Environment

Yukon Energy Corporation

Marsh Lake Fall-Winter Storage Concept Hydrology Baseline Report

Prepared by:

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Project Number:

60146345

Date:

March, 2011

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March 28, 2011

Hector Campbell
Director, Resource Planning & Regulatory Affairs
Yukon Energy Corporation
2 Miles Canyon Rd.
Whitehorse, YT Y1A 6S7

Dear Mr. Campbell:

Project No: 60146345

Regarding: Marsh Lake Fall-Winter Storage Concept Hydrology Baseline Report

AECOM is pleased to present our Marsh Lake Fall-Winter Storage Concept Hydrology Baseline Report. This report provides a compilation of the hydrological baseline conditions of the Southern Lakes.

If there are any questions or comments on this report, please contact the undersigned. Thank you for the opportunity to work on this project.

Sincerely,
AECOM Canada Ltd.

David Morissette, P.Eng., M. Eng.
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1. Overview

1.1 Study Area

Marsh Lake is the lake located furthest downstream in a chain of lakes, referred to as the Southern Lakes, which forms the headwaters of the Yukon River. The Southern Lakes system spans the border between British Columbia and Yukon. The Yukon River drains north, through Yukon and Alaska and into the Bering Sea. Figures 1 and 2 of the Southern Lakes Hydrological Routing Study (NHC, 2010) provide an overview of the Southern Lakes study area and of the hydrometric gauging stations that are available for this study. Those figures are presented hereafter. The surface area of each of the lakes and their respective watershed are also presented. The watershed area of Marsh Lake is approximately 18 700 km².

The watershed is fed in the spring and early summer by snowmelt, while glacier melting and rainfall constitutes the main inflows later in the season (late summer and fall). The flows are low in the winter due to the cold temperatures experienced in the Yukon. The yearly hydrographs generally show a single peak at the end of the summer resulting from the combination of sources outlined above. The response time of the watershed to any precipitation event is slow due the large drainage basin area and to extensive routing through all of the lakes.

Yukon Energy Corporation operates the Whitehorse Rapids Dam and Power Plant, located on the Yukon River at the City of Whitehorse, approximately 40 km downstream from the Marsh Lake outlet. A control structure at the Marsh Lake outlet, Lewes Dam, operates in conjunction with the power plant, regulating the water level during fall and winter months to provide additional winter power generation.

Lewes Dam is a low head regulating dam. The structure consists of a boat lock, a fish ladder and 30 sluice gates, allowing the Marsh Lake outlet to either flow unimpeded, or be regulated. The current water licence (No. HY99-010) allows Lewes Dam to regulate the Marsh Lake water level through the winter until May 15, at which point all gates are to be fully opened. The gates are required to remain open between May 15 and August 15, although low water level conditions allow the closure of up to 20 gates as early as July 7. Gate closure is governed by a number of criteria, including whether or not Marsh Lake has attained its Full Supply Level (FSL) of 656.234 m.

It should be noted that the head difference between Marsh Lake and Tagish/Bennett Lake is very small (less than 1 m) such that the control structure at Marsh Lake has influence also on the water levels of those 2 lakes. Reverse routing from Tagish Lake towards Bennett Lake may even be possible in certain circumstances during low flow periods. The focus of the current work is then on those 3 lakes and on M'Clintock River which is the most important tributary to the lake outside from the Tagish River (outlet of Tagish Lake).

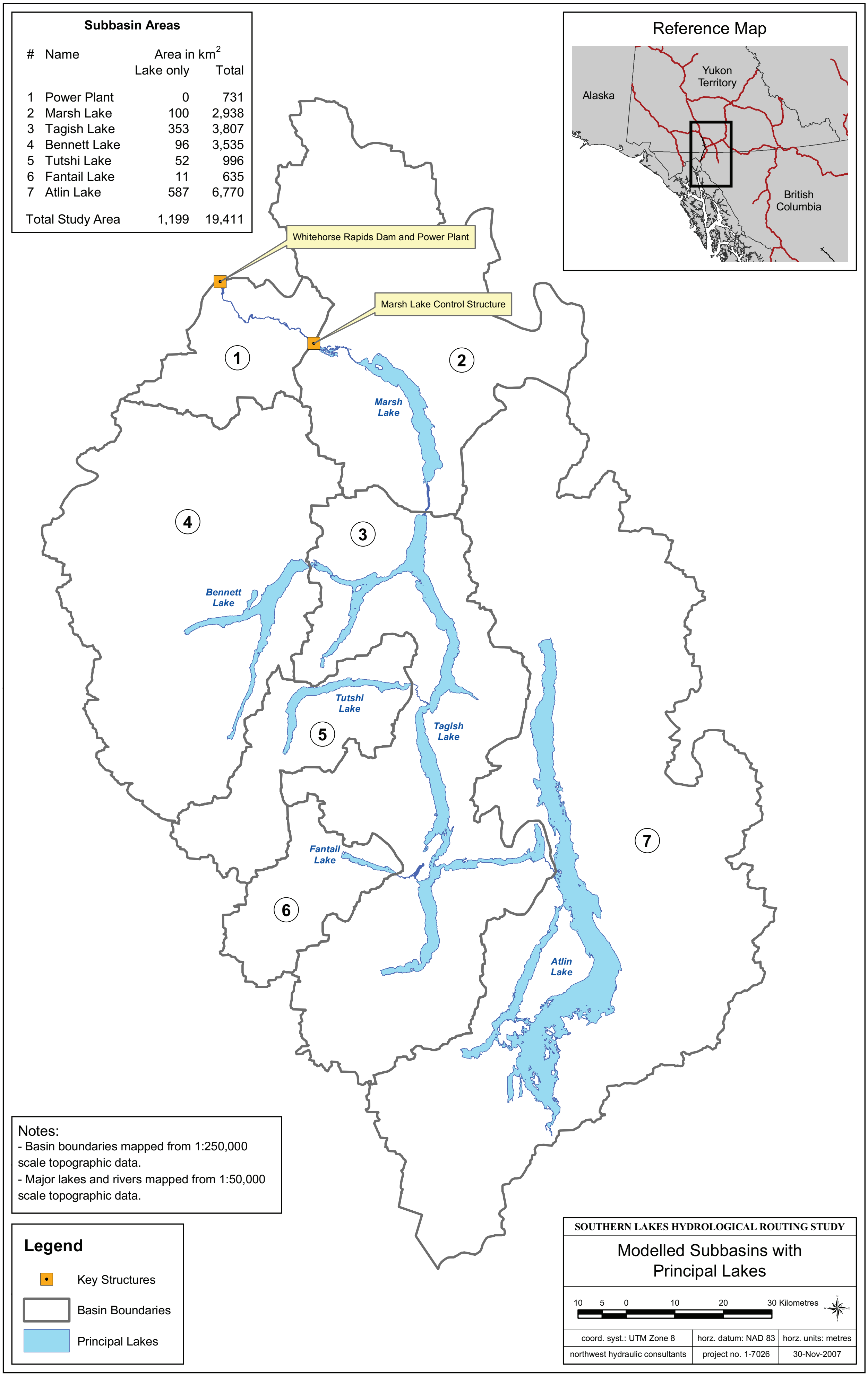
1.2 Scope of Work

The scope of this report is to review the most recent hydrological and meteorological data available for Marsh Lake, and to provide baseline data necessary for the Marsh Lake Fall – Winter Storage Project. The review is also intended to complement the Southern Lakes Hydrological Routing Study, whose first phase was completed by Northwest Hydraulic Consultants (NHC) in 2010. The routing study provides a complete 50 years hydrological record, including synthesized data for un-gauged sub-basins.

The objective of the first phase of the Southern Lakes Hydrological Routing Study was to assess the hydrology of the Southern Lakes basin and complete routing model simulations of the flows through the inter-connected lake sub-basins. The assessment included:

1. A compilation of available data from WSC stations for the 50 year period 1958 – 2007.
2. Development of historic hydrographs for the inflows to each of the six Southern Lakes and for the inflow downstream of Lewes Dam. This included the synthesis of hydrographs for un-gauged sub-basins.
3. The development of rating curves for each of the six lakes.
4. An analysis of lake level interactions to determine which lakes are affected by the downstream water level of other lakes.

The results of the assessment were incorporated into a hydrologic routing model that simulates flow rates and water levels for each of the principal lakes. The results of the model included a summary of the monthly inflows to each sub-basin.



Subbasin Areas

#	Name	Area in km² Lake only	Total
1	Power Plant	0	731
2	Marsh Lake	100	2,938
3	Tagish Lake	353	3,807
4	Bennett Lake	96	3,535
5	Tutshi Lake	52	996
6	Fantail Lake	11	635
7	Atlin Lake	587	6,770
	Total Study Area	1,199	19,411

Notes:
- Basin boundaries mapped from 1:250,000 scale topographic data.
- Major lakes and rivers mapped from 1:50,000 scale topographic data.

Figure 1

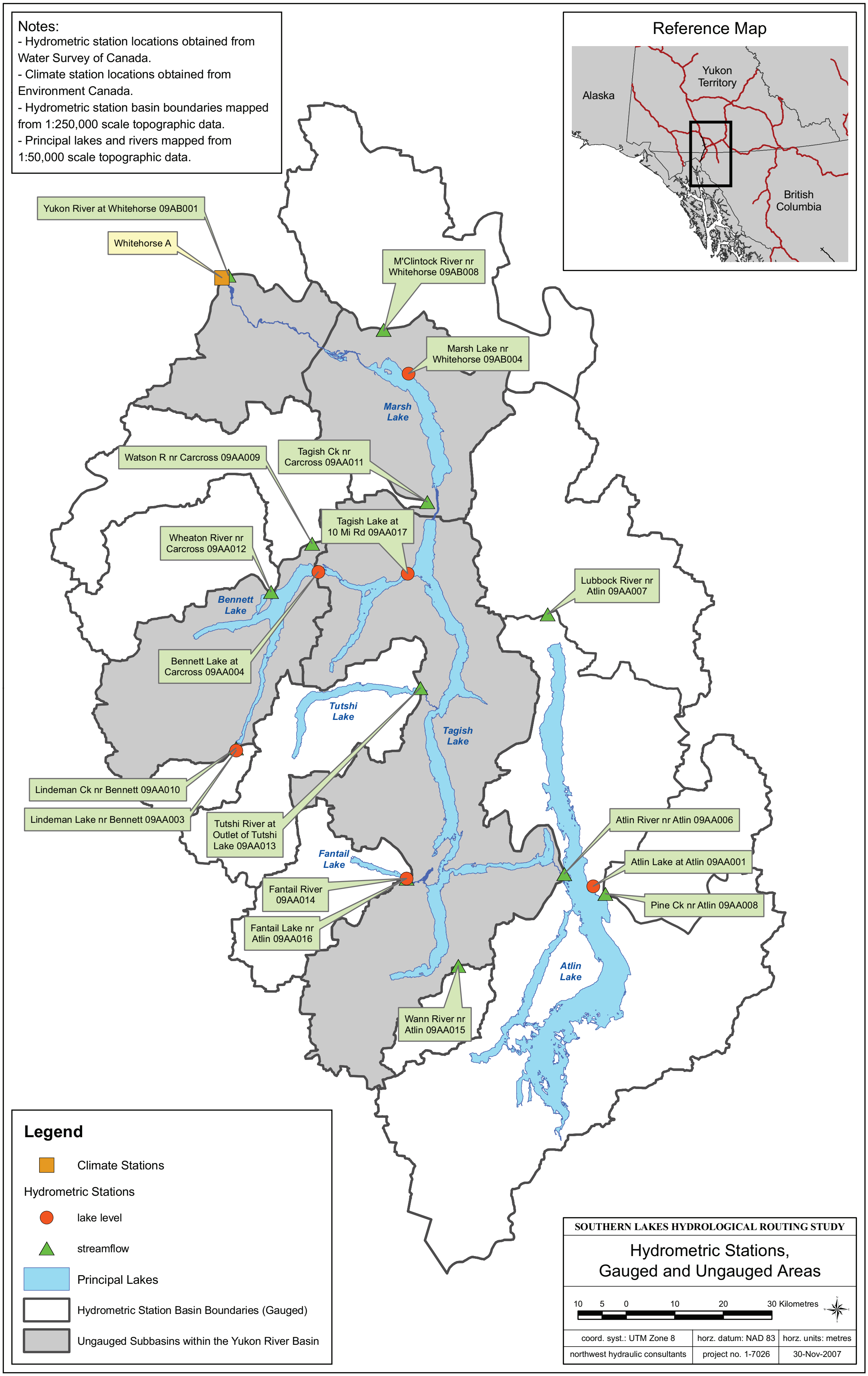


Figure 2

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2. Data Summary

The following sub-sections provide summaries of the hydrological and meteorological data available for Marsh Lake. Figures 2.1 – 2.10 and 2.11 - 2.12 present the mean monthly hydrological and meteorological data respectively. The figures also present separate curves for 2009 and 2010 mean monthly data, when applicable. The years 2009 and 2010 correspond to the time over which the majority of the field work was completed for the Marsh Lake Fall-Winter Storage Concept.

2.1 Water Survey Canada Hydrometric Stations

The Water Survey of Canada (WSC) hydrometric stations relevant to the Marsh Lake hydrology are presented in Table 2.1. Estimates of the inflow from upstream lakes and sub-basins can be acquired from NHC (2010) for the period 1958 - 2007.

