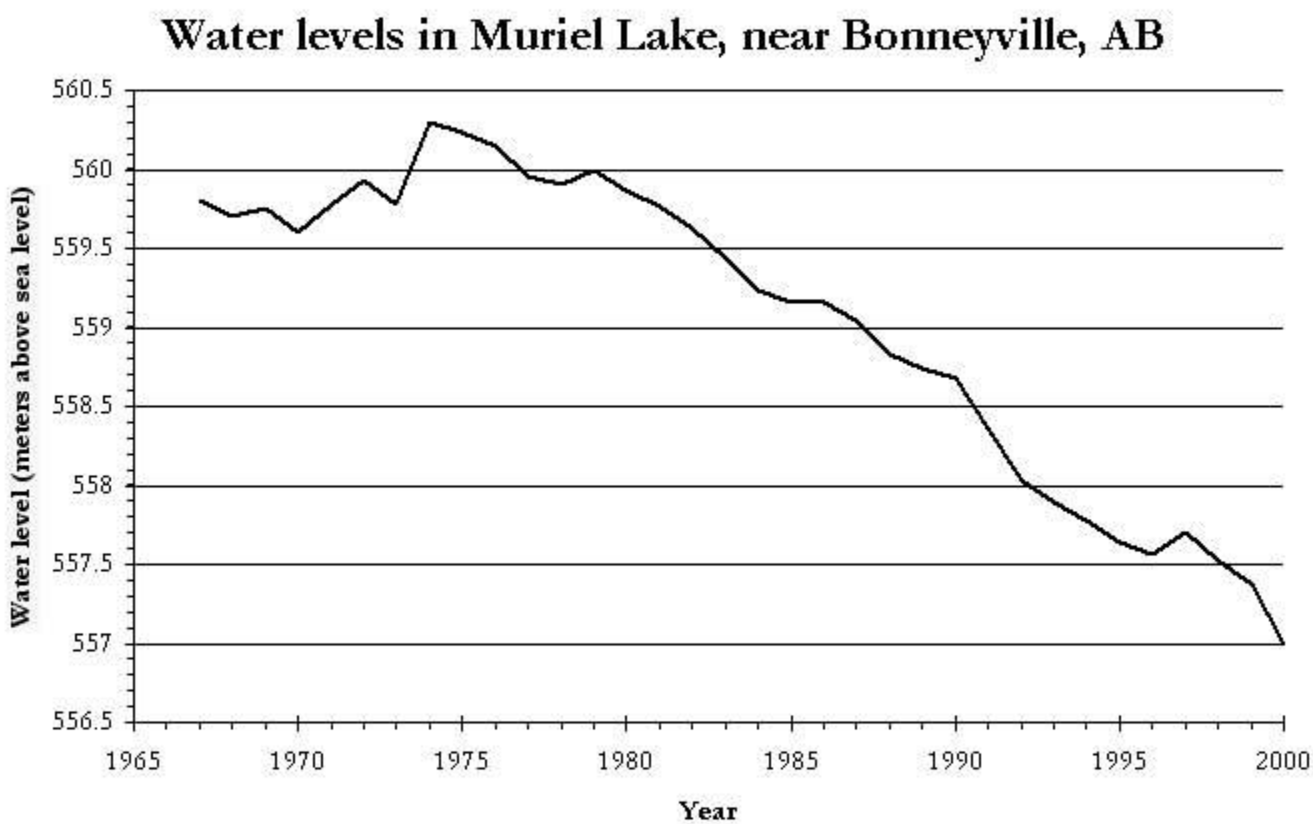
# Muriel Lake

## Why the water level dropped

In this section the factors which have contributed to the decrease in water levels in Muriel Lake are explored.

Muriel Lake has experienced a long term trend of dropping water level. From its highest recorded level of 560.3 masl in 1974 the water level dropped year after year to a low of 555.5 masl in 2015. Here is a graph of water level from https://sites.ualberta.ca/~ersc/water/climate/muriel.htm




Reduced Precipitation

Obviously, precipitation levels are a key factor to be considered when evaluating changes in most lakes in the Canadian prairies. Western Canada has experienced a widespread change in precipitation, and the Muriel Lake area is no exception. Precipitation data for Muriel Lake is shown below:

Data from Pengrowth report:

| Period | Average Annual Precipitation, mm |
|---|---|
| 1940 to 1949 | 378 |
| Before 1950 | 362 |
| 1970-1979 | 490 |
| 1951 to 1980 | 459 |
| 1981 to 2010 | 422 |

Muriel Lake has seen level changes before. Anecdotally, the lake level was said to be very low in the 1930's and early 1940's. The 1970's saw high levels of precipitation, and high water levels. The lake level started dropping in the late 1970's and did not rise (year over year) until 2016.

| Period | Average Annual Precipitation, mm |
|---|---|
| 1961-1970 | 427 |
| 1971-1980 | 459 |
| 1981-1990 | 416 |
| 1991-2000 | 417 |
| 2001-2010 | 380 |
| 2010-2017 | 428 |

This data is from http://agriculture.alberta.ca/acis/township-data-viewer.jsp

Precipitation is not the whole story. While Muriel Lake experienced year over year decline, other lakes went up and down. Other factors are at play, including evaporation from the lake and the amount of surface runoff from precipitation falling onto land around the lake.

