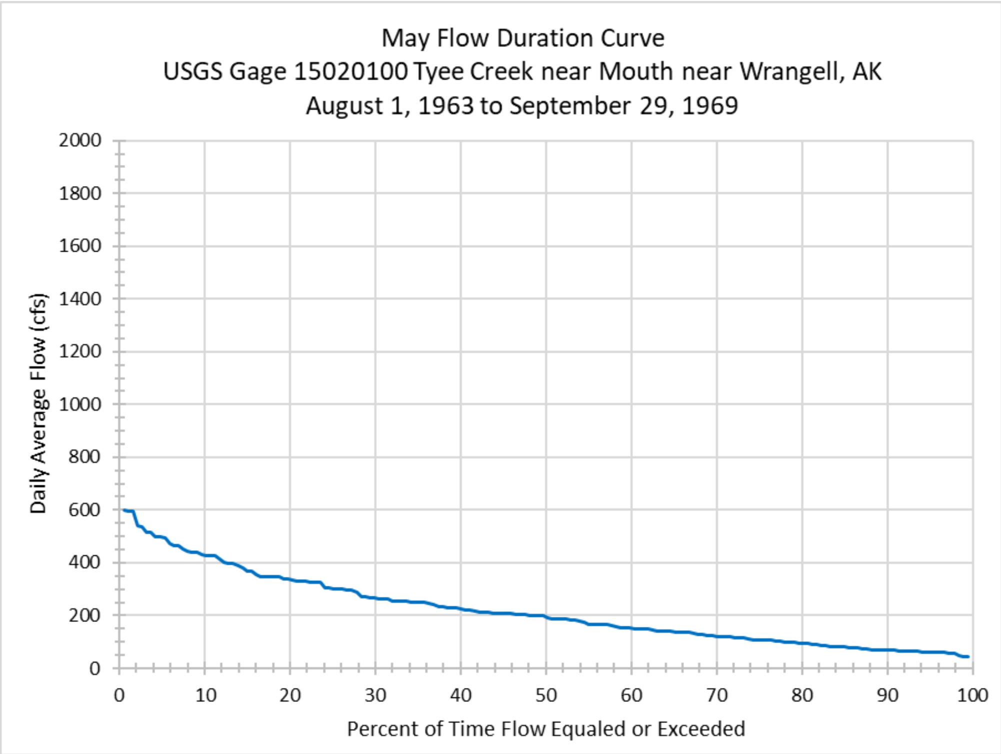

Figure B1-6 May Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

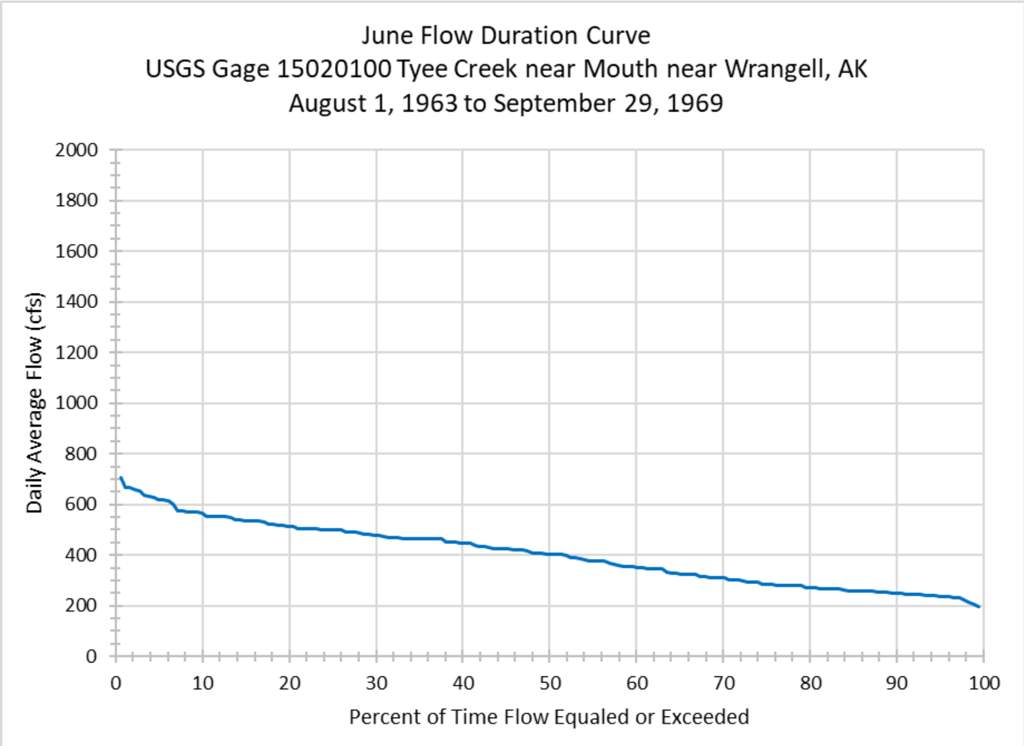

Figure B1-7 June Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

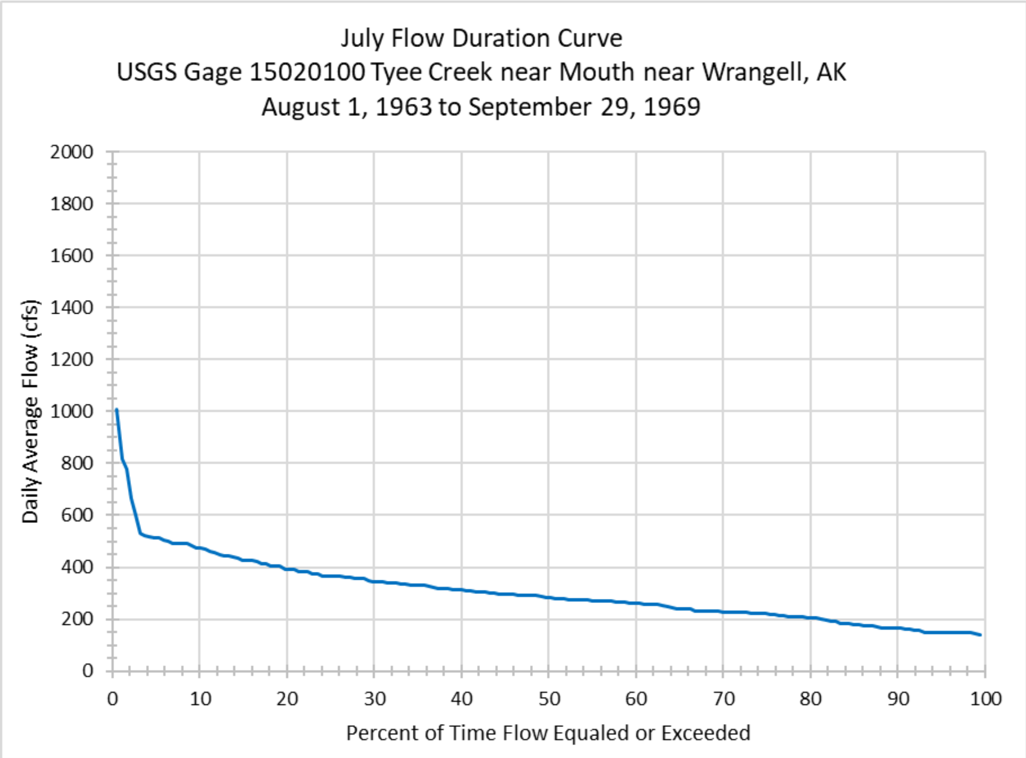

Figure B1-8 July Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

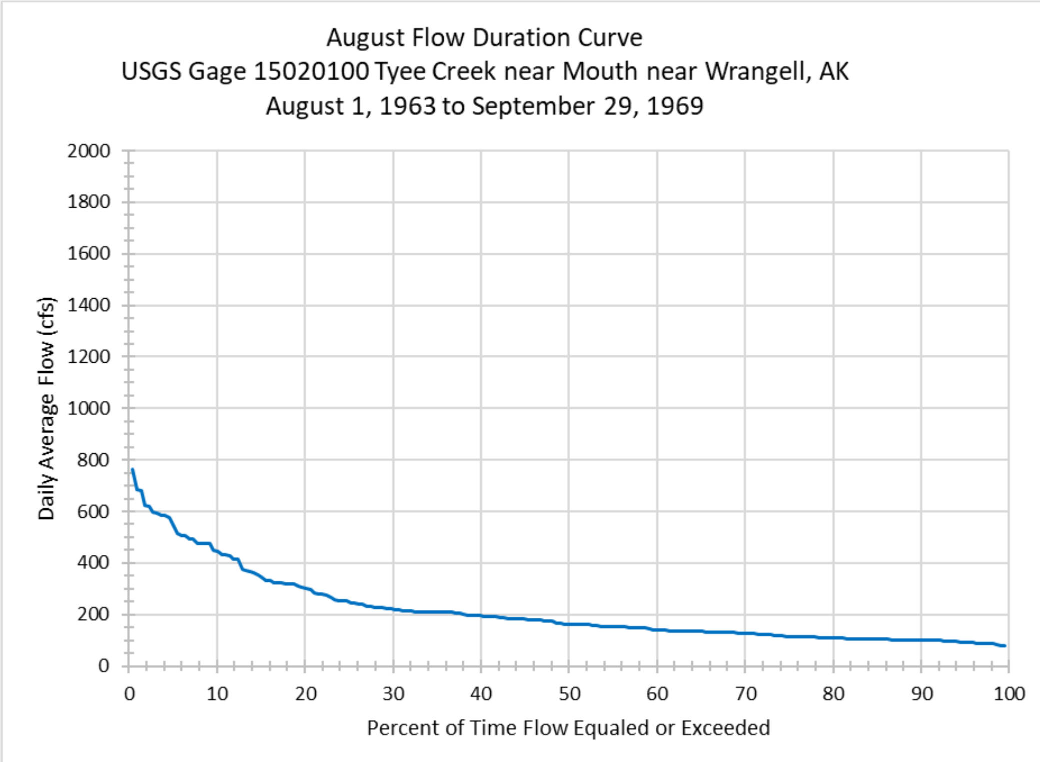

Figure B1-9 August Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

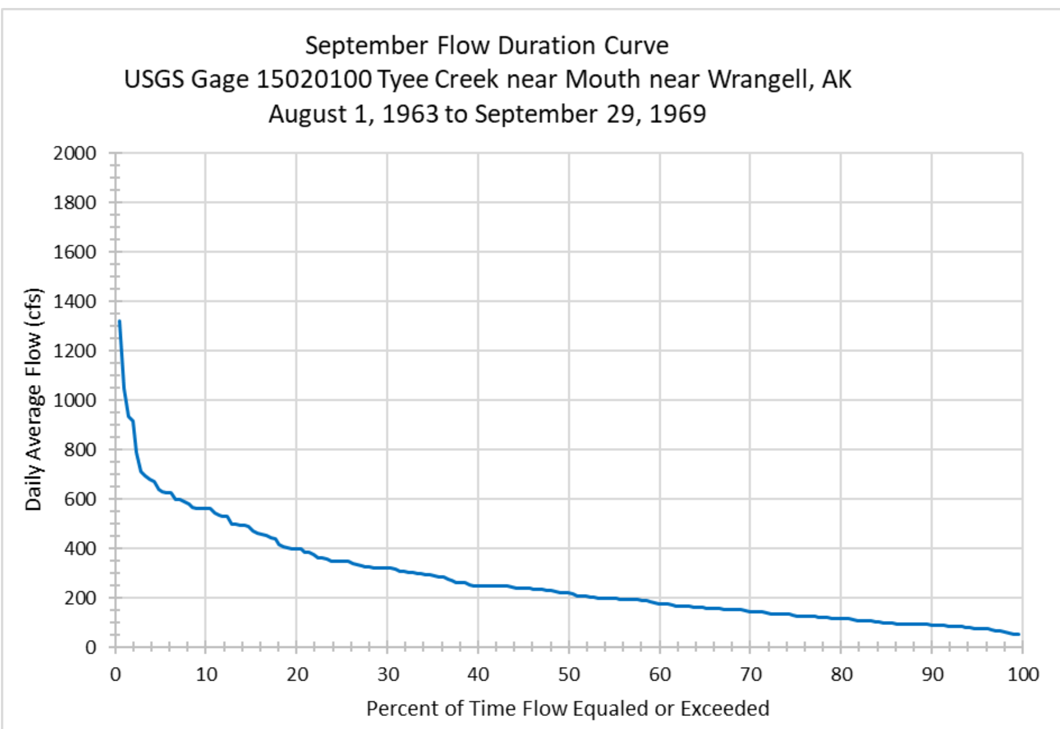

Figure B1-10 September Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