Table 2.1. Water Survey Canada Hydrometric Stations near Marsh Lake

Station	Station name	Location	Drainage Area (m^2)	Record Period	Type of Data
09AA004	Bennett Lake at Carcross	60°09'50" N, 134°42'27" W	n.a.	1947 - 2010	Water levels
09AA017	Tagish Lake at 10 Mile Road	60°09'34" N, 134°22'32" W	n.a.	1995 - 2010	Water levels
09AB001	Yukon River at Whitehorse	60°42'50" N, 135°02'35" W	19400	1902 – 1942	Water levels
				1943 – Present	Continuous discharge
				1973 – Present	Power plant gauge
09AB002	Yukon River above Control Dam	60°34'37" N, 134°40'42" W	n.a.	1941 – 1957	Water levels
09AB003	Yukon River below Control Dam	60°34'45" N, 134°41'15" W	n.a.	1941 – 1945	Water levels
				1950 – 1960	Water levels
09AB004	Marsh Lake near Whitehorse	60°31'50" N, 134°21'55" W	n.a.	1950 – 1951	Continuous water levels
				1952 – 1952	Seasonal water levels
				1953 – 1953	Continuous water levels
				1954 – 1955	Seasonal water levels
				1956 – 1965	Continuous water levels
				1966 – 1973	Continuous water levels
				1974 – 1974	Seasonal water levels
				1975 – Present	Continuous water levels
09AB008	M'Clintock River near Whitehorse	60°36'45" N, 134°27'27" W	1700	1956 - 1957	Continuous discharge
				1958 - 1965	Seasonal discharge
				1966 - 1995	Continuous discharge

Monthly averaged hydrological data from all stations are presented in this report, with the exception of Stations 09AB002 and 09AB003. The data from these stations have not been presented due to a lack of discharge data and due to the measurement periods occurring more than 50 years ago.

2.2 Environment Canada Meteorological Stations

The Environment Canada meteorological stations relevant to the Marsh Lake hydrology are presented in Table 2.2.

Table 2.2. Environment Canada Meteorological Stations near Marsh Lake

Station name	Location	Record Period	Type of Data
Whitehorse Airport	60°43' N, 135°04' W	1942 – Present	Daily temperature, precipitation
		1953 – Present	Hourly temperature, precipitation
		1957 – Present	Hourly wind speed and direction
Marsh Lake	60°26' N, 134°15' W	1941 – 1957	Hourly temperature, precipitation

2.3 Hydrometric Data 1984 – 2010

The hydrometric data are presented for selected stream flow and lake level stations near Marsh Lake. The majority of the data are presented for the years 1984 through 2010. Hydrometric data earlier than 1984 are not retained due to the installation of a fourth turbine in the Whitehorse Rapids Power Plant in that year, which doubled the capacity of the plant. Changes to the plant's operating regimes following the installation are expected to have altered the hydrological trends. The exception is Station 09AB008 – M'Clintock River near Whitehorse, which is unaffected by the power plant. Data for this station is presented for the years 1956 through 1995. Data for all stations in the Southern Lakes are available for an extended period of time, from 1958 through 2007, in NHC (2010).

The long-term maximum, mean, and minimum mean monthly discharges for Yukon River and M'Clintock River (09AB001 and 09AB008) are shown on Figures 2.1 and 2.2. The Yukon River mean monthly discharges for years 2009 and 2010 are also included on Figure 2.1. Tables of the Yukon River and M'Clintock River mean monthly discharges are given in Appendix A.

Representative years for Yukon River and M'Clintock River were determined by calculating the annual flow volume for all years of record and determining the maximum, median and minimum years. The representative maximum, median, and minimum years are 2007, 1987, and 1984 for the Yukon River and 1992, 1976, 1989 for the M'Clintock River. The mean monthly discharges for these years are plotted on Figures 2.3 and 2.4. The representative years are plotted to illustrate actual extreme year hydrographs, as opposed to the range of mean monthly discharges shown in Figures 2.1 and 2.2.

The long-term maximum, mean, and minimum mean monthly water levels for Marsh Lake, Bennett Lake and Tagish Lake (09AB004, 09AA004, 09AA017) are shown on Figures 2.5, 2.6 and 2.7. The Full Supply Level for Marsh Lake is also included on Figure 2.5, providing a reference point for the water levels. A comparison of the mean monthly water levels for all three lakes is shown on Figure 2.8. The water level difference between lakes is small, with the greatest difference occurring during the spring and summer months.

Representative maximum, median and minimum years for Marsh Lake and Bennett Lake were determined from the Yukon River annual flow volume and are 2007, 1987, and 1984 respectively. Representative years are not shown for Tagish Lake as a result of the station's short record period (data is not available for the years 1987 and 1984). The mean monthly water levels for the representative years are shown on Figures 2.9 and 2.10. The designated Full Supply Level for Marsh Lake is also shown on Figure 2.9, providing a reference point for the water levels. Tables of the Marsh Lake, Bennett Lake and Tagish Lake mean monthly water levels are given in Appendix A.

Table 2.3 is a summary of the annual maximum discharge and maximum water level occurrences by month for Stations 09AB001 – Yukon River at Whitehorse and 09AB004 – Marsh Lake near Whitehorse. Two years of maximum discharge data are not available. The table shows that Yukon River maximum discharges occur most often in August. Maximum discharge events for 2009 and 2010 occurred September 11 and August 28 respectively. The Marsh Lake peak water levels occur over a much winder range of months. Peak water levels for 2009 and 2010 occurred September 2 and October 19 respectively.

Yukon River discharge and Marsh Lake water level are influenced by both upstream runoff and Lewes Dam. A review of the Lewes Dam yearly operations would be required to determine the relation between Southern Lakes hydrological events and maximum discharge and water level occurrences.

Table 2.3. Number of Occurrences of Annual Maximum Events by Month, 1984 - 2010

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peak Discharge Occurrences	0	0	0	0	0	0	1	18	6	0	0	0
Peak Water Level Occurrences	0	0	0	0	0	0	1	12	5	8	1	0

2.4 Meteorological Data

Meteorological data available for the Marsh Lake area includes the meteorological stations at Whitehorse Airport and Marsh Lake. A review of the National Ecological Framework for Canada indicates that both Marsh Lake and Whitehorse Airport are located within the same Eco-District (905) and that both locations are expected to have similar weather patterns. A comparison of the available mean monthly temperature and precipitation data for Marsh Lake and Whitehorse Airport confirmed the similarity. Data from the Whitehorse Airport station are presented in this report instead of the Marsh Lake station due to the long record period and presence of wind speed information.

Although the two locations are expected to have similar weather patterns, local variation in the daily weather patterns is expected. For this reason, data are presented in this report as mean monthly, and not as mean weekly or daily.

The Whitehorse Airport mean monthly temperature and total monthly precipitation is shown in Figures 2.11 and 2.12. The figures include the 1971 – 2000 climate normals and the mean data for the years 2009 and 2010. The largest three-day storm on record for the Whitehorse Airport occurred on June 27, 1985 and resulted in 58 mm of rainfall. The spatial extent of this event is not known, since the Marsh Lake meteorological station was not operational at that time. Yukon River mean daily discharge measurements do not show a noticeable peak resulting from the storm, however, a more gradual increase in discharge may have been masked by the increasing trend for that time of year.

Table 2.4 presents the mean monthly wind speed data from the 1971 – 2000 climate normals for Whitehorse Airport. The most frequent direction of the wind is from the south east, with the exception of the months November through February, when the most frequent direction is from the south. The maximum recorded gust speed occurred in November and was measured to be 106 km/h.

Table 2.4. Wind Speed Data for Whitehorse Airport, 1971 – 2000 Climate Normals

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean Monthly Wind Speed (km/h)	12.9	13.5	12.7	12.7	12.6	11.5	10.4	11.1	13	14.7	14.1	13.9	12.7
Most Frequent Direction	S	S	SE	SE	SE	SE	SE	SE	SE	SE	S	S	SE
Maximum Gust Speed (km/h)	100	106	93	89	85	90	91	84	101	97	106	97	n.a.
Direction of Maximum Gust	SE	SE	SW	N	SE	W	SE	SE	S	S	SE	SE	n.a.

Additional meteorological information for the Marsh Lake basin has been obtained from the Canadian Ecodistrict Climate Normals, which are computed as weighted averages of the climate data from meteorological stations within each ecodistrict. Data for Ecodistrict 905 includes average monthly precipitation and temperature in addition to other measurements and calculations which are used to derive potential evapotranspiration, calculated using the Penman method. The monthly precipitation surplus results for Ecodistrict 905, defined as the difference between the monthly precipitation and the monthly potential evapotranspiration, are presented in Table 2.5. Positive values through the winter result in the accumulation of snowpack. Negative values from April through August indicate that the amount of surface water and soil moisture gained through precipitation is less than the maximum potential evapotranspiration.

Table 2.5 also includes the estimated water deficit for a soil with 100 mm water holding capacity within Ecodistrict 905. The water deficit is a measure of the amount of water required to fill the soil to capacity. The results show that the ecodistrict has a water deficit throughout the summer months. April is the sole month without a water deficit, likely a result of spring snowmelt.

Table 2.5. Precipitation Surplus and Water Deficit Calculations for Ecodistrict 905

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Potential Evaoptranspiration (mm)	0	0	0	24	86	110	107	74	36	8	0	0	446
Precipitation Surplus (mm)	29	20	20	-12	-64	-80	-60	-35	9	28	30	29	-79
Water Deficit (mm)	0	0	0	-1	24	55	50	31	0	0	0	0	160

It should be noted that this discussion provides a preliminary review of available data. During the review of the Canadian Ecodistrict Climate Normals data, it was noted that most winter precipitation measurements (snow water equivalent) nearly matched the winter snowfall measurements (depth of snow). It is recommended that a more in-depth review be completed before these data are used for any analyses.

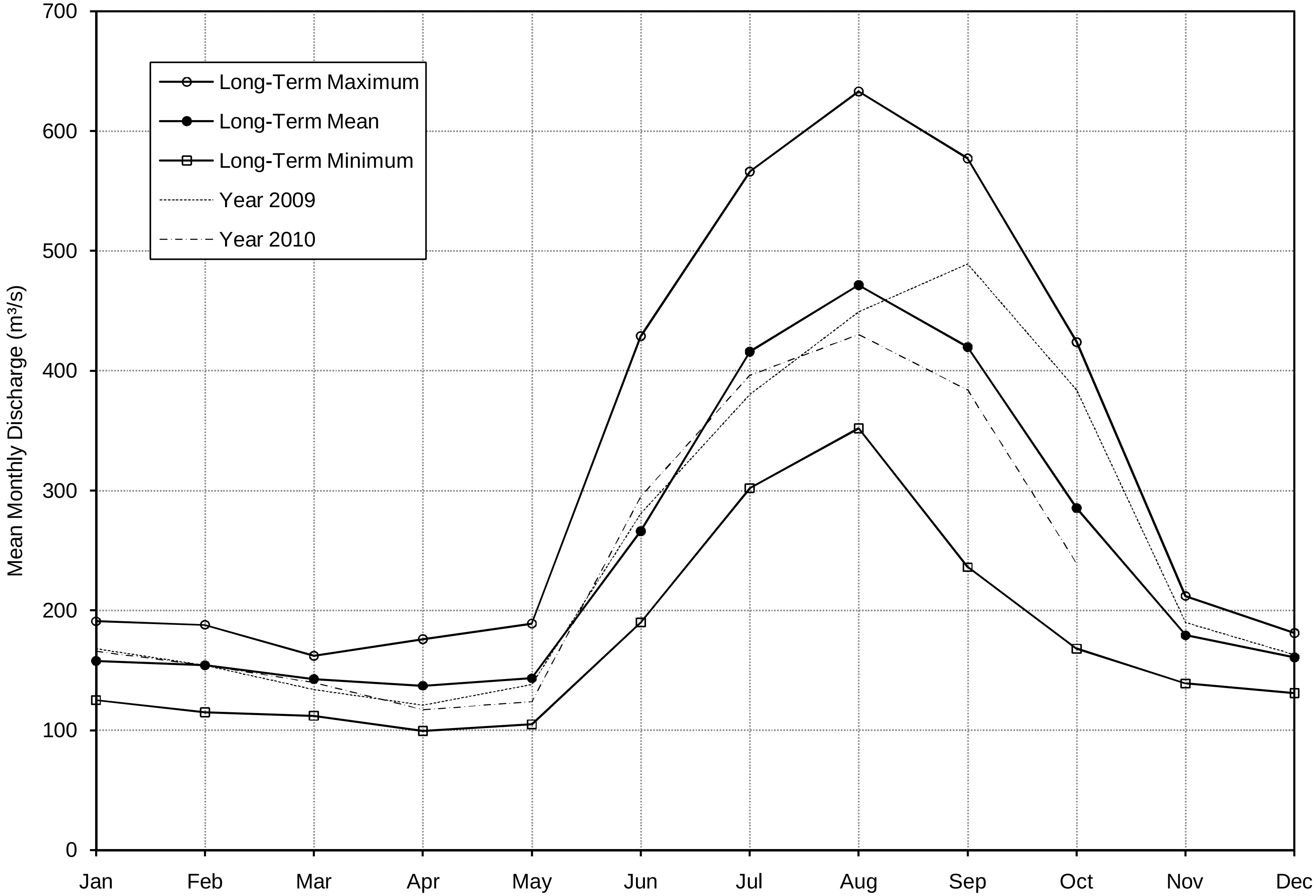

Figure 2.1. Yukon River Mean Monthly Discharge, 1984 – 2010

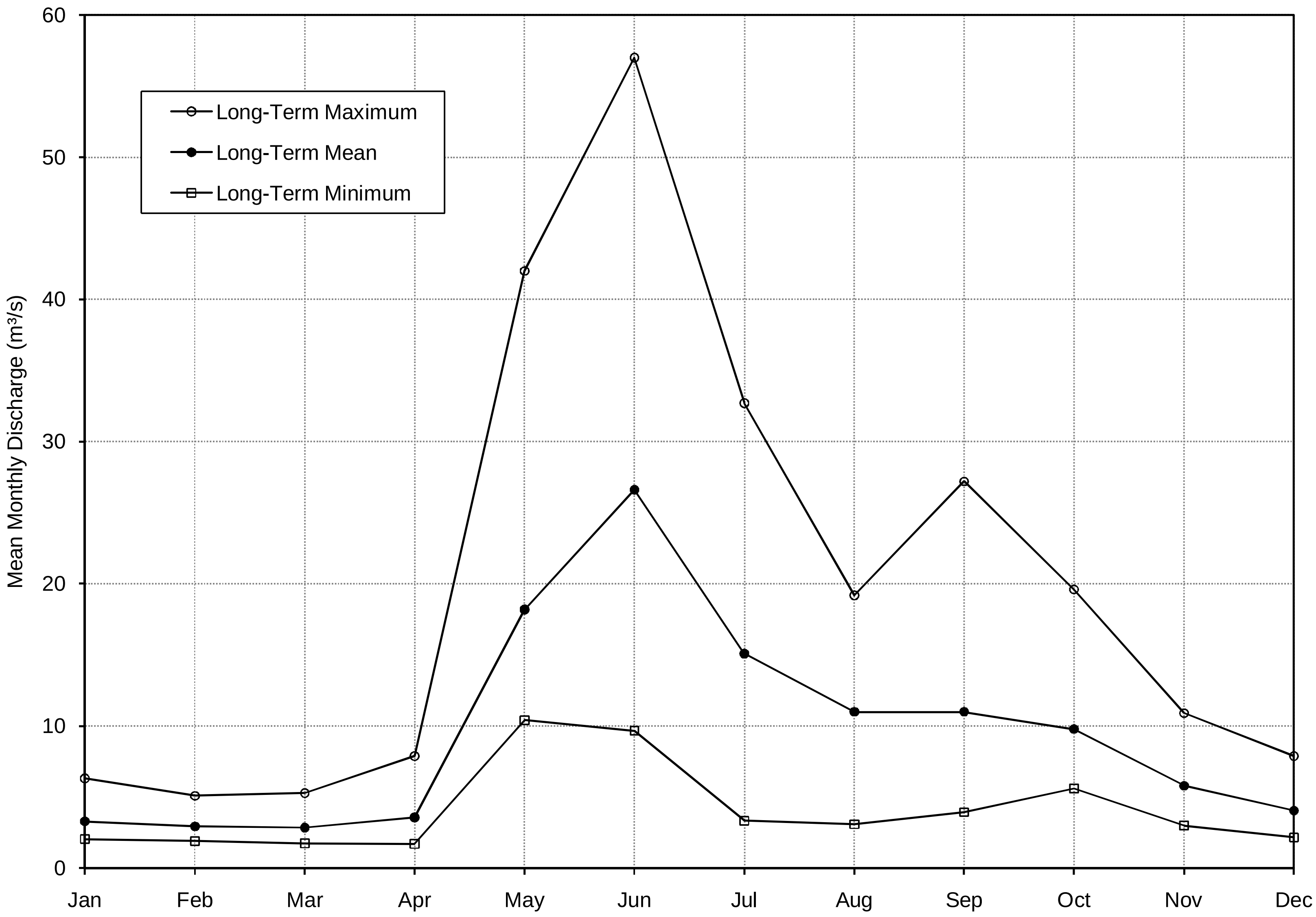

Figure 2.2. M'Clintock River Mean Monthly Discharge, 1956 – 1995

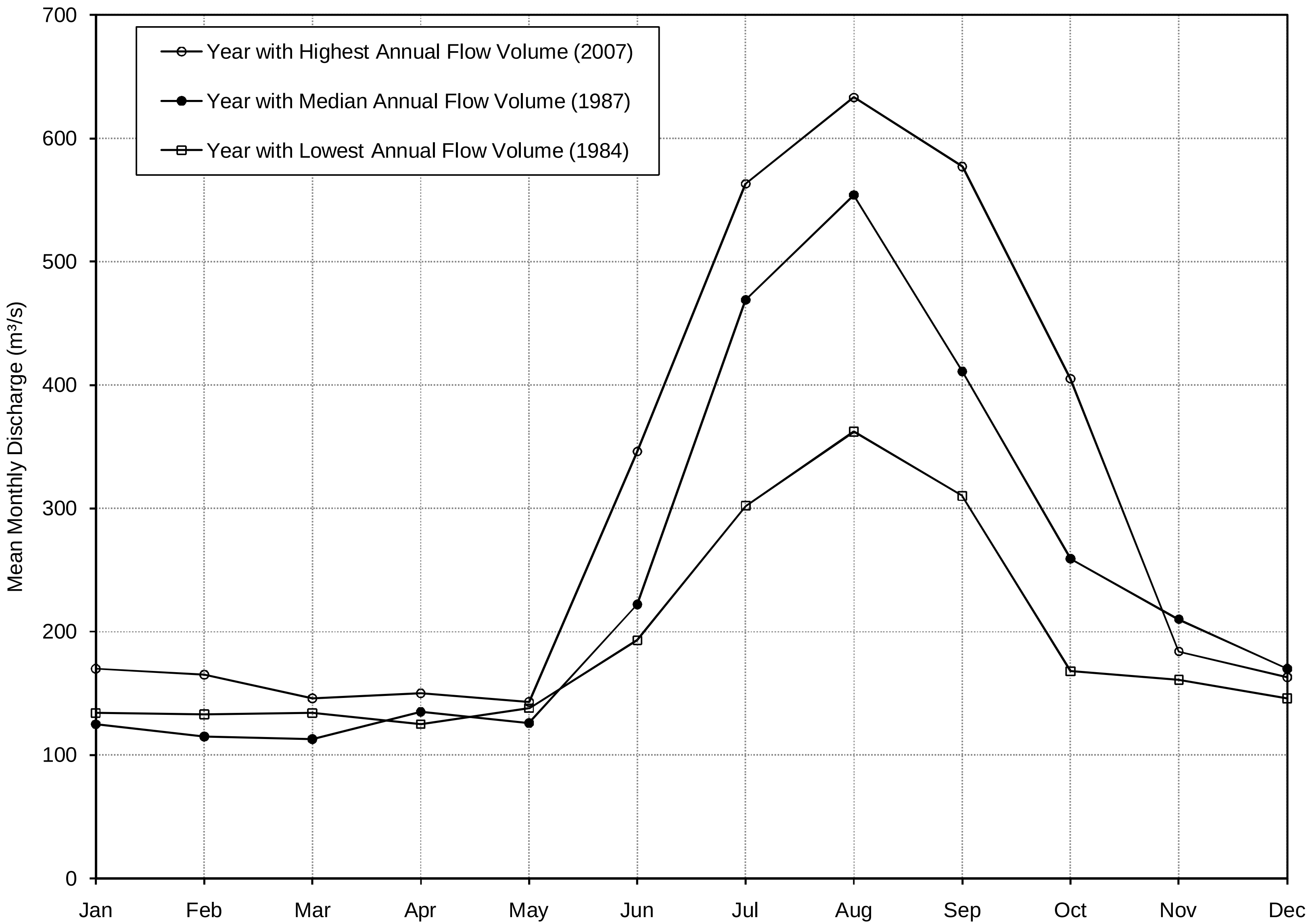

Figure 2.3. Yukon River Mean Monthly Discharge for Representative Years, 1984 – 2010

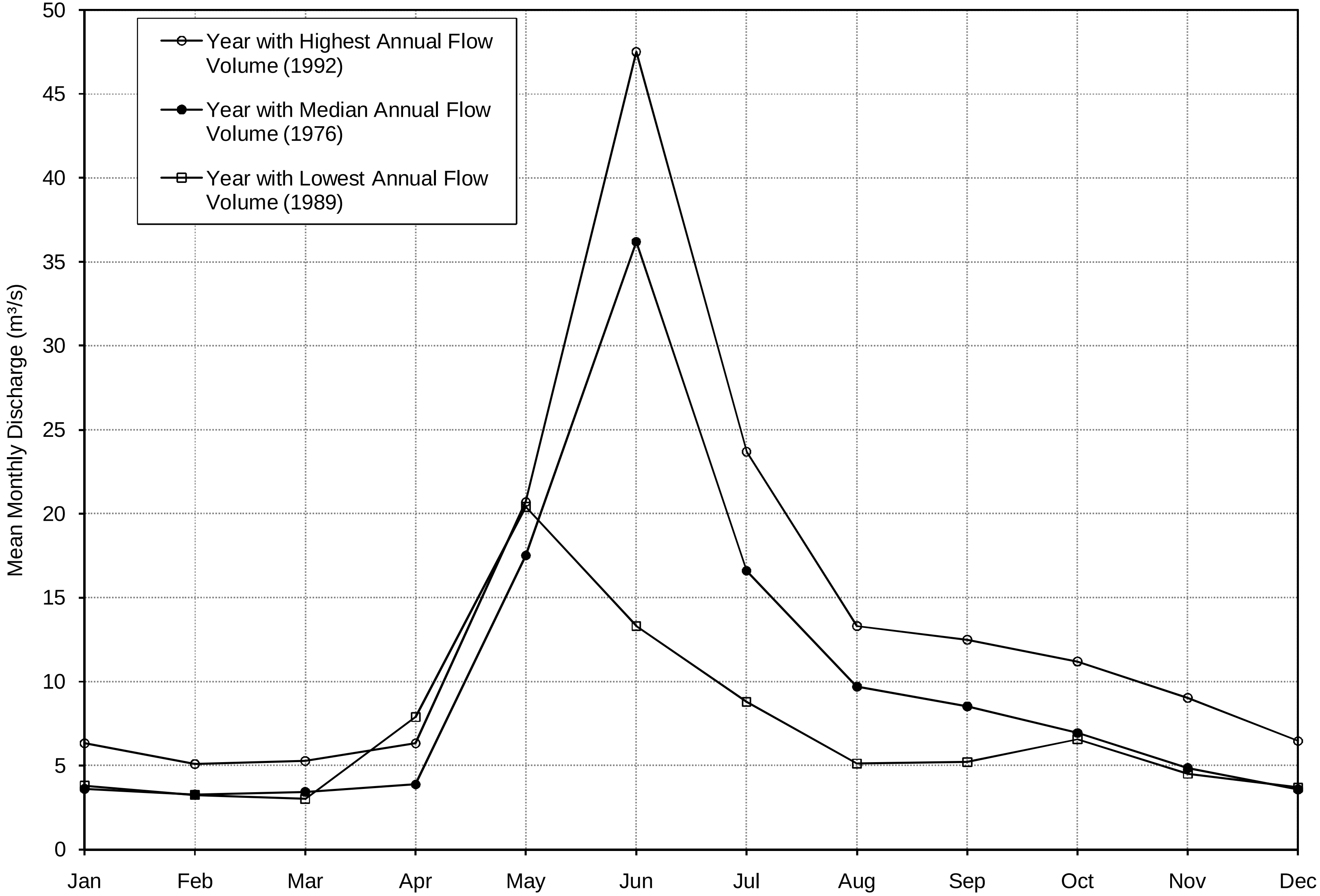

Figure 2.4. M'Clintock River Mean Monthly Discharge for Representative Years, 1956 – 1995

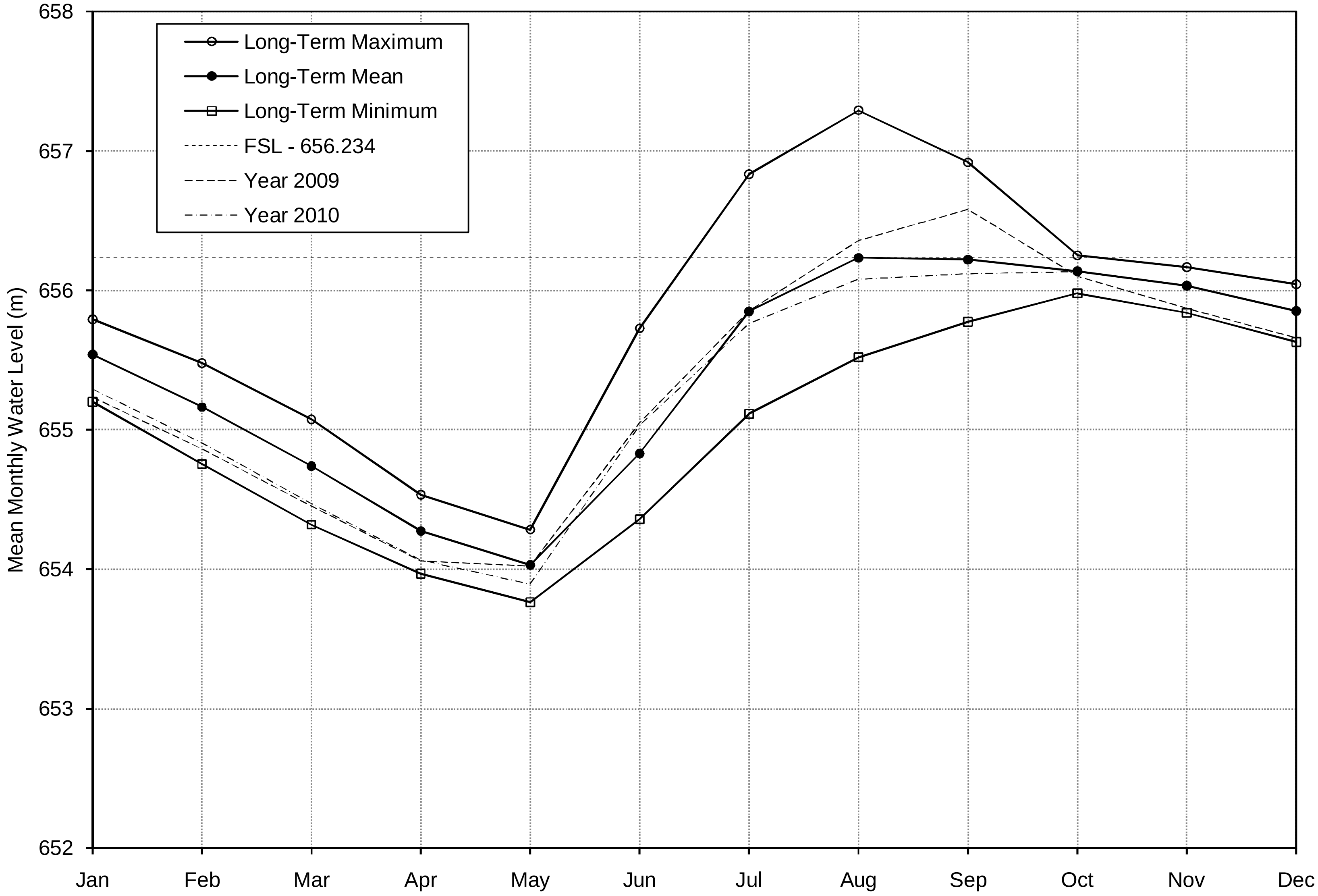

Figure 2.5. Marsh Lake Mean Monthly Water Level, 1984 – 2010

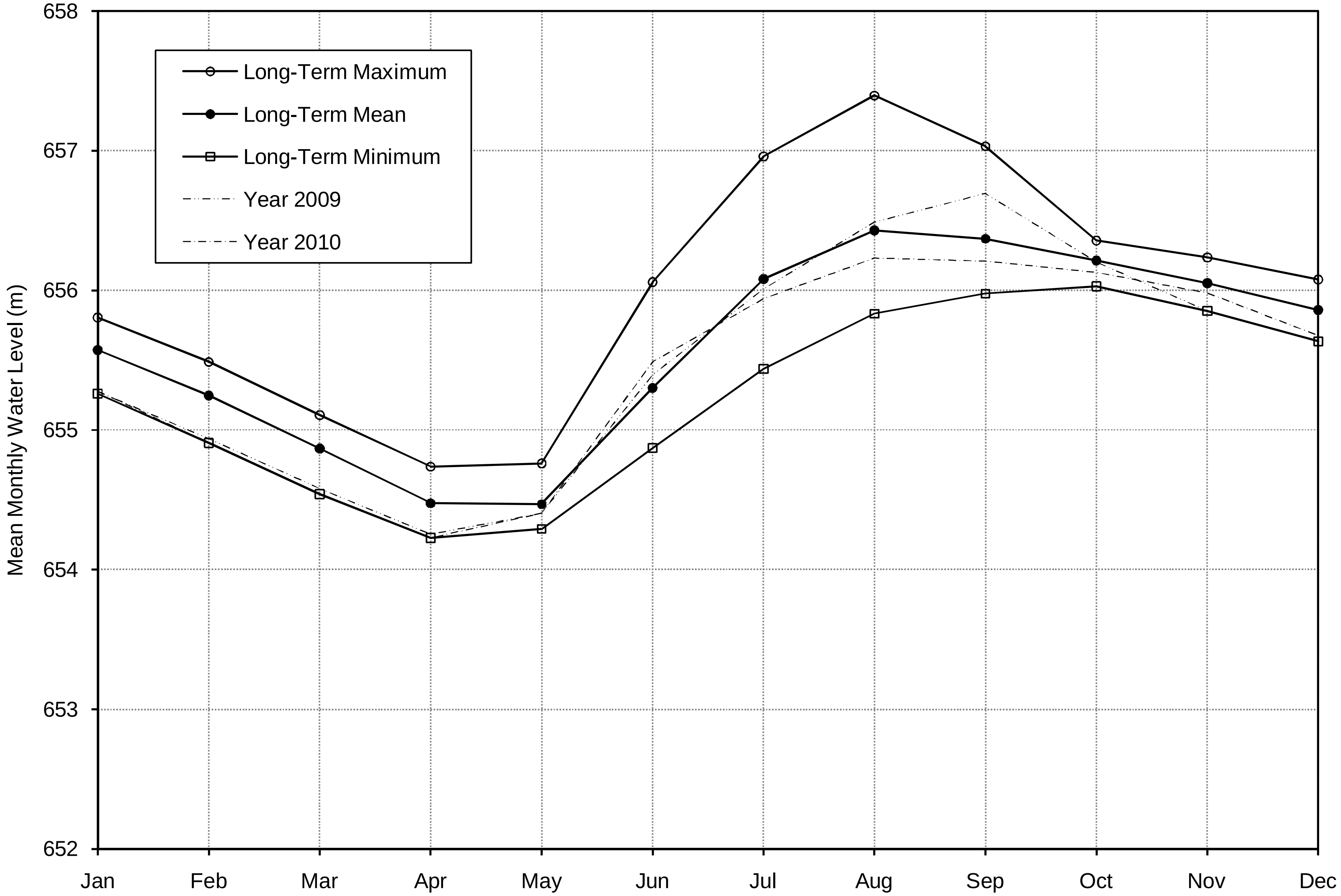

Figure 2.6 Bennett Lake Mean Monthly Water Level, 1984 – 2010

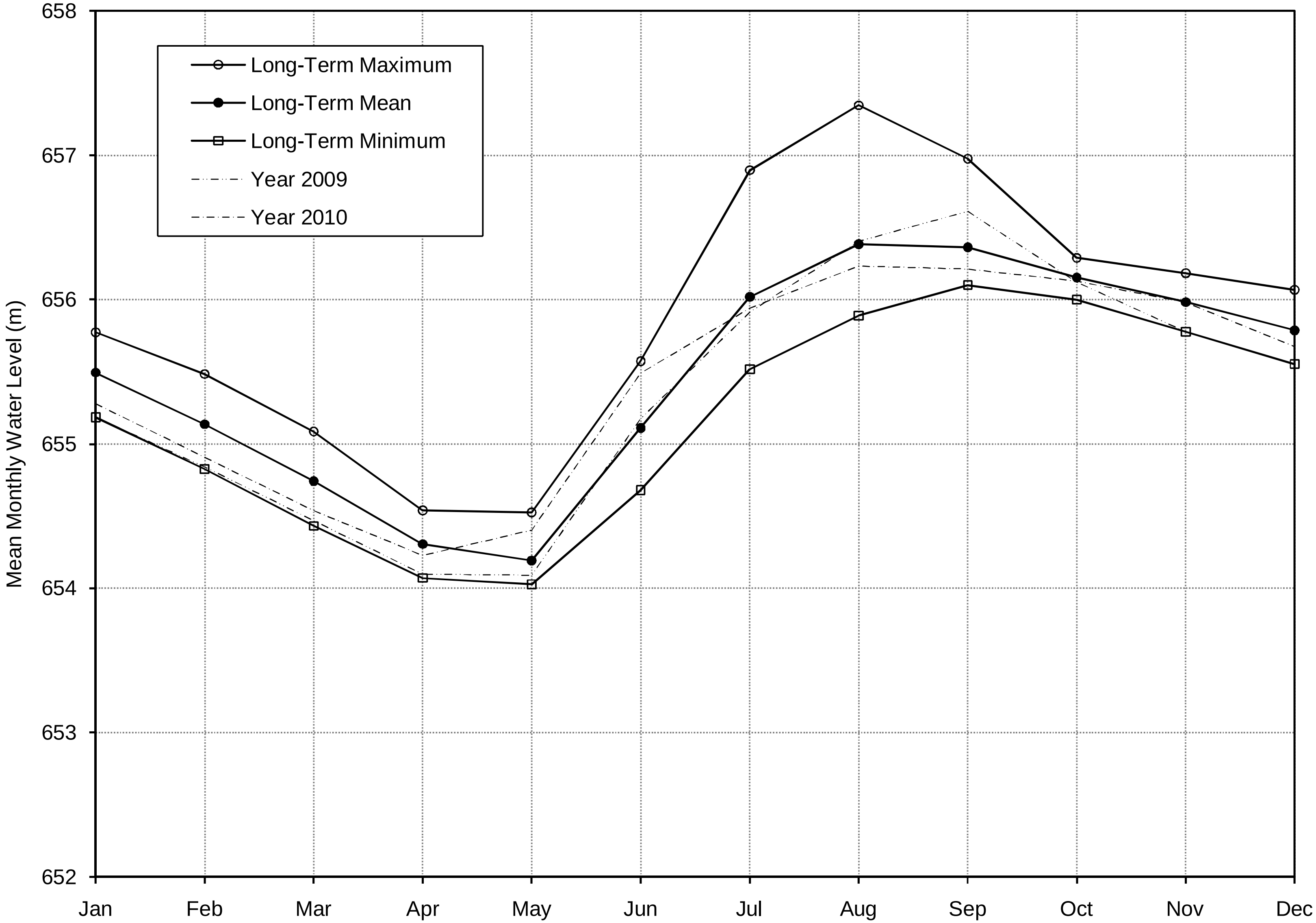

Figure 2.7. Tagish Lake Mean Monthly Water Level, 1996 – 2010

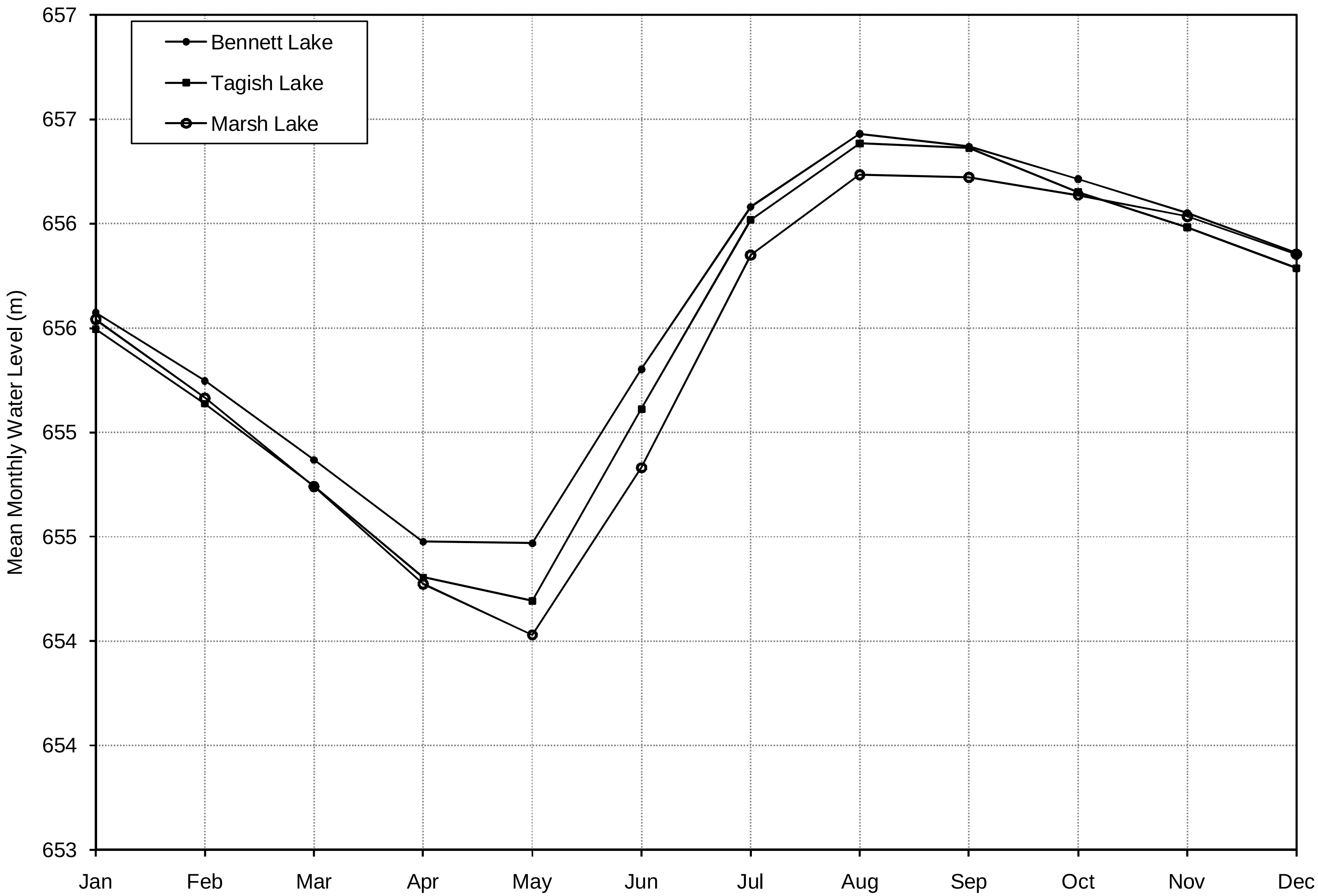

Figure 2.8. Mean Monthly Water Levels for Bennett, Tagish and Marsh Lakes.

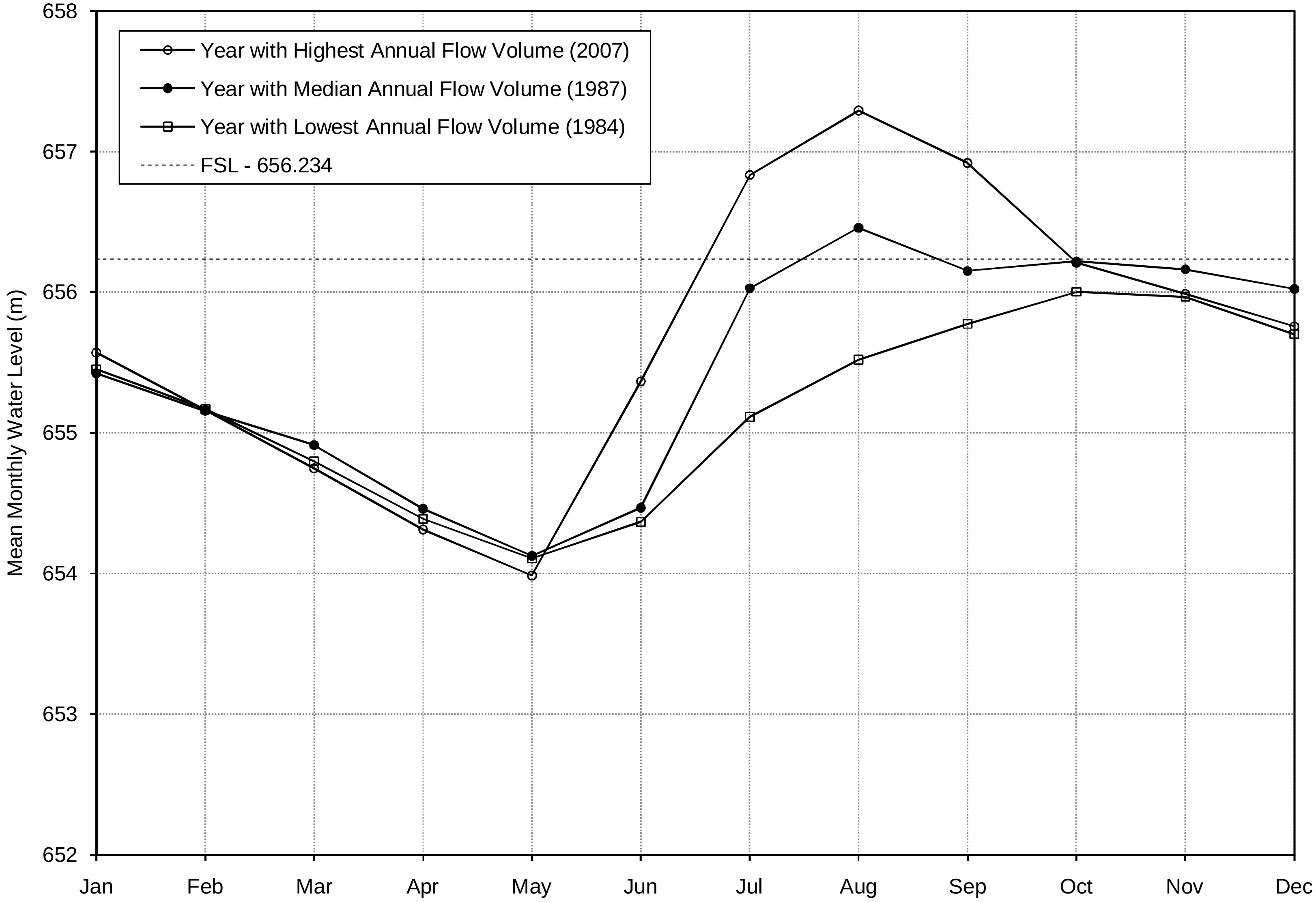

Figure 2.9. Marsh Lake Mean Monthly Water Levels for Representative Years, 1984 – 2010

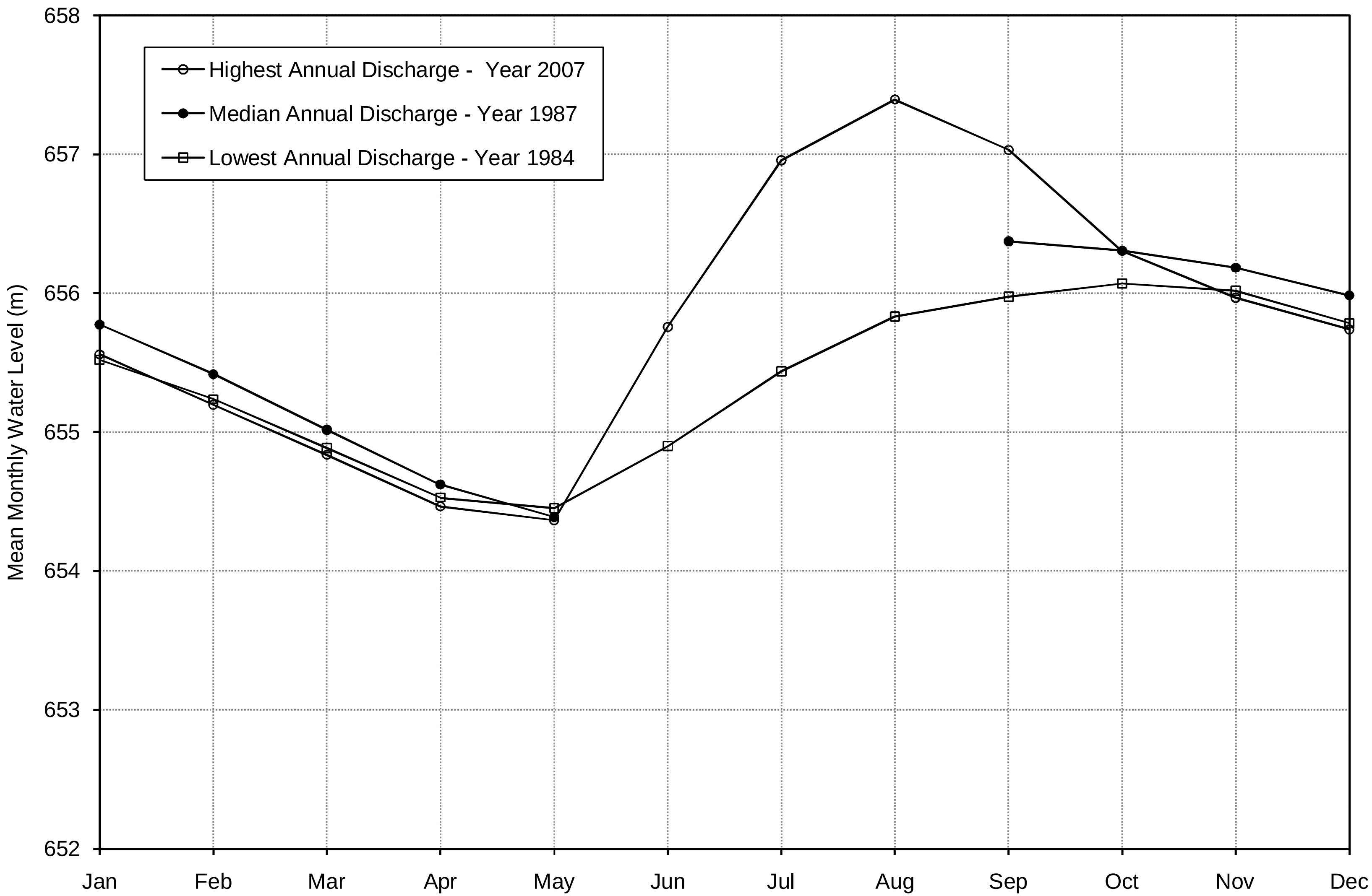

Figure 2.10. Bennett Lake Mean Monthly Water Levels for Representative Years, 1984 – 2010. Three months of data during the summer of 1987 are not available.

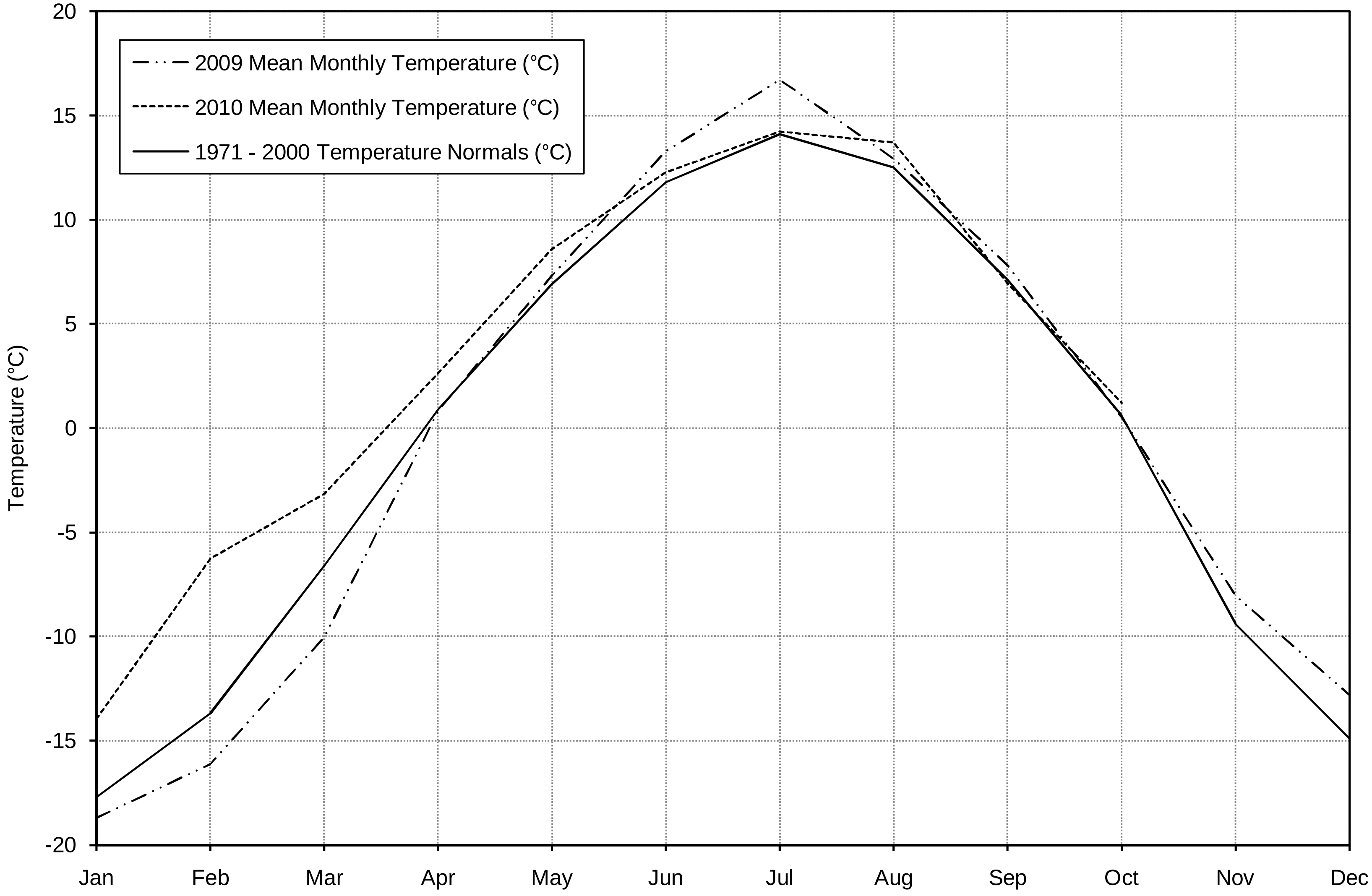

Figure 2.11. Whitehorse Airport Mean Monthly Temperature

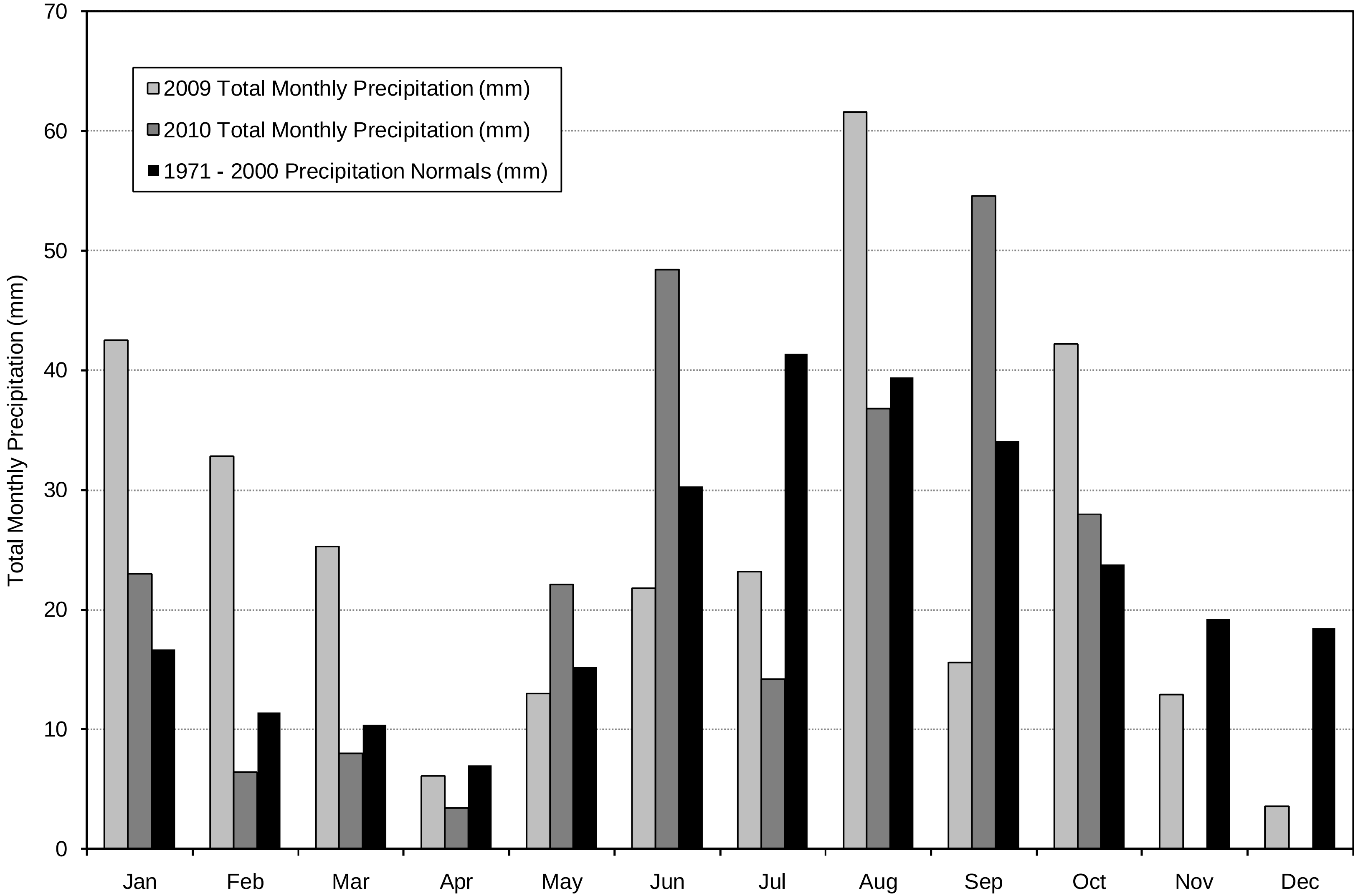

Figure 2.12. Whitehorse Airport Mean Monthly Precipitation

3. Extreme Year Analysis

The extreme year analysis has been completed to provide an accurate representation of the variation in the annual flow volume through the Yukon River at the Whitehorse Rapids Power Plant. Marsh Lake water level data are compared to these results, to determine how frequently the lake's FSL is attained.