When we began asking why Muriel Lake was losing water level, Alberta Environment was quick to point out that Muriel Lake has a relatively small drainage basin, that is, the area from which precipitation drains to the lake is relatively small. Other lakes have a much larger ratio of drainage basin area to lake surface area. We were told this makes Muriel Lake more vulnerable to loss of level in dry periods. A table showing the relative drainage basin areas is shown below.

| Lake | Drainage Area ($km^2$) | Lake Surface Area ($km^2$) | Ratio |
|---|---|---|---|
| Muriel | 456 | 69 | 6.6 |
| Muriel (adjusted) | 344 | 68.2 | 5.0 |
| Garnier | 26 | 2 | 13:1 |
| Bluet | 11 | 1 | 11:1 |
| Kehewin Lake | 160 | 6.6 | 24.2 |
| Moose Lake | 796 | 40.4 | 19.7 |
| Chickenhill Lake | 23.2 | 3.67 | 6.3 |
| Cold Lake | 6450 | 351 | 18.4 |

In the table above, Alberta Environment presented an "adjusted" drainage basin area for Muriel Lake to reflect the nature of runoff from the "Sinking Lake" area to the west of the lake. This is a low-lying area and AEP believe there would not be any runoff from the area.

Water Balance

One of the best tools for examining changes in a lake's water level is the water balance. A water balance is a series of calculations which estimate the magnitude of all the factors affecting the amount of water in a lake. The difference in all the inputs and outputs to/from the lake should equal the change in water level in the lake (Inflow – Outflow = Change in Volume). Inputs would include precipitation falling directly onto the lake, surface water flow into the lake via creeks and streams, while outputs would include surface water flow out of the lake evaporation from the lake. Groundwater flow can be either an input or output, depending on the individual lake. While some of these variables are well measured and documented (precipitation, lake level) others are not directly measured and must be estimated.

Alberta Environment has published water balance studies of Muriel Lake at least twice. In 2006 a report titled “Cold Lake – Beaver River Basin Surface Water Quantity and Aquatic Resources” (http://www.assembly.ab.ca/lao/library/egovdocs/2006/alen/161293.pdf ) presented results for a water balance covering the period from October 1981 to December 2000, during which time the level in Muriel Lake dropped from about 559.65 masl to 557.0 masl. Alberta Environment believe the spill level for Muriel Lake is about 559.7 masl, so there was no surface water out of the lake for this period. The study adjusted the estimated water content of Muriel Lake with lake level using lake bottom contours based on a hydrographic survey of the lake done in 1962. Precipitation and evaporation data from Cold Lake were used, Cold Lake being the closest station for which this data was available. While precipitation is measured, evaporation is estimated using complex calculations involving many parameters. Alberta Environment publish the estimated annual evaporation from a number of lakes located throughout the province. Surface water flow into the lake was estimated using the flow measured at Atimoswe Creek climate station. Atimoswe Creek is located just outside the Muriel Lake basin, near Elk Creek. Based on this measured stream flow, the study used 10.4 mm of runoff times the drainage basin area of 384 $km^2$ to calculate an annual inflow of 3.9936 million $m^3$. The resulting calculations generated predicted declining water levels in the lake which matched the actual measured levels, so Alberta Environment concluded the model. One flaw in this study is that while Alberta Environment acknowledged that there is a net flow of groundwater into the lake, the study assumed it to be zero, or very small. Recognizing groundwater flow into the lake would have resulted in predicted water levels to be higher than actually measured, or meant that other assumed values (such as the 10.4 mm runoff) were inaccurate.

In the period 2008 to 2010 Alberta Environment conducted additional research which attempted to quantify the magnitude of groundwater flow into or out of a number of lakes in the Cold Lake – Beaver river basin. This study took place in winter, when the lake is covered with ice and so surface water flows, outflows and evaporation are negligible. The study methodology was experimental and was altered a couple of times. Results for the first 3 years, based on sampling a single point on the lake, showed high levels of groundwater flow into the lake. In the 4$^{th}$ year measurements were taken at 20 points across the lake, but snow drifting effects were observed and the result was a measured loss. The most reliable result seems to be the last study year, when groundwater was observed to add 0.14 mm/d to lake level. The average of the 5 years results is a gain of 0.136 mm/d. This means groundwater flow is into the lake – groundwater is contributing water to the lake and is offsetting any loss of level.