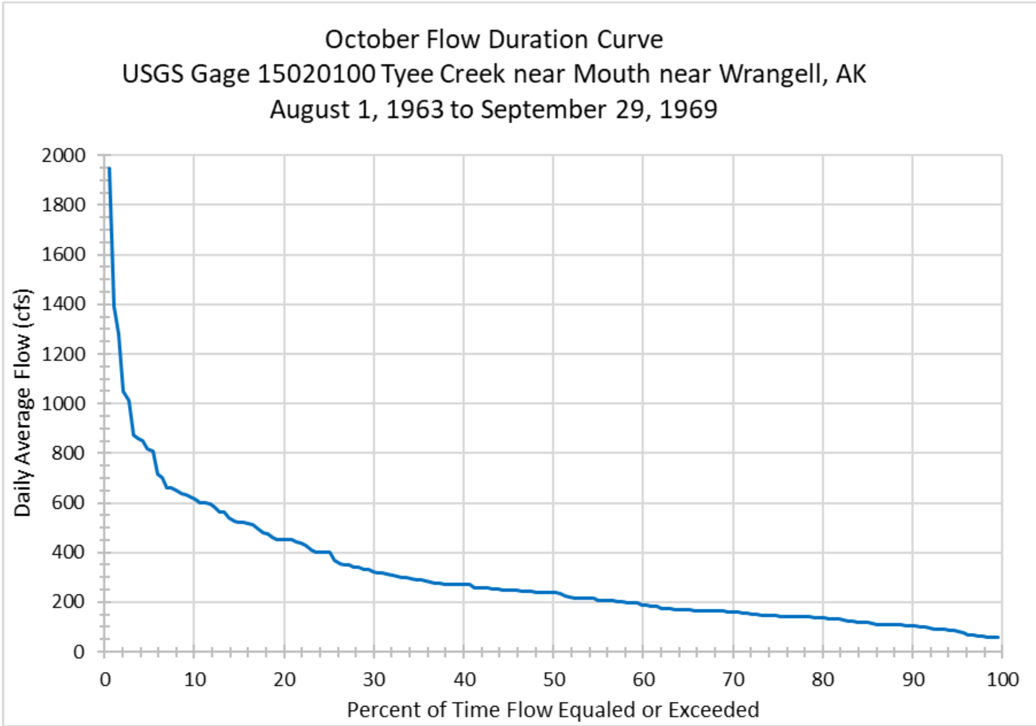

Figure B1-11 October Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

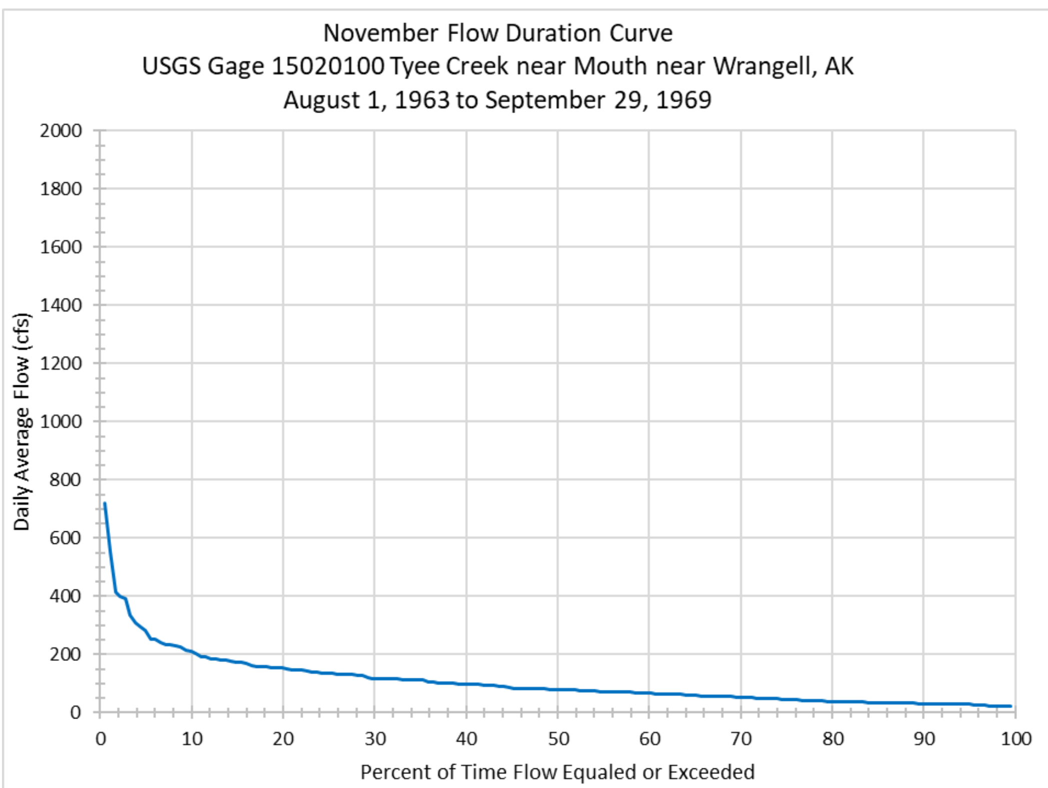

Figure B1-12 November Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.

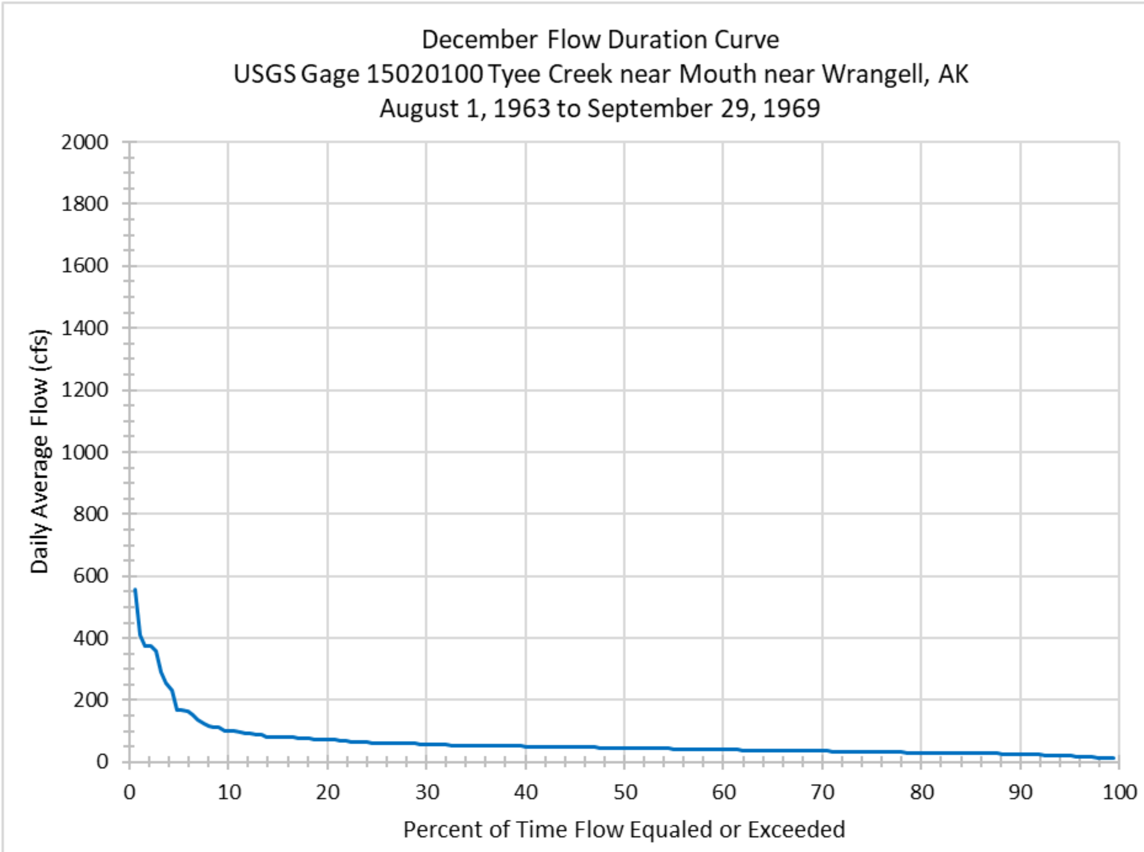

Figure B1-13 December Flow Duration Curve, USGS Gage 15020100 Tyee Creek near Mouth near Wrangell, AK.