3.1 Yukon River Flow Volume

Data used to compute the variation in the annual (calendar year) flow volume are from the WSC Station 09AB001 at the Whitehorse Rapids Power Plant. Thresholds have been set to identify wet and dry years, with respect to the annual flow volume. The thresholds used are the estimated 10- and 20-year return period events, as determined by fitting the available data (1944 – 2009) to a lognormal distribution. The annual flow volume results, including the rank and plotting position are included in Appendix A. The calculated coefficients for the lognormal distribution are: $\mu = 22.7533$ and $\sigma = 0.12745$.

Table 3.1 tabulates the annual flow volumes and representative hydrographs for the 10- and 20-year wet and dry thresholds. The hydrographs for the representative wet and dry years are included in Figure 3.1.

Table 3.1. Wet and Dry Year Thresholds for Yukon River Annual Flow Volume

Return Period	Annual Flow Volume (m^3)	Representative Year
Median Year		1987
Wet Year Threshold		
10-year	8,970,000,000	1990
20-year	9,390,000,000	1963
Dry Year Threshold		
10-Year	6,470,000,000	1985
20-Year	6,170,000,000	1996

3.2 Marsh Lake Water Level

The WSC Station 09AB004 provides water level data for Marsh Lake for the period 1951 - present. Peak lake level data are not available for this station for the years 1955 – 1965, 1969. The data from this station was used to determine wet and dry year water levels and to determine which years the Marsh Lake FSL was attained.

The hydrographs for the representative wet and dry years are included in Figure 3.2. The representative years are as given in Table 3.1. The hydrograph for the 20-years wet threshold representative year is excluded from the figure due to a lack of data. Note that the mean monthly water levels are plotted in this hydrograph, and as a result, the profiles do not show peak water levels attained.

Peak water level data (mean daily) are presented in Table 3.2. Mean monthly water level data are also presented to illustrate the difference between the mean monthly and mean daily data. Years where Marsh Lake's Full Supply Level (FSL = 656.234 m) was surpassed are highlighted. The Marsh Lake FSL was not attained for 17 of the 47 years of record available. The Marsh Lake peak water levels of the 10- and 20-years dry thresholds, 1985 and 1996 respectively, were below the FSL.

Table 3.2. Peak Daily and Monthly Water Level Data from WSC 09AB004

Year	Peak Water Level (m)		Year	Peak Water Level (m)		Year	Peak Water Level (m)		Year	Peak Water Level (m)	
	Daily	Monthly		Daily	Monthly		Daily	Monthly		Daily	Monthly
1951	655.643	655.553	**1975**	656.557	656.450	**1987**	656.279	656.190	**1999**	656.246	656.184
1953	656.664	656.600	**1976**	656.375	656.302	**1988**	656.432	656.373	**2000**	656.563	656.513
1954	656.070	655.990	**1977**	656.746	656.593	**1989**	656.704	656.619	**2001**	656.352	656.322
1966	655.969	655.902	**1978**	656.292	656.206	**1990**	656.603	656.468	**2002**	656.216	656.149
1967	656.393	656.189	**1979**	656.676	656.612	**1991**	656.248	656.221	**2003**	656.224	656.175
1968	656.079	655.987	**1980**	656.337	656.260	**1992**	656.802	656.718	**2004**	656.787	656.700
1970	655.826	655.739	**1981**	656.992	656.873	**1993**	656.608	656.548	**2005**	656.343	656.259
1971	656.896	656.748	**1982**	656.177	656.114	**1994**	656.595	656.466	**2006**	656.374	656.341
1972	656.420	656.275	**1983**	656.222	656.160	**1995**	656.213	656.137	**2007**	657.338	657.292
1973	655.902	655.862	**1984**	656.094	656.003	**1996**	656.158	656.099	**2008**	656.262	656.168
1974	656.115	656.076	**1985**	656.112	656.050	**1997**	656.310	656.238	**2009**	656.632	656.583
			1986	656.553	656.458	**1998**	656.331	656.252	**2010**	656.210	656.135

Notes: Highlighted years indicate that the Marsh Lake Full Supply Level (FSL) was attained

Data for 2010 are unpublished data acquired from WSC.

There appears to be a general correlation between the Marsh Lake water level exceeding the FSL and the annual flow volume. The Marsh lake water level in all dry seasons drier than the 10-years dry threshold does not exceed the FSL. However, the Marsh Lake FSL was not exceeded in many of the years with greater annual flow volume than the 10-years dry threshold. The reverse is true for the 10-years wet threshold. The year with the largest annual flow volume where the Marsh Lake FSL was not exceeded was 1982. This year had a significantly greater annual flow volume than the median annual flow volume. Table 3.3 contains a list of the annual flow volume in increasing order, indicating the years that the Marsh Lake FSL was attained. Years lacking peak water level data are noted with dashed lines.

Since 1984 (year of installation of the fourth turbine at WGRS), the FSL at Marsh Lake was reached most of the years, and for the years that it wasn't, it was generally less than 10 cm below it. In the last 10 years, the FSL within a precision of 3 cm was reached every year. Management of Marsh Lake has likely evolved through the years and has become tighter in recent years due to the increasing demand of power on the Yukon grid, especially during the winter months. Based on the previous results, it is then likely that the current FSL be reached every year with adequate management, except for potentially extreme dry years.

Table 3.3. Annual Flow Volume in Increasing Order

Year	Annual Flow Volume (m^3)	FSL Reached	Year	Annual Flow Volume (m^3)	FSL Reached	Year	Annual Flow Volume (m^3)	FSL Reached	Year	Annual Flow Volume (m^3)	FSL Reached
1973	5861808000	No	**2008**	6923836800	Yes	**1986**	7677158400	Yes	**1980**	8325849600	Yes
1955	5869100160	--	**1983**	7001251200	No	**1968**	7693652160	No	**1964**	8425676160	--
1984	6085238400	No	**1965**	7058292480	--	**1971**	7712064000	Yes	**1977**	8438774400	Yes
1956	6102043200	--	**1966**	7113484800	No	**1967**	7734502080	Yes	**1994**	8571744000	Yes
1996	6182697600	No	**1947**	7214564160	--	**1976**	7800796800	Yes	**1962**	8640008640	--
1970	6191683200	No	**1945**	7309154880	--	**1948**	7830172800	--	**1961**	8690328000	--
1985	6428505600	No	**2001**	7352121600	Yes	**1982**	7834320000	No	**1992**	8726140800	Yes
1999	6631372800	Yes	**1952**	7369349760	--	**2006**	8003145600	Yes	**1990**	8909913600	Yes
2003	6662476800	No	**1950**	7369868160	--	**1975**	8008243200	Yes	**1953**	9015278400	Yes
1978	6714576000	Yes	**1954**	7379112960	No	**2000**	8031398400	Yes	**1957**	9070712640	--
1998	6740755200	Yes	**1997**	7382016000	Yes	**2009**	8038483200	Yes	**1989**	9104918400	Yes
1949	6763651200	--	**1960**	7398846720	--	**1988**	8226835200	Yes	**1993**	9111225600	Yes
1974	6777129600	No	**1969**	7406424000	--	**2005**	8233747200	Yes	**1963**	9308131200	--
1951	6823681920	No	**1972**	7419686400	Yes	**1991**	8255433600	Yes	**2007**	9611395200	Yes
2002	6851520000	No	**1946**	7586870400	--	**2004**	8292672000	Yes	**1981**	9900403200	Yes
1958	6856142400	--	**1987**	7632144000	Yes	**1979**	8297769600	Yes	**1944**	10012973760	--
1959	6914911680	--	**1995**	7674307200	No						

Other data sources were reviewed to determine if it is possible to extend this peak water level record. The WSC Station 09AB001 provides flow rate data for the Yukon River at Whitehorse from 1943 to present. A rating curve provided by NHC (2010) relates the estimated discharge from the Yukon River at Whitehorse, less the estimated local inflows between the Lewes Dam and Whitehorse, to the Marsh Lake water level. This rating curve was created using only data from June and July (the unregulated period), and cannot accurately reflect changes to the operation of the Lewes Dam control structure in other months. Historically, peak water levels on Marsh Lake are most often attained in August or September. In addition, this rating curve is valid for the third configuration of the Lewes Dam. It cannot accurately predict historical Marsh Lake water levels prior to this configuration. Marsh Lake water level data calculated from this rating curve was used only to confirm other calculations.