In February 2015 Alberta Environment presented MLBMS with a second, updated water balance analysis of Muriel Lake covering the period 1972 to 2013. This study used the Muriel Lake water levels reported by the government monitoring station at Gurneyville. The data for Cold Lake was again used for precipitation (measured) and evaporation (calculated). This study also used “streamflow from a nearby WSC station” but did not specify which station (probably the Atimoswe Creek station again). Again, groundwater was assumed to be insignificant and not accounted for. One change was made in that the Sinking Lake portion of the drainage basin was excluded as it is believed that there would not be any runoff from this area (104 $km^2$) except in extremely wet years. Alberta Environment again found that their calculated results closely match the actual observed lake level. Their report is shown in this website under STUDIES AND REPORTS.

AEP provided some additional analysis to accompany the results of their study. Using recent data, AEP calculated the “Mean Annual Net Evaporation Deficit” – which is the difference between the amount of water which falls directly into the lake as precipitation and the amount which evaporates from the lake each year. In order to have a constant level, this is the amount of water that needs to flow into the lake as runoff or from groundwater. AEP used 421 mm annual precipitation, 22 mm runoff per $m^2$ drainage area, and a lake size of 68 $km^2$ to quantify the annual deficit at 15,400,000 $m^3$: (conversion factors not shown, 1 $dam^3$ = 1000 cubic meters per year). Some minor presentation errors and terminology is changed AEP (since AEP assumed groundwater flow was zero they referred to Water Inflow as Surface Runoff only, we have used the term Water Flow).

| | | |
|---|---|---|
| Mean Annual precipitation on the lake: | 421 $mm/m^2/y$ x 68 $km^2$ | = 28,600 $dam^3$ |
| Less Mean Annual Evaporation from the lake: | 647 $mm/m^2/y$ x 68 $km^2$ | = 44,000 $dam^3$ |
| Mean Annual Net Evaporation Deficit: | | = 15,400 $dam^3$ |

This shows that 15,400 dam3 of surface water runoff or groundwater flow is required per year to maintain the lake at constant water level.

AEP estimated the additional water flow into the lake as shown below:

| | | |
|---|---|---|
| Effective drainage basin area (excludes lake): | 344 $km^2$ – 68 $km^2$ | = 276 $km^2$ |
| Water Flow into the lake: | 276 $km^2$ x 22 mm/m/y | = 6,100 $dam^3$ |

The amount of water the lake is in deficit for this year/set of data is:

| | | |
|---|---|---|
| Mean Annual Net Deficit: | 15,400 $dam^3$ – 6,100 dam3 | = 9,300 $dam^3$ |

This corresponds to a drop in level of 9,300,000 $m^3$ / 68 $km^2$ = 0.14 m, or just over 5 $^h$ inches.

The water balance models constructed with the above calculations closely matched the year to year fluctuations in water level. This lead Alberta Environment to conclude that the lakes decline is a purely natural phenomenon. MLBMS accepts the calculations presented are valid, but a closer look shows that Alberta Environments conclusion is hasty and unjustified.

One questionable assumption made in AEP’s model is their assumption for surface water flow. While there is no better data available, the assumption that surface water flow is proportional to the flow in a creek that is not located in the Muriel Lake basin deserves further investigation.

Another flaw or oversimplification in Alberta Environment’s work is that they intentionally excluded the impact of groundwater flow into or out of the lake, on the grounds that it is felt to be relatively small. They did not use the new information provided by the Walsh – Kerkhoven study, even though that study recommended its use to improve water balance calculations. Let’s look at what happens when an inflow of groundwater is acknowledged and used in the water balance calculations. The volume of groundwater flowing into the lake can be estimated as:

Groundwater flow into the lake: 0.14 mm/d x 365 d/y x 68 km2 = 3,475 $dam^3$

Adding groundwater water flow into the lake model without adjusting any other parameter would mean that the model would predict higher water levels than actually observed. Over the 14 year study period, adding 0.14 mm/d of groundwater flow into the lake without any other change would predict a lake level 0.715 m (2.34 feet) higher. Alternatively, the estimated surface water flow number would have to be reduced if the calculated lake level is to match the actual.

If one accepts the data proposed for precipitation, evaporation, land areas etc., that the calculated lake levels are close to actual, and the calculated overall water input into the lake is correct, the assumed flow of surface water into the lake must be reduced to keep the water balance.

Water flow into the lake: 6,100 $dam^3$

Minus groundwater flow into the lake: -3,475 $dam^3$

Surface water flow into the lake: 2,625 $dam^3$

This is a much lower value! Is it reasonable? From a drainage area of 276 $km^2$, this is equivalent to 9.69 mm of runoff, pretty close to the 10 mm value AEP used in their first version of the water balance. The Alberta WaