Memo

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Date: September 8, 2025

Subject: Hydrologic Analysis of Pond Inlet

Our File: 24-7458

1.0 Introduction

Dillon Consulting Limited (Dillon) has undertaken a water balance assessment for the Hamlet of Pond Inlet's water supply system to investigate water source reliability and reservoir storage requirements to meet both the existing and projected future (20- year design life) water demand for the community. Currently, the potable water supply is sourced from a reservoir serving as the water supply reservoir that receives both direct precipitation and surface runoff from the surrounding (0.33 km^2) catchment area before being treated at the treatment plant found on its shoreline and delivered to the community. The natural recharge of the reservoir alone is unable to meet the community's current demand and is therefore supplemented seasonally from the nearby Salmon Creek. It has been anticipated that with increased future demands due to population growth, increased water use at the proposed new WTP, as well as impacts from climate change, the current supplemental resupply will not be adequate, and the current reservoir is not large enough to meet the growing demand over the winter.

This assessment has focused on investigating the feasibility of extracting supplementary source water from the nearby Salmon Creek to meet projected water treatment storage requirements to satisfy the growing demand.

The objectives of this study are to:

1. Estimate the required additional water volume for treatment needed to meet the projected future water demand for a 20-year design horizon; and
2. Investigate the feasibility of increasing supplementary pumping from Salmon Creek to meet the projected future increase in water demand.

Please note this report submission is a revised version of the original submission dated July 8, 2024. This revised submission reflects updated potable water consumption volumes as recommended by the Government of Nunavut (GN).

1.1 Background

The Hamlet of Pond Inlet, Nunavut is located at 72°42’ N latitude and 77°57’ W longitude and is found in the northern regions of Baffin Island. The Hamlet currently relies on the reservoir shown in Figure 1 as its main water supply, supplemented seasonally by nearby Salmon Creek shown in Figure 2.



Figure 1: Site Location



Figure 2: Salmon Creek (July 2024, CGS)

The current source water reservoir is found approximately 3.5 km south of the community and Salmon Creek, which flows north westerly to Baffin Bay, and is found only approximately 100 m further to the south. Notably, water is generally only available in Salmon Creek during the open water season (June to September). The Salmon Creek watershed possesses a drainage area of approximately 41km^2 and is ungauged. Part of this investigation has focussed on estimating the creek's annual discharge trends to assess its adequacy to meet the estimated future water demand of the community.

2.0 Methodology

To meet the objectives of this investigation, a review of both regional meteorological data and hydrometric data from Environment and Climate Change Canada (ECCC) database sources was conducted. These historical data records were used to identify water balance inputs for the constructed water balance model (precipitation, evaporation, temperature, etc.,) for the water supply reservoir, as well as for establishing local seasonal discharge trends from neighboring gauged watersheds. This discharge data was used to investigate and estimate the hydrology of the contributing reservoir catchment area and the Salmon Creek watershed as a supplementary water source.

2.1 Meteorology Data

The Hamlet of Pond Inlet has a sufficient history of available climate data for use in this investigation to understand precipitation and temperature trends pertinent to the project area. Five sets of ECCC meteorological records complete with daily data were identified. The period of record between the five climate stations spans 101 years. In general, a good understanding of recent climate conditions would ideally require at least 20 years of recent data. Therefore, the available climate data and particularly the

long period of record allows for a strong understanding of the climatic variables required for this assessment. The five ECCC stations are presented in Table 1.

Table 1: ECCC Meteorological Stations Within the Primary Watershed

ID	Station Name	Climate Data	Elev. (m)	Latitude	Longitude	Proximity to Study Site (km)
1773	POND INLET	1922-1965	4.00	72.68	-77.98	1.73
43223	POND INLET CLIMATE	2005-2023	64.66	72.69	-77.96	2.32
1774	POND INLET A	1975-2014	61.60	72.69	-77.97	2.44
51080	POND INLET A	2013-2023	61.60	72.69	-77.97	2.44
47488	POND INLET AWOS	2008-2013	61.60	72.69	-77.97	2.44

2.2 Regional Hydrometric Stations

A review of regional hydrometric stations was undertaken using ECCC's HYDAT database to assess the hydrology of the study area. While there are numerous hydrometric stations in the database covering the Nunavut Territory, some are quite remote from Pond Inlet or are found to be located in potentially different climatic regions and terrains, possessing limited periods of record, and other key differences from the study watershed (e.g. significantly different watershed size). Stations were selected based on proximity to the site, watershed size, period of record, latitudinal position, along with geographic location due to climatic influences. Three stations were selected for use in this study as shown in Table 2. It is notable that within this selection of 3 stations, some are quite remote and possess relatively short periods of record. Despite this, these stations were found to be the most hydrologically similar to the Salmon Creek watershed.

Table 2: WSC Hydrometric Stations Used for Study

ID	Station Name	Drainage Area (km^2)	Recorded Years of Record	Completed Years of Record	Latitude	Longitude	Proximity to Study Site (km)
10UH002	APEX RIVER AT APEX	58.50	48	18	63.73	-68.45	1068.03
10UB001	MARCIL CREEK NEAR ARCTIC BAY	139.00	5	3	72.99	-84.99	235.41
10UE001	TULUGAK RIVER ON BROUGHTON ISLAND	27.40	8	0	67.56	-63.98	774.33

With the exception of 'MARCIL CREEK NEAR ARCTIC BAY', station 10UB001, all stations are located further south of the study area which may skew the seasonality of flows due to different exposure to weather patterns, and watershed characteristics. Both `APEX RIVER AT APEX` and `MARCIL CREEK NEAR ARCTIC BAY` are larger than the target watershed area of $40.5km^2$. `TULUGAK RIVER ON BROUGHTON ISLAND`, being smaller, gives the estimation a higher confidence as the Salmon Creek watershed lies within the upper and lower watershed size limits of the three stations.

3.0 Results

3.1 Meteorological Station Selection

The Canadian Climate Normal from 1991-2020 for Pond Inlet show that the annual total precipitation of Pond Inlet is 195.1 mm/year. This was found from a range of stations around Pond Inlet, recording data from different intervals to produce a climate normal with average precipitation depths that can be expected in the area.

Table 1 above shows that the `POND INLET CLIMATE` station records, station ID 43223, has the most recent years of data in the region and as a result was selected as a representative station for current meteorological conditions. The average monthly precipitation that this station produced was approximately 184mm/year. This station's average annual precipitation depth is lower compared to the climate normal produced by ECCC. However, this difference is likely due to the climate normal data set spanning from 1991 to 2020 (30 Year averages) and includes a composite of the data from several of the stations, while the data in the `POND INLET CLIMATE` station contains data from 2005-2023 (18 years) and is most representative of current conditions. The data was considered to be suitable as it represents a conservative amount of precipitation from a water supply perspective.

3.1.1 Temperature

Pond Inlet falls in the Arctic climate zone which is characterized by long cold winters, and short cool summers. Maximum, minimum, and average monthly temperature data are seen in Figure 3. Temperatures are below zero from approximately October until May, with February being the coldest month of the year with a mean temperature of -32.5°C. Temperatures rise above zero in June, with average temperatures being highest in July at 7.4°C.

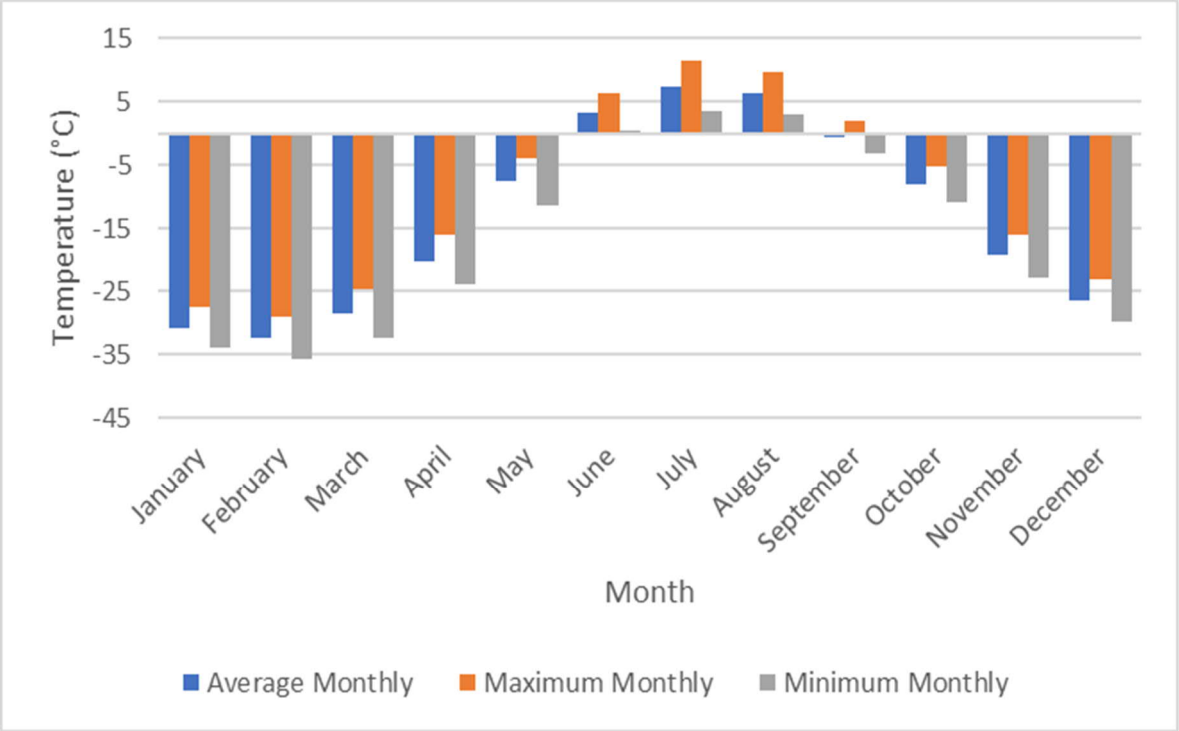


Figure 3: Maximum, Minimum, and Mean Average Monthly Temperatures (2005-2023)

3.1.2 Precipitation

The annual precipitation for the composite record is presented in Figure 4. Mean annual precipitation from the `POND INLET CLIMATE` station is approximately 185mm/year. A mostly consistent trend in mean annual precipitation is apparent in Figure 4. During a wet weather year, such as in 2017, the precipitation totals were equal to approximately 455mm/year. During a dry year, such as in 2007, the precipitation totals equal to 73.5mm/year, displaying the variance in annual precipitation patterns.

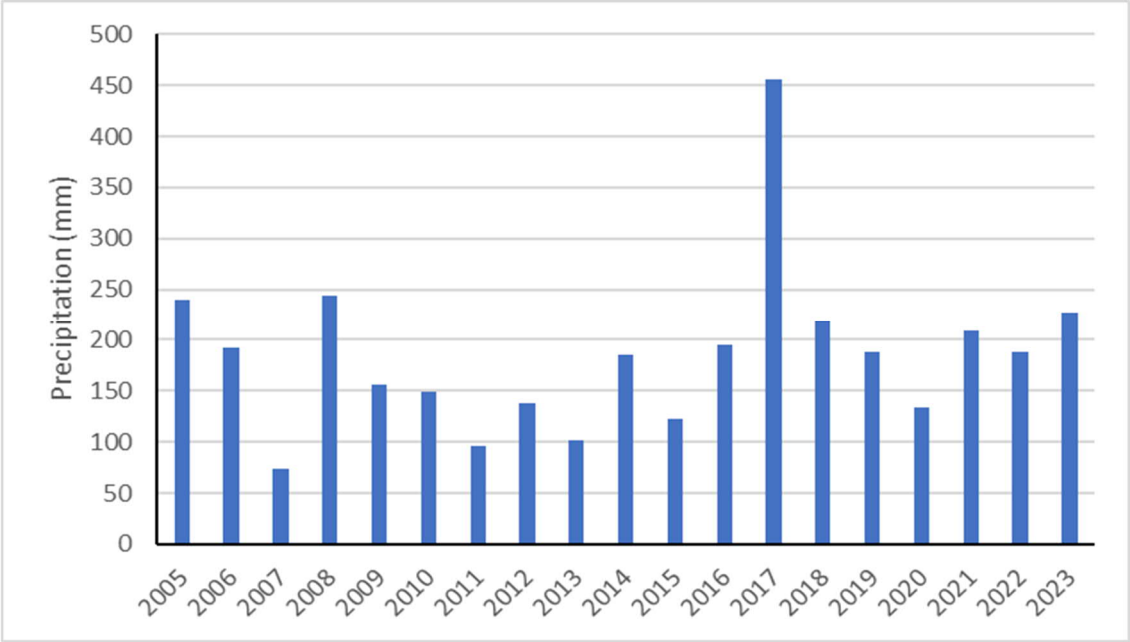


Figure 4: Annual Precipitation Patterns at Pond Inlet

The summer months (June to August) receive the highest precipitation amounts, with August receiving the most precipitation on average. Figure 5 demonstrates the potential for wet conditions to at least October.

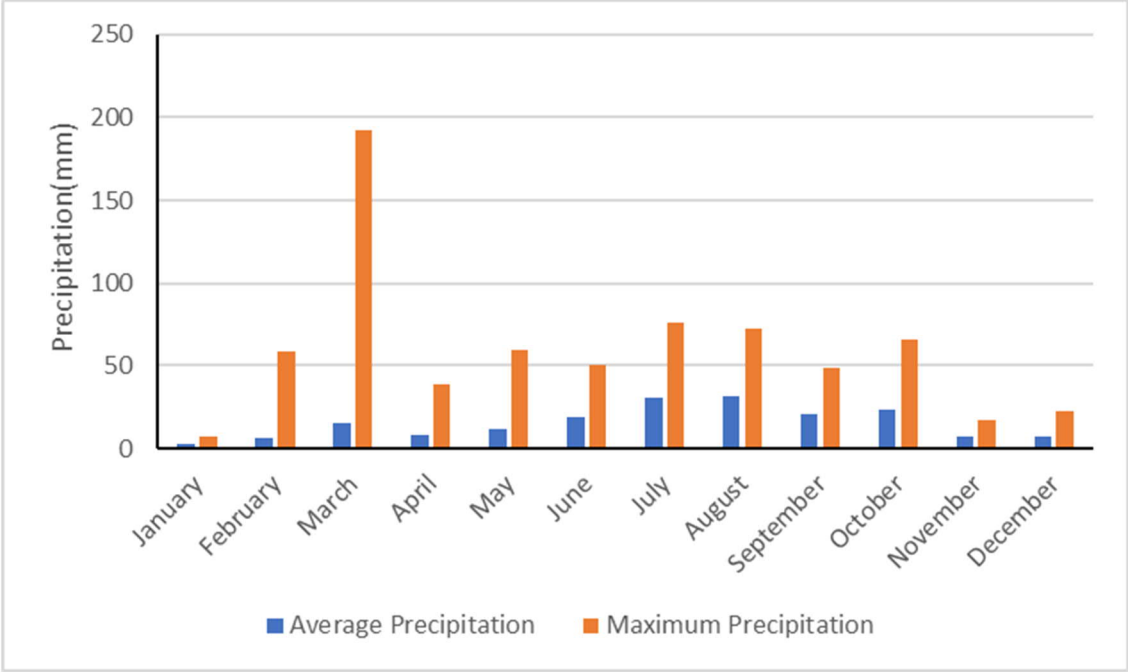


Figure 5: Long Term Precipitation from Composite Precipitation Record (2005-2023)

3.1.3 Evaporation

There is no recorded evaporation data for the Pond Inlet reservoir, and as such assumptions had to be made to estimate evaporation in the area. Surface evaporation was estimated using an average of the Hydrological Atlas of Canada (1978), the USGS Thornthwaite model for actual evapotranspiration, and research done on Baffin Island (Young et al, 2015). The Hydrological Atlas of Canada along with the research done on Baffin Island provided results based on data recorded in similar climatic zones, while the USGS model used site specific characteristics to estimate evaporation rates based on temperature and precipitation. The average of these values resulted in approximately 200mm/year annually. Figure 6 below displays the comparison of the different sources of evaporation.

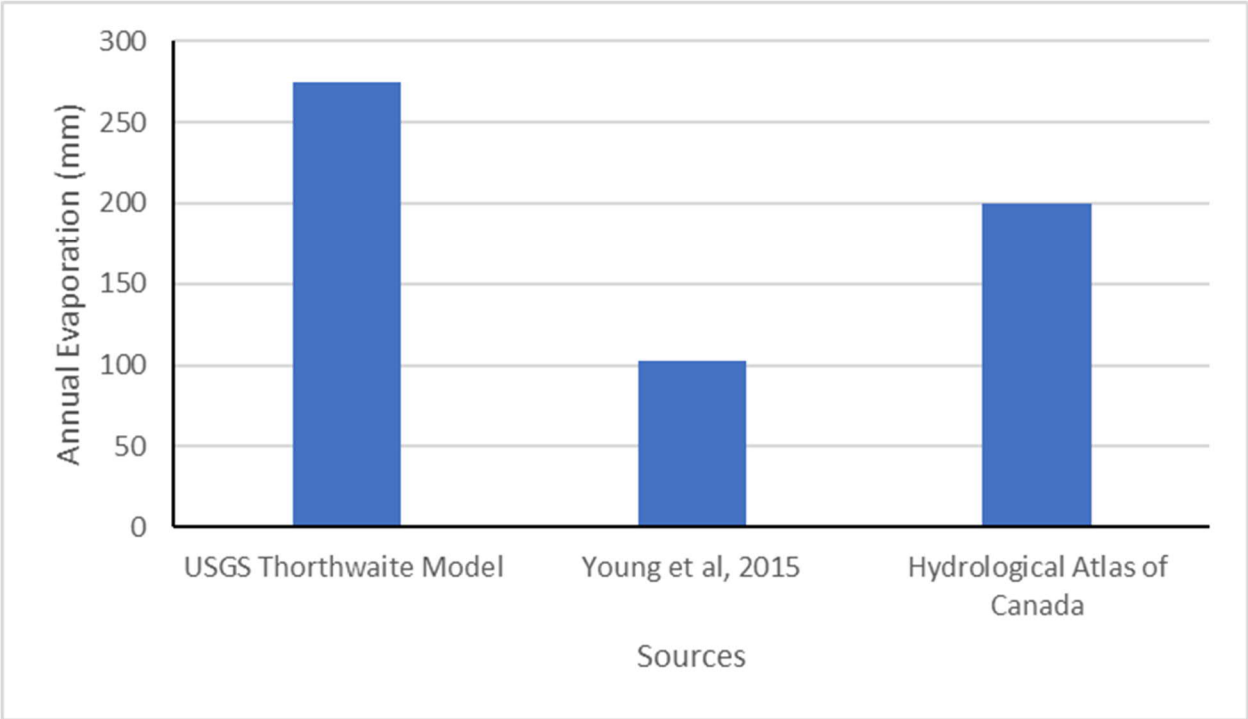


Figure 6: Summary of Annual Evaporation by Source

3.2 Hydrometric Station Analysis

3.2.1 Station Selection

To better understand the discharge of Salmon Creek as a supplementary water source, the seasonal unit area runoff rates from June to September for the 3 stations presented in Table 2 were examined to identify regional flow trends and develop a range of anticipated runoff for each of the 3 stations. These unit runoff values were assessed during the target withdrawal months of June to September. Due to the various periods of records, the study also included common years between the stations to identify

trends, and increase confidence in the estimations. The average seasonal (June-September) unit area runoff averages are displayed in Figure 7.

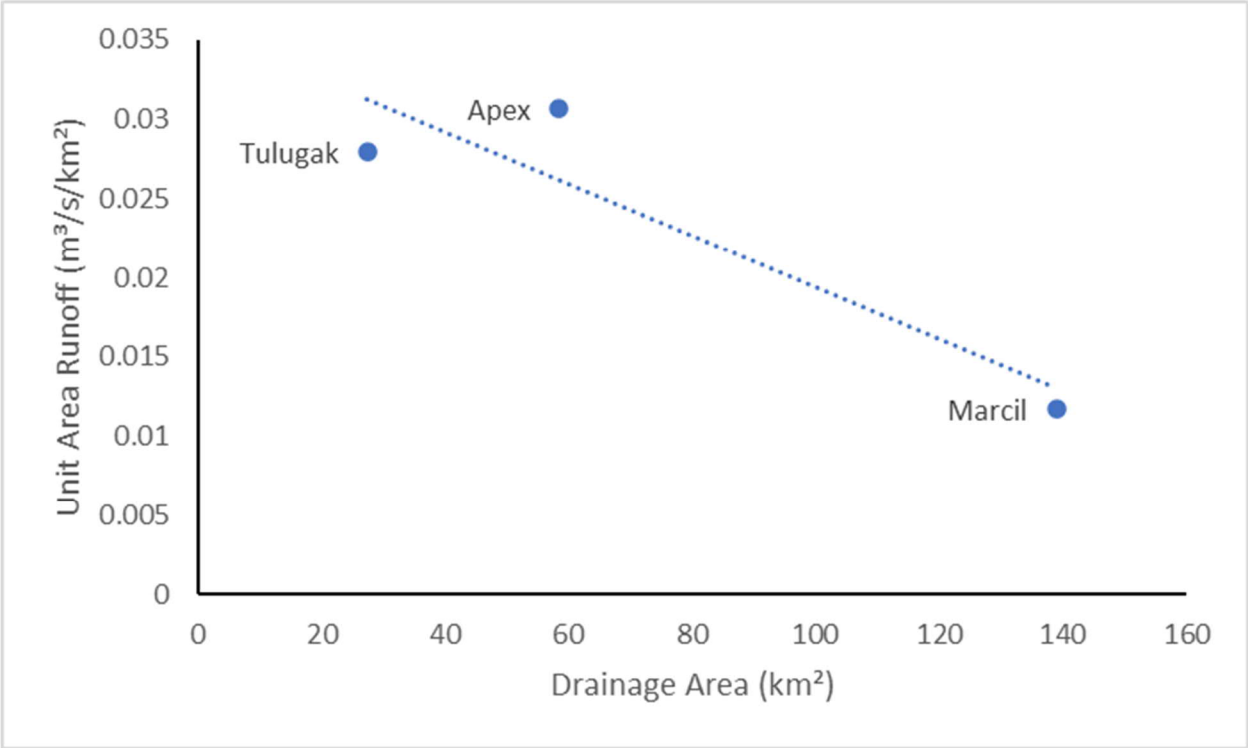


Figure 7: Average Seasonal Unit Area Runoff (June to September)

Figure 7 above displays an inverse trend of drainage area versus unit area runoff, demonstrating that the larger the areas generally yield a lower unit runoff rate. This trend is often the result of a higher potential for attenuation (watershed storage effect) typically found in larger drainage areas. The Salmon Creek watershed is 40.5km^2, therefore the watershed selected to pro rate flows for Salmon Creek should have a similar drainage area to reflect accurate watershed characteristics within the Salmon Creek watershed.

To support this data, the study also considered the long-term monthly record of each station to understand trends on an annual timestep. Including the long-term monthly record of each station helps to provide a comprehensive understanding of annual discharge patterns and trends, ensuring the reliability and accuracy of the supplementary water source assessment. A summary of average monthly unit runoff rates for each of the three stations considered is presented in Figure 8.

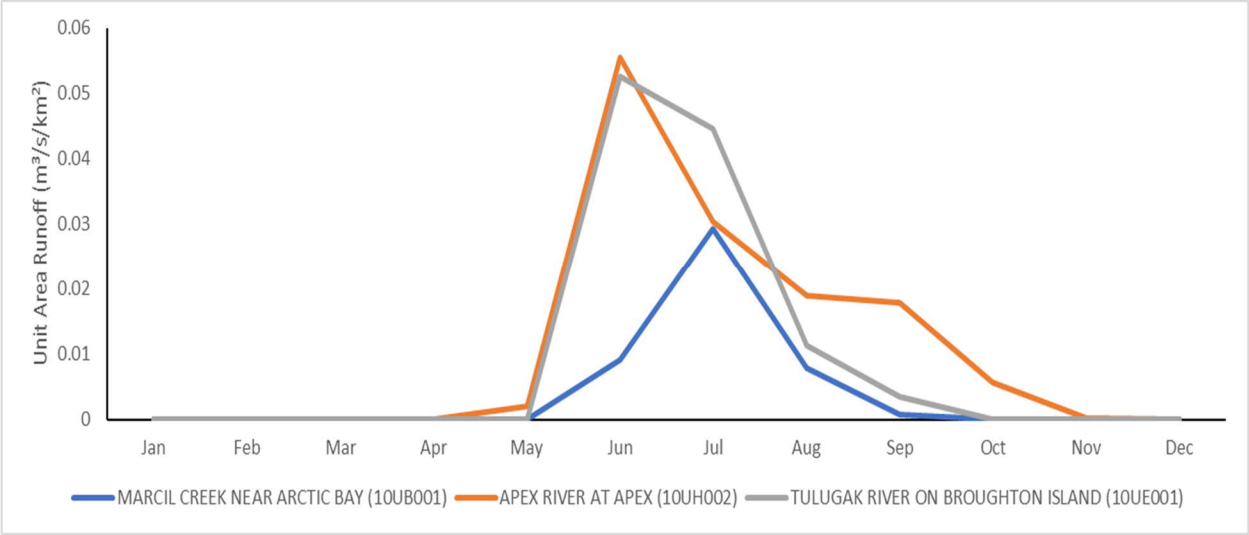


Figure 8: Average Monthly Unit Area Runoff Hydrograph for Selected Stations

Based on the hydrograph displayed in Figure 8 above, the `APEX RIVER AT APEX`, and `TULUGAK RIVER ON BROUGHTON ISLAND` stations have similar unit area runoff values, while the `MARCIL CREEK NEAR ARCTIC BAY` station is lower. `APEX RIVER AT APEX`, and `TULUGAK RIVER ON BROUGHTON ISLAND` both experience the highest average flows in June while `MARCIL CREEK NEAR ARCTIC BAY` occurs in July. All stations start recording flows during the late spring, presuming around the time of the freshet in the respective watersheds. All stations continue to report flow until at least October, with `APEX RIVER AT APEX` reporting flows until November.

While `MARCIL CREEK NEAR ARCTIC BAY' is closer to Salmon Creek, it is a larger watershed, which includes more attenuation and results in less runoff per unit area. This is supported by the data shown in Figures 7 and 8, showing lower unit area runoff results compared to similar stations. Due to the robust record of station 10UH002, `APEX RIVER AT APEX`, the station was used to prorate discharge values to better understand the flows occurring at Salmon Creek. Figure 9 below shows the pro-rated discharge values that are estimated to occur in Salmon Creek based on available data.

Historically, snowmelt typically occurred in early June; however, with a warming climate, studies have shown that melt now begins one to two weeks earlier—often by late May—across much of the Canadian and North American Arctic (NOAA Arctic Report Card, 2024; Natural Resources Canada, 2019). While `MARCIL CREEK NEAR ARCTIC BAY' is closer to the community of Pond Inlet and, as seen above in Figure 8, has a later spring freshet, Dillon utilized the hydrometric data recorded at `APEX RIVER AT APEX` (Station ID10UH002), due to the projected freshet under climate change to begin earlier than usual.

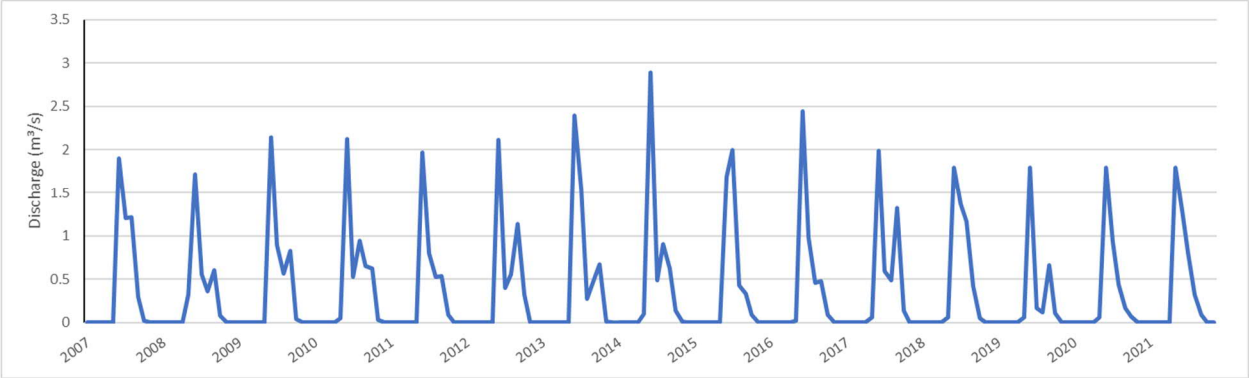


Figure 9: Estimated Discharge Values Occurring at Salmon Creek

Based on the pro- rated discharge values from the `APEX RIVER AT APEX` station, the average monthly flows estimated for Salmon Creek are shown below in Table 3.

Table 3: Estimated Discharge Values for Salmon Creek

Month	Mean Discharge (m^3/s)	Mean Discharge (L/s)
June	1.79	1790.00
July	0.99	990.00
August	0.61	610.00
September	0.57	570.00
Average Creek Discharge*	0.99	990.00

*Based on months stated in the table.

4.0 Current and Projected Demand Conditions

Table 4 below shows the current and projected drinking water demand expected from the community. This water balance used the population of Pond Inlet to be approximately 1,636 (2023). This results in a calculated average annual water use of 83,838 $m^3/year$. Actual consumption in the community does not appear to be this high, but it is expected to increase immediately with the commissioning of the new facility, assumed to occur in the year 2028, pending permitting and construction processes.

A summary of the existing and projected future water demand is provided in Table 4.

Table 4: Current and Projected Drinking Water Demand

Year	Years Following Commissioning[1]	Annual Water Use (m^3/year)
2023	NA	83,838[2]
2038	10	132,365
2048	20	166,846

[1]Commission year anticipated as 2028
[2]This value was also calculated using the same method as for future years, since records for actual water use in the community are deemed incomplete and not reliable.

The total area of the existing reservoir is approximately 40,000m^2 with an overflow pipe at 99.5 masl. This results in a total usable storage of approximately 120,000m^3. During peak winter conditions, with an assumed maximum 2m of ice on the surface of the reservoir, the total usable volume is reduced to approximately 48,000m^3.

5.0 Water Balance

5.1 Pond Inlet Water Balance Model

A water balance model was developed for the Pond Inlet water supply reservoir for the 2005 to 2023 period of record. The water balance simulation was based on results obtained from background research, excel models, and the USGS Thornthwaite monthly water balance model. The Thornthwaite model employs an accounting procedure to analyze and allocate water in different stages of the hydrologic cycle. Inputs into the model include a runoff factor, direct runoff factor, soil-moisture storage capacity, latitude of location, rain temperature threshold, and maximum snow-melt rate of the included snow storage.

A schematic of the water balance is presented in Figure 10. Monthly precipitation totals were calculated using the composite hydrometric dataset. The water balance equation used for model creation is as follows:

$$\Delta S = (P + R) - (E + A)$$

Where:

ΔS = Change in reservoir storage (m^3)

P = Precipitation (m^3)

R = Runoff from the Pond Inlet watershed (m^3)

E = Evaporative losses from the reservoir surface (m^3)

A = Municipal Water Abstraction (m^3)

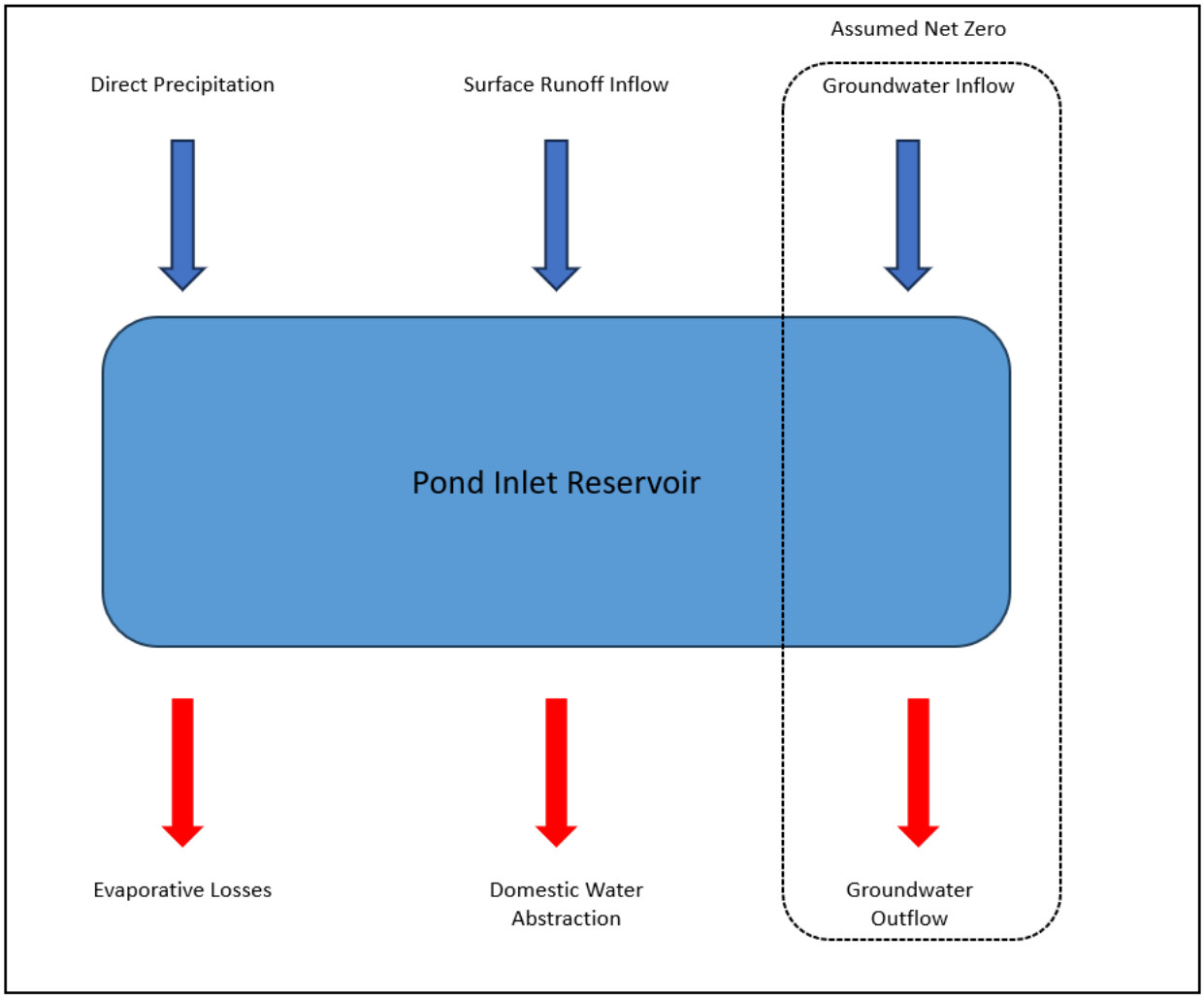


Figure 10: Schematic of the Pond Inlet Water Balance Model

5.2 Assumptions

Evaporative losses were estimated using the Thornthwaite model and background research as there was no recently recorded regional data available. Watershed characteristics, such as depressions and slopes, were estimated which could slightly affect surface inflow values. Due to limited regional hydrometric data in the region, estimated flows in the Salmon Creek carry a level of uncertainty as a result of varying geographic locations which affect climatic factors such as precipitation.

Permafrost was not considered in the model resulting in a conservative approach to recharge rates. The only losses in the model included reservoir surface evaporation and domestic water withdrawal. The net groundwater contribution was assumed to be zero due to the presence of continuous permafrost. A 2m reservoir winter ice cover thickness is suggested in the DFO Protocol for Winter Water Withdrawals from Ice-Covered water bodies in the Northwest Territories and Nunavut. The ice cover was assumed a net zero based on annual melting and freezing patterns.

5.3 Model Results

Monthly and annual historical water balances were carried out for the composite period of record spanning 2005-2023. Table 5 and Figure 11 present the annual change in several reservoir characteristics including the direct reservoir precipitation, reservoir inflow (watershed runoff), reservoir surface evaporation, overflow, domestic water abstraction, remaining reservoir volume (after abstraction, ice cover considerations, and overflow), and reservoir level. The annual water balance is calculated based on the water year, equivalent to the open water season (October to September) to account for snow storage in the hydrologic cycle in the winter months.

Table 5 indicates that after incorporating the domestic water abstraction, the average annual change in available water in the reservoir has historically been negative, with the values in red denoting a shortfall relative to the required annual water demand. Evaporative processes in a northern climate comprise a significant portion of the overall hydrologic budget and are often underestimated. The results show that even in a wet year with sufficient recharge amount to fill the reservoir before the winter season, these deficits unable to meet future demand without resupply.

Table 5: Historic Pond Inlet Reservoir Water Balance Summary (1990-2023)

Water Year (to-from)		Direct Precip. (m^3)	Reservoir Inflow (m^3)	Reservoir Surface Evaporation (m^3)	Municipal Withdrawal (m^3)	Overflow (m^3)	Net Gain/Deficit[1] (m^3)
1990	1991	12,936	43,764	14,600	83,838	0	-41,738
1991	1992	14,637	49,722	14,600	83,838	0	-34,079
1992	1993	9,125	32,606	14,600	83,838	0	-56,707
1993	1994	11,731	42,498	14,600	83,838	0	-44,209
1994	1995	13,512	46,040	14,600	83,838	0	-38,886
1995	1996	21,053	72,801	14,600	83,838	0	-4,584
1996	1997	13,914	46,868	14,600	83,838	0	-37,656
1997	1998	17,608	61,161	14,600	83,838	0	-19,669
1998	1999	11,665	42,367	14,600	83,838	0	-44,406
1999	2000	9,359	32,327	14,600	83,838	0	-56,752
2000	2001	8,074	29,160	14,600	83,838	0	-61,204
2001	2002	18,206	58,588	14,600	83,838	0	-21,644
2002	2003	20,177	67,824	14,600	83,838	0	-10,437
2003	2004	13,388	44,007	14,600	83,838	0	-41,043
2004	2005	21,068	73,611	14,600	83,838	0	-3,759
2005	2006	16,067	57,016	14,600	83,838	0	-25,355
2006	2007	3,219	10,463	14,600	83,838	0	-84,756
2007	2008	18,148	59,431	14,600	83,838	0	-20,859
2008	2009	12,359	41,472	14,600	83,838	0	-44,607
2009	2010	7,512	26,027	14,600	83,838	0	-64,899
2010	2011	8,578	29,274	14,600	83,838	0	-60,586
2011	2012	6,811	23,690	14,600	83,838	0	-67,937
2012	2013	13,323	44,148	14,600	83,838	0	-40,967
2013	2014	6,147	22,596	14,600	83,838	0	-69,695
2014	2015	15,352	54,008	14,600	83,838	0	-29,078

2015	2016	23,696	85,666	14,600	83,838	0	10,924**
2016	2017	16,140	54,964	14,600	83,838	0	-27,334
2017	2018	13,031	45,423	14,600	83,838	0	-39,984
2018	2019	9,702	33,547	14,600	83,838	0	-55,189
2019	2020	9,001	30,479	14,600	83,838	0	-58,958
2020	2021	9,570	34,284	14,600	83,838	0	-54,584
2021	2022	19,418	68,618	14,600	83,838	0	-10,402
2022	2023	22,031	77,857	14,600	83,838	0	1,450[2]
Average		13,532	46,737	14,600	83,838	0	-38,169

[1]Deficit is equal to the direct precipitation plus the inflow into the reservoir minus the reservoir surface evaporation and municipal water withdrawal.
[2]This value is in green as it is the only year with no deficit due to an extreme precipitation event.

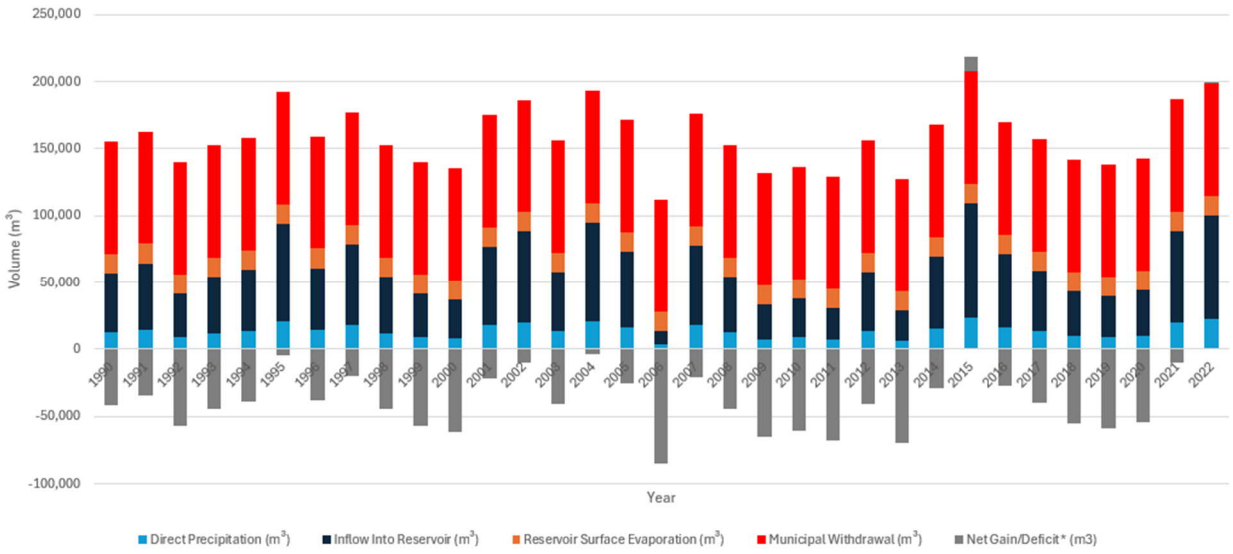


Figure 11: Historical Pond Inlet Reservoir Water Balance Summary (1990-2023)

Figure 12 below shows the current state of the reservoir, indicating it fills during the wet spring and summer months but does not receive sufficient precipitation and surface inflow to supply the community through the winter. Due to frozen conditions, there is no catchment or direct resupply during winter, and snow on top of the reservoir cannot contribute to the inflow until it melts during the warmer spring and summer months. This emphasizes the need for both additional storage and a secondary source of supplemental water. Figure 12 assumes current conditions of the reservoir stated above with the intake pipe being at 94 masl, and the overflow pipe at 99.5 masl.

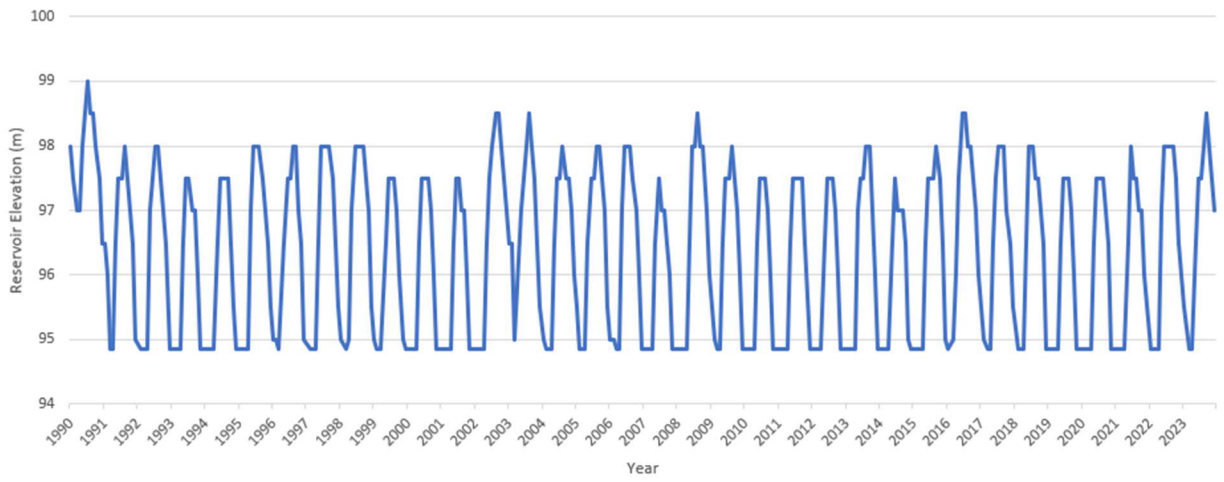


Figure 12: Current Storage Condition of Pond Inlet Reservoir

5.4 Climate Change

Climate change is anticipated to have a noticeable effect on northern communities and has been considered in this assessment. It should be noted that estimating the effect on climate change is difficult and can vary significantly based on multiple factors such as emission standards.

Using the publicly accessible online source ClimateData.ca, the projected 2021-2050 climate normals for the Pond Inlet region were used. The website uses the Shared Socioeconomic Pathways (SSP) climate change scenario projections and offers varying degrees of severity. The median of the SSP5.85 climate impact scenarios was used. Based on the ClimateData.ca projections, total yearly precipitations are predicted to increase by approximately 13%, while temperature is predicted to increase by approximately 15%.

Using the adjusted climate data, the USGS Thornthwaite model was rerun to get updated evapotranspiration values. The updated values were then compared to the historical results and found to show an average increase of approximately 3% in evaporation values. To account for the expected increase in evaporation losses, the evaporation values used in the future scenario were increased by 3% from 200mm/year to 206 mm/year.

The projected increase in precipitation is expected to contribute a larger volume of water to the water supply system. This results in an increase in average rainfall depth from approximately 181mm/year to 204mm/year.

Overall, under the projected future climate, there is an expectation of a larger volume of water becoming available to the community.

5.5 Supplemental Resupply

The average natural resupply into the reservoir from the watershed, using climate conditions up to the year 2023, is approximately 60,269$m^3/year$, based on the results presented above in Table 5. The average withdrawal based on withdrawal and evaporation conditions up to the year 2023 is approximately 98,438 $m^3/year$. This presents an annual deficit of 38,169 $m^3/year$.

With the existing reservoir condition having a storage capacity during peak winter conditions of approximately 48,000m^3, and an average municipal water use of 6,987$m^3/month$, based on 2023 annual demand values, this only provides the community with 6 months of municipal water supply. No inputs into the reservoir are expected for 8 months of the year due to ice conditions, highlighting a deficit in water supply under the current reservoir size. With the projected increase in municipal water demand stated above in Section 5, the statistics emphasize the need for both expanded reservoir storage, along with an increased supplemental resupply.

To better understand the impact of climate change on future conditions, the climate change analysis described above resulted in an increase in average inflow and evaporation. After increasing both the precipitation and evaporation depth for future conditions, the results are summarized below in Table 6.

Table 6: Projected Pond Inlet Reservoir Water Balance Summary

Timeline	Inflow	Outflow	Net
Existing	60,269	-98,438	-38,169
10-year	68,420	-147,403	-78,983
20-year	68,081	-181,884	-113,803

5.6 Proposed Resupply Strategy

The reservoir will be supplemented with water pumped from the nearby Salmon Creek during the open water season.

The supplementary pumping window is proposed for 8 weeks, operating 8 hours per day.

The pumping system will be designed to meet the maximum projected demand: the 20-year design horizon deficit. Although the 10-year demand is lower, using the 20-year deficit ensures the system is future-proofed. For the 10-year horizon, the pump will simply operate for a shorter duration to draw the necessary, smaller volume of water. This approach ensures the instantaneous pumping rate is sufficient to meet the maximum long-term requirement while remaining flexible for lower demands.

This study focused on the 20-year design horizon deficit to determine the necessary pump capacity. While the 10-year design horizon requires less water, the same pumping system will be used but will operate for a shorter duration to draw the smaller volume needed.

Table 7 below presents a summary of supplemental pumping for the 10- and 20- year design horizon with the stage storage stated in Section 4.

Table 7: Future Recharge Rate Estimations

	20 Year Horizon
Average Monthly River Discharge (m^3/s)[1]	0.990
Proposed River Withdrawal (m^3/s)[2]	0.099
% of River Discharge	10%

[1]Values were calculated based on an average of the monthly average estimated flows at Salmon Creek during June- September.
[2]Selected to be 10% of average river discharge.

6.0 Summary

This assessment found that the current water supply system in Pond Inlet, primarily sourced from a natural upland reservoir and supplemented by Salmon Creek, will not meet future water demands due to population growth causing increased water demand. It was noted that even with the current system, the natural recharge of the reservoir was insufficient to meet the estimated current demands during the winter season when there are no inputs to the reservoir. The findings present the need for additional supplemental pumping from Salmon Creek, as well as expanding the existing storage capacity.

It is noted that during the initial year of filling an expanded reservoir resupply volumes may be higher than this analysis considered. Based on the expansion strategy including a phased approach to increasing the stored volume of water and lower consumption than in the 20-year design year, the resupply volumes are anticipated to remain within the annual limits.

The analysis indicates that the estimated flows in Salmon Creek are sufficient to cover the projected water deficit. The proposed supplementary pumping rate is projected to take 10% of the creek's average discharge during the open water season (June to September).