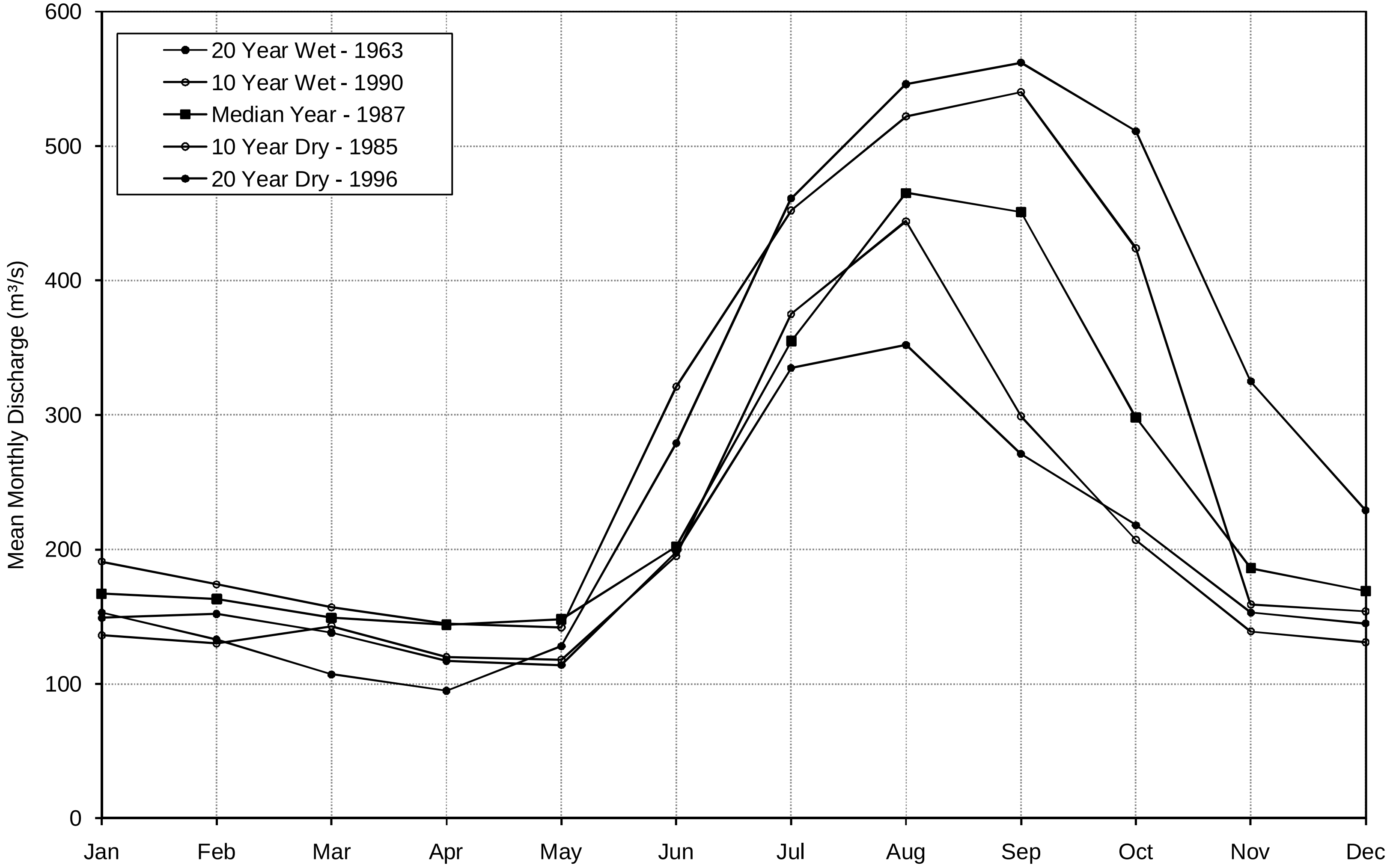

Figure 3.1. Yukon River Mean Monthly Discharge, Representative Wet and Dry Years

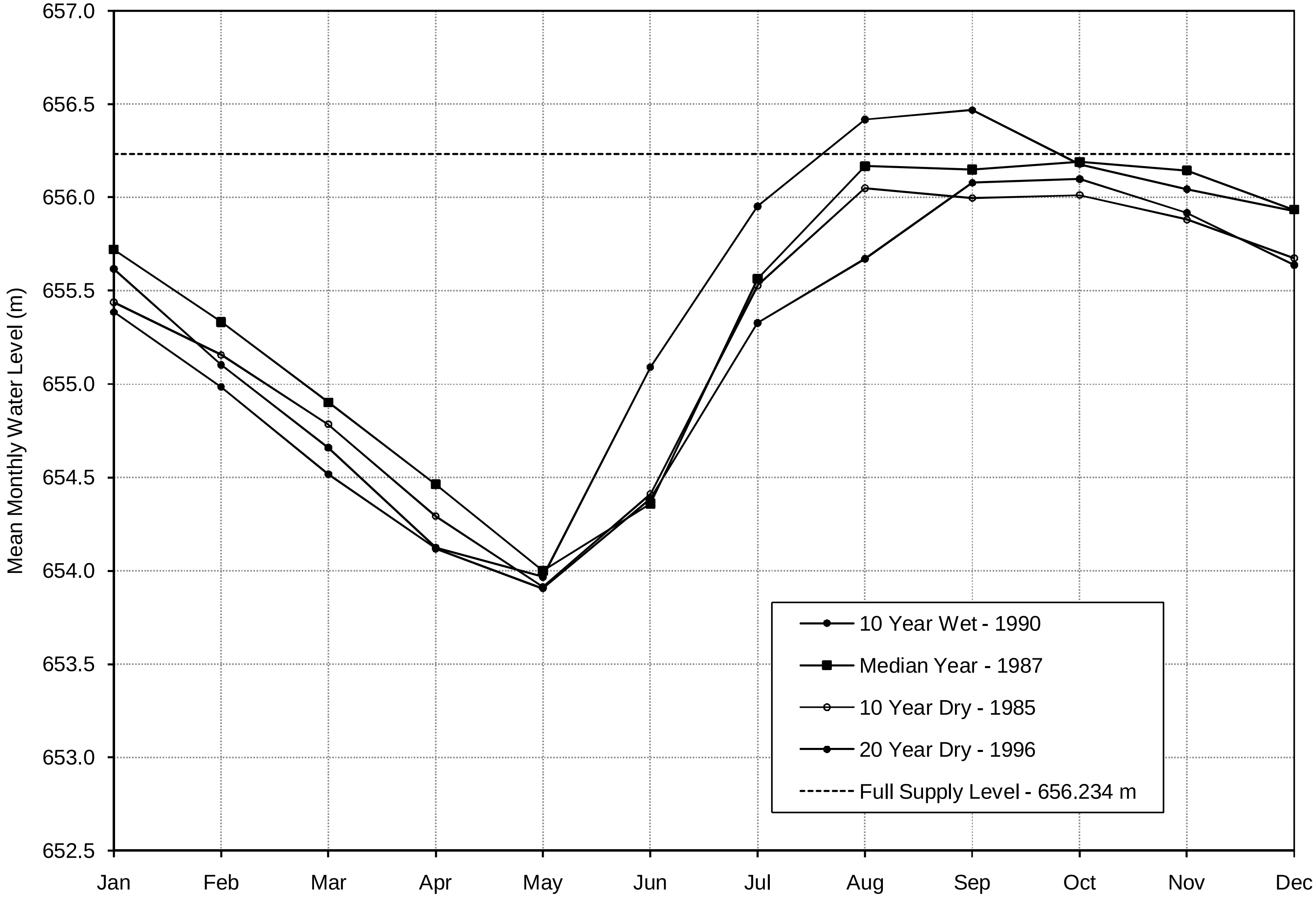

Figure 3.2. Marsh Lake Mean Monthly Water Level, Representative Wet and Dry Years

4. References

Southern Lakes Hydrological Routing Study Final Report, Northwest Hydraulic Consultants, 2010

5. Summary

A summary of the available hydrometric and meteorological data for selected Stations near Marsh Lake are presented. The data includes mean monthly discharge measurements from Yukon River and M'Clintock River (Stations 09AB001 and 09AB008) and mean monthly water level measurements from Marsh Lake, Bennett Lake, and Tagish Lake (Stations 09AB004, 09AA004 and 09AA017). The data also includes mean monthly temperature, precipitation and wind speed measurements for Whitehorse Airport.

Hydrometric data earlier than 1984 are not retained due to the installation of a fourth turbine in the Whitehorse Rapids Power Plant in that year, which doubled the capacity of the plant. Changes to the plant's operating regimes following the installation are expected to have altered the hydrological trends. A more comprehensive data set, including synthesized data for un-gauged sub-basins is available in the Southern Lakes Hydrological Routing Study.

An extreme year analysis has been completed to provide an accurate representation of the variation in the annual flow volume through the Yukon River at the Whitehorse Rapid Power Plant. Marsh Lake water level data are compared to these results, to determine how frequently the lake's FSL is attained. The Marsh Lake water level in all seasons drier than the 10-years dry threshold does not exceed the FSL. However, the Marsh Lake FSL was not exceeded in many of the years with a greater annual flow volume than the 10-years dry threshold. The reverse is true for the 10 years wet threshold. In total, the Marsh Lake FSL was not attained for 17 of the 47 years of record available.

Appendix A

Hydrological Data Summary

Table A.1. Mean Monthly Discharge, 09AB001 – Yukon River at Whitehorse, 1984 – 2010

	Mean Monthly Discharge (m^3/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
1984	134	133	134	125	138	193	302	362	310	168	161	146	192
1985	136	130	143	120	118	195	375	444	299	207	139	131	204
1986	125	115	113	135	126	222	469	554	411	259	210	170	244
1987	167	163	149	144	148	202	355	465	451	298	186	169	242
1988	154	154	157	133	153	296	464	519	421	295	189	180	260
1989	172	166	151	156	189	309	465	561	551	375	179	180	289
1990	191	174	157	145	142	321	452	522	540	424	159	154	282
1991	158	173	139	140	163	233	406	463	501	365	212	181	262
1992	187	188	157	176	169	298	566	581	449	224	159	151	276
1993	157	144	120	145	176	429	504	536	483	391	193	178	289
1994	--	--	159	168	163	268	437	533	510	407	194	156	271
1995	155	166	162	154	177	279	385	425	401	276	179	155	243
1996	149	152	138	117	114	198	335	352	271	218	153	145	196
1997	154	140	112	99	121	250	413	478	477	226	--	--	234
1998	172	168	154	125	107	258	371	396	236	222	188	162	214
1999	156	149	141	118	105	209	367	418	292	220	178	163	210
2000	161	160	158	138	127	229	442	499	470	325	189	144	254
2001	134	153	143	157	--	237	416	463	419	218	155	156	233
2002	150	126	119	144	141	253	341	394	372	224	184	153	217
2003	156	156	147	141	144	190	311	384	311	251	177	161	211
2004	160	151	144	134	150	315	461	521	481	283	190	152	262
2005	144	149	157	135	184	355	464	504	477	228	163	165	261
2006	166	173	141	132	142	295	446	475	419	297	184	168	254
2007	170	165	146	150	143	346	563	633	577	405	184	163	305
2008	161	152	138	131	128	229	345	371	326	281	186	175	219
2009	168	154	134	121	138	281	380	449	489	384	190	163	255
2010	166	154	140	117	124	295	396	430	384	239	--	--	--
Mean	158	154	143	137	143	266	416	472	420	286	179	161	245
Maximum - Monthly Average	191	188	162	176	189	429	566	633	577	424	212	181	305
Minimum - Monthly Average	125	115	112	99	105	190	302	352	236	168	139	131	192
Maximum - Daily Average	199	197	199	188	284	497	637	645	614	547	297	203	--
Minimum - Daily Average	91	108	93	88	86	119	245	280	181	83	101	117	--
10% Percentile - Daily Average	138	129	119	115	112	171	324	379	265	187	149	143	--
90% Percentile - Daily Average	176	174	161	164	178	371	517	563	533	443	213	180	--

Table A.2. Mean Monthly Discharge, 09AB008 – M'Clintock River near Whitehorse, 1955 – 1995

	Mean Monthly Discharge (m³/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
1955	-	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	2.10	2.00	2.50	16.6	15.0	9.10	5.40	6.50	5.60	3.5	2.6	-
1957	2.20	2.10	1.90	4.20	42.0	30.9	13.8	9.60	7.30	6.30	7.0	3.3	10.9
1958	2.70	2.40	2.60	2.60	11.3	9.7	3.30	3.10	3.90	-	-	-	-
1959	2.30	1.90	1.70	1.90	-	24.5	9.10	13.1	12.7	7.00	3.90	3.50	-
1960	3.00	2.50	2.00	-	-	21.8	11.5	11.2	11.2	8.40	5.70	3.70	-
1961	3.10	2.70	2.70	2.70	-	33.7	18.8	18.2	18.1	12.7	5.40	4.80	-
1962	4.00	3.50	3.50	3.50	16.2	57.0	22.4	11.2	10.6	-	-	-	-
1963	-	-	-	-	-	28.5	27.8	14.4	15.7	17.0	-	-	-
1964	-	-	-	-	-	-	16.7	12.3	-	-	-	-	-
1965	-	-	-	-	12.1	21.5	10.7	5.40	6.00	6.30	4.00	3.00	-
1966	2.60	2.40	2.30	4.30	11.7	29.2	13.0	12.6	12.9	11.6	7.30	5.20	9.60
1967	4.10	3.40	3.20	3.20	24.3	44.6	17.1	13.9	12.7	8.20	5.90	3.80	12.1
1968	3.30	3.20	3.10	3.30	21.4	19.2	12.3	13.3	16.3	12.9	5.60	3.60	9.80
1969	3.00	3.10	3.00	3.60	23.2	28.0	18.0	19.0	19.4	12.1	7.40	5.50	12.2
1970	3.70	3.40	3.30	3.40	15.6	13.4	8.30	6.80	9.80	9.80	5.10	3.50	7.20
1971	3.10	3.20	3.10	3.00	10.4	32.1	12.3	9.20	8.10	6.20	4.00	3.30	8.20
1972	2.80	2.30	1.90	2.10	20.2	44.3	12.3	13.3	9.80	7.70	5.50	4.10	10.5
1973	3.10	2.50	2.60	2.90	16.7	31.3	16.6	11.1	12.3	8.20	3.90	2.70	9.50
1974	2.70	2.70	2.70	2.90	22.2	25.7	14.2	18.4	12.9	10.2	5.90	5.00	10.5
1975	3.50	2.90	2.70	3.30	20.1	25.6	20.5	-	-	-	6.90	4.20	-
1976	3.60	3.30	3.40	3.90	17.5	36.2	16.6	9.70	8.50	6.90	4.80	3.60	9.80
1977	3.50	3.60	3.20	3.70	13.1	28.8	20.3	11.8	10.9	10.7	5.80	3.40	9.90
1978	3.00	2.70	2.50	2.90	13.6	17.8	7.50	-	-	-	4.20	2.90	-
1979	2.50	2.40	2.70	3.40	18.8	25.4	25.5	11.8	9.80	9.20	6.30	4.10	10.2
1980	3.30	3.00	2.70	3.50	13.6	16.7	9.40	10.2	14.4	16.9	9.80	4.60	9.00
1981	4.30	4.10	4.10	4.40	26.7	19.8	17.7	9.30	9.80	9.70	7.00	4.40	10.1
1982	3.00	2.50	2.00	1.70	12.3	32.8	9.70	7.40	7.30	7.40	5.30	3.70	7.90
1983	3.20	3.30	3.20	3.40	15.0	20.2	12.4	7.60	10.2	8.20	3.00	2.20	7.70
1984	2.10	2.60	3.10	3.00	14.0	19.1	9.4	9.40	9.40	7.10	4.20	3.70	7.30
1985	3.30	2.70	2.80	3.10	16.0	31.6	20.3	9.70	8.70	7.20	4.00	3.70	9.50
1986	3.30	2.60	2.40	3.20	10.9	32.9	22.0	14.2	11.7	14.6	7.10	4.60	10.8
1987	4.00	3.60	3.00	4.20	15.3	27.8	13.5	7.90	7.10	7.50	5.10	3.60	8.60
1988	2.50	2.70	2.90	3.20	22.4	24.1	32.7	19.2	11.9	11.1	8.40	5.20	12.2
1989	3.80	3.20	3.00	7.90	20.4	13.3	8.80	5.10	5.20	6.60	4.50	3.70	7.20
1990	2.90	2.40	2.40	3.20	18.6	27.2	14.2	6.90	6.20	5.70	3.90	3.30	8.10
1991	2.80	2.60	2.40	2.90	19.2	21.3	16.7	16.6	27.2	19.6	10.9	7.90	12.5
1992	6.30	5.10	5.30	6.30	20.7	47.5	23.7	13.3	12.5	11.2	9.00	6.50	13.9
1993	4.40	3.70	3.40	4.00	22.5	23.7	15.0	9.90	10.1	11.0	6.60	3.70	9.90
1994	3.70	3.30	3.10	5.70	18.6	22.2	12.4	7.30	8.80	12.2	6.40	5.10	9.10
1995	4.30	3.70	3.50	5.50	22.2	12.7	9.00	-	-	-	-	-	-
Mean	3.30	3.00	2.90	3.60	18.2	26.6	15.1	11.0	11.0	9.80	5.80	4.10	9.80
Maximum	6.30	5.10	5.30	7.90	42.0	57.0	32.7	19.2	27.2	19.6	10.9	7.90	13.9
Minimum	2.10	1.90	1.70	1.70	10.4	9.70	3.30	3.10	3.90	5.60	3.00	2.20	7.20

Table A3. Mean Monthly Water Level, 09AA004 – Bennett Lake at Carcross, 1984 – 2010

	Mean Monthly Water Level (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
1984	655.52	655.24	654.89	654.53	654.45	654.90	655.44	655.83	655.98	656.07	656.02	655.78	655.39
1985	655.52	655.25	654.92	654.47	654.29	654.91	655.87	656.26	656.12	656.08	655.94	655.72	655.45
1986	655.46	655.20	654.97	654.62	654.40	655.12	656.28	656.66	656.26	656.26	656.24	656.08	655.63
1987	655.77	655.42	655.02	654.62	654.39	-	-	-	656.37	656.31	656.18	655.98	-
1988	655.67	655.30	654.88	654.46	654.52	655.16	-	-	656.33	656.26	656.15	656.00	-
1989	655.69	655.34	654.94	654.53	654.76	655.53	656.38	656.83	656.72	656.32	656.15	656.03	655.77
1990	655.69	655.26	654.81	654.42	654.51	655.52	656.17	656.65	656.69	656.34	-	-	-
1991	-	-	654.93	654.57	654.52	655.02	655.92	-	-	-	-	-	-
1992	655.81	655.44	655.11	654.74	654.52	655.44	656.82	656.89	656.36	-	-	-	-
1993	655.32	655.02	654.75	654.46	654.73	656.06	656.52	656.74	656.49	656.30	656.15	656.06	655.72
1994	655.76	655.40	655.00	654.54	654.52	655.24	656.14	656.68	656.54	656.36	656.10	655.96	655.69
1995	655.71	655.34	654.91	654.47	654.72	655.25	655.88	656.11	656.29	656.23	656.00	655.75	655.56
1996	-	-	-	-	654.33	654.95	655.56	655.88	656.19	656.17	655.95	655.67	-
1997	655.26	-	-	-	-	655.19	655.94	656.34	656.42	656.27	656.17	656.04	-
1998	655.66	655.20	654.71	654.30	654.39	655.54	655.91	656.06	656.15	656.27	656.15	655.83	655.52
1999	655.46	-	-	-	-	655.16	655.84	656.19	656.13	656.20	656.11	655.88	-
2000	655.68	655.34	654.88	654.42	654.35	655.17	656.35	656.67	656.45	656.22	656.02	655.91	655.62
2001	655.78	655.49	655.10	654.62	654.29	655.24	656.17	656.48	656.36	656.15	656.07	655.87	655.64
2002	655.59	655.28	654.99	654.58	654.43	655.24	655.71	656.10	656.26	656.16	656.12	656.02	655.54
2003	655.77	655.40	654.99	654.56	654.42	654.87	655.56	656.06	656.13	656.22	656.04	655.83	655.49
2004	655.52	655.14	654.74	654.36	654.60	655.59	656.50	656.86	656.56	656.13	655.92	655.68	655.64
2005	655.45	655.18	654.77	654.37	654.74	655.63	656.25	656.43	656.32	656.03	655.98	656.00	655.60
2006	655.73	655.32	654.88	654.51	654.37	655.51	656.29	656.49	656.34	656.19	656.01	655.82	655.63
2007	655.56	655.20	654.84	654.46	654.37	655.76	656.96	657.40	657.03	656.30	655.97	655.74	655.80
2008	655.43	655.07	654.69	654.34	654.32	654.97	655.61	655.97	656.19	656.17	655.98	655.66	655.37
2009	655.28	654.94	654.58	654.26	654.40	655.40	656.01	656.49	656.70	656.20	655.85	655.63	655.48
2010	655.28	654.91	654.54	654.23	654.40	655.49	655.94	656.23	656.21	656.13	655.98	655.68	655.42
Mean	655.57	655.25	654.87	654.48	654.47	655.30	656.08	656.43	656.37	656.21	656.05	655.86	655.58
Maximum	655.81	655.49	655.11	654.74	654.76	656.06	656.96	657.40	657.03	656.36	656.24	656.08	655.80
Minimum	655.26	654.91	654.54	654.23	654.29	654.87	655.44	655.83	655.98	656.03	655.85	655.63	655.37

Table A4. Mean Monthly Water Level, 09AA017 – Tagish Lake at 10 Mile Road, 1996 – 2010

	Mean Monthly Water Level (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
1996	-	-	-	-	-	654.79	655.60	655.92	656.20	656.19	655.98	655.71	-
1997	655.30	654.86	654.47	654.16	654.15	655.03	655.97	656.40	656.45	656.29	656.18	656.07	655.45
1998	-	-	-	654.25	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	656.23	656.13	655.90	-
2000	655.70	655.35	654.89	654.40	654.18	654.91	656.28	656.66	656.45	656.22	656.03	655.92	655.58
2001	655.77	655.48	655.09	-	654.16	654.94	656.12	656.47	656.35	656.15	656.07	655.87	-
2002	655.57	655.27	654.97	654.54	654.23	655.07	655.67	656.07	656.23	656.13	656.08	655.99	655.49
2003	655.73	655.36	654.95	654.51	654.25	654.68	655.52	656.03	656.10	656.19	656.02	655.80	655.43
2004	655.47	655.09	654.69	654.28	654.32	655.47	656.47	656.83	656.52	656.10	655.89	655.65	655.57
2005	655.41	655.14	654.73	654.30	654.53	655.56	656.22	656.39	656.28	656.00	655.95	655.96	655.54
2006	655.70	655.29	654.84	654.46	654.16	655.26	656.22	656.45	656.28	656.14	655.96	655.78	655.55
2007	655.52	655.16	654.79	654.41	654.18	655.57	656.90	657.35	656.98	656.24	655.90	655.67	655.73
2008	655.36	654.99	654.61	654.21	654.03	654.76	655.52	655.89	656.11	656.08	655.90	655.57	655.25
2009	655.19	654.84	654.47	654.10	654.09	655.18	655.91	656.40	656.61	656.12	655.78	655.55	655.36
2010	655.20	654.83	654.43	654.07	654.04	655.24	655.84	656.15	656.13	656.04	655.89	655.58	655.29
Mean	655.49	655.14	654.74	654.31	654.19	655.11	656.02	656.38	656.36	656.15	655.98	655.79	655.48
Maximum	655.77	655.48	655.09	654.54	654.53	655.57	656.90	657.35	656.98	656.29	656.18	656.07	655.73
Minimum	655.19	654.83	654.43	654.07	654.03	654.68	655.52	655.89	656.10	656.00	655.78	655.55	655.25

Table A.5. Mean Monthly Water Level, 09AB004 – Marsh Lake near Whitehorse, 1984 – 2010

	Mean Monthly Water Level (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
1984	655.45	655.17	654.80	654.39	654.11	654.37	655.11	655.52	655.77	656.00	655.97	655.70	655.20
1985	655.44	655.16	654.79	654.29	653.91	654.41	655.53	656.05	656.00	656.01	655.88	655.68	655.26
1986	655.42	655.16	654.91	654.46	654.13	654.47	656.03	656.46	656.15	656.22	656.16	656.02	655.47
1987	655.72	655.33	654.90	654.46	654.00	654.36	655.56	656.17	656.15	656.19	656.15	655.94	655.41
1988	655.60	655.24	654.77	654.28	654.08	654.92	656.04	656.37	656.14	656.15	656.09	655.95	655.47
1989	655.63	655.23	654.79	654.32	654.23	655.13	656.11	656.62	656.49	656.16	656.10	655.98	655.57
1990	655.62	655.10	654.66	654.13	653.97	655.09	655.95	656.42	656.47	656.18	656.04	655.93	655.46
1991	655.65	655.24	654.86	654.44	654.12	654.55	655.66	656.05	656.22	656.15	656.12	656.03	655.42
1992	655.75	655.32	655.02	654.54	654.20	655.11	656.62	656.72	656.19	655.98	655.84	655.63	655.58
1993	655.31	--	654.72	654.29	654.17	655.73	656.32	656.55	656.30	656.16	656.13	656.04	655.61
1994	655.68	--	--	654.34	654.08	654.80	655.89	656.47	656.32	656.18	--	--	655.47
1995	655.66	655.28	654.77	654.19	654.16	654.86	655.62	655.88	656.12	656.14	655.96	655.71	655.36
1996	655.39	654.99	654.52	654.12	653.91	654.39	655.33	655.67	656.08	656.10	655.92	655.64	655.17
1997	655.20	654.76	654.32	653.97	653.91	654.68	655.72	656.16	656.24	656.21	656.17	656.04	655.28
1998	655.63	655.14	654.58	654.06	653.80	654.91	655.62	655.81	656.09	656.25	656.15	655.83	655.32
1999	655.45	655.01	654.54	654.02	653.76	654.39	655.55	655.95	656.03	656.18	656.10	655.88	655.24
2000	655.66	655.32	654.83	654.27	653.97	654.63	656.11	656.51	656.30	656.15	656.03	655.93	655.48
2001	655.79	655.48	655.08	654.50	653.97	654.69	655.97	656.32	656.20	656.12	656.07	655.87	655.51
2002	655.58	655.28	654.97	654.48	654.06	654.83	655.49	655.91	656.14	656.15	656.13	656.04	655.42
2003	655.77	655.39	654.95	654.46	654.05	654.40	655.30	655.86	656.03	656.18	656.04	655.83	655.35
2004	655.50	655.11	654.68	654.19	654.12	655.25	656.33	656.70	656.41	656.08	655.93	655.70	655.50
2005	655.46	655.15	654.70	654.18	654.28	655.35	656.09	656.26	656.18	656.01	656.01	656.03	655.48
2006	655.75	655.31	654.83	654.46	654.01	655.05	656.11	656.34	656.20	656.14	656.02	655.85	655.50
2007	655.57	655.16	654.75	654.31	653.99	655.37	656.83	657.29	656.92	656.21	655.99	655.76	655.68
2008	655.42	655.01	654.63	654.15	653.91	654.62	655.44	655.84	656.17	656.17	656.02	655.67	655.25
2009	655.23	654.86	654.45	654.06	654.02	655.05	655.85	656.36	656.58	656.10	655.87	655.66	655.34
2010	655.29	654.91	654.47	654.06	653.90	655.03	655.76	656.08	656.12	656.14	--	--	--
Mean	655.54	655.16	654.74	654.27	654.03	654.83	655.85	656.23	656.22	656.14	656.03	655.85	655.41
Maximum - Monthly Average	655.79	655.48	655.08	654.54	654.28	655.73	656.83	657.29	656.92	656.25	656.17	656.04	655.68
Minimum - Monthly Average	655.20	654.76	654.32	653.97	653.76	654.36	655.11	655.52	655.77	655.98	655.84	655.63	655.17
Maximum - Daily Average	655.92	655.66	655.30	654.82	654.80	656.36	657.27	657.34	657.19	656.58	656.25	656.15	--
Minimum - Daily Average	654.97	654.54	654.16	653.83	653.70	653.81	654.76	655.22	655.67	655.86	655.79	655.45	--
10^{th} Percentile - Daily Average	655.28	654.90	654.43	653.99	653.84	654.18	655.27	655.77	655.98	656.01	655.88	655.62	--
90^{th} Percentile - Daily Average	655.79	655.42	655.02	654.57	654.22	655.53	656.43	656.68	656.55	656.24	656.15	656.07	--

Table A.6. Annual Flow Volume in Descending Order, 1944 - 2009

Year	Annual Flow Volume (m3)	Wet Year Rank	Dry Year Rank	Year	Annual Flow Volume (m3)	Wet Year Rank	Dry Year Rank
1944	10012973760	1	66	**1987**	7632144000	34	33
1981	9900403200	2	65	**1946**	7586870400	35	32
2007	9611395200	3	64	**1972**	7419686400	36	31
1963	9308131200	4	63	**1969**	7406424000	37	30
1993	9111225600	5	62	**1960**	7398846720	38	29
1989	9104918400	6	61	**1997**	7382016000	39	28
1957	9070712640	7	60	**1954**	7379112960	40	27
1953	9015278400	8	59	**1950**	7369868160	41	26
1990	8909913600	9	58	**1952**	7369349760	42	25
1992	8726140800	10	57	**2001**	7352121600	43	24
1961	8690328000	11	56	**1945**	7309154880	44	23
1962	8640008640	12	55	**1947**	7214564160	45	22
1994	8571744000	13	54	**1966**	7113484800	46	21
1977	8438774400	14	53	**1965**	7058292480	47	20
1964	8425676160	15	52	**1983**	7001251200	48	19
1980	8325849600	16	51	**2008**	6923836800	49	18
1979	8297769600	17	50	**1959**	6914911680	50	17
2004	8292672000	18	49	**1958**	6856142400	51	16
1991	8255433600	19	48	**2002**	6851520000	52	15
2005	8233747200	20	47	**1951**	6823681920	53	14
1988	8226835200	21	46	**1974**	6777129600	54	13
2009	8038483200	22	45	**1949**	6763651200	55	12
2000	8031398400	23	44	**1998**	6740755200	56	11
1975	8008243200	24	43	**1978**	6714576000	57	10
2006	8003145600	25	42	**2003**	6662476800	58	9
1982	7834320000	26	41	**1999**	6631372800	59	8
1948	7830172800	27	40	**1985**	6428505600	60	7
1976	7800796800	28	39	**1970**	6191683200	61	6
1967	7734502080	29	38	**1996**	6182697600	62	5
1971	7712064000	30	37	**1956**	6102043200	63	4
1968	7693652160	31	36	**1984**	6085238400	64	3
1986	7677158400	32	35	**1955**	5869100160	65	2
1995	7674307200	33	34	**1973**	5861808000	66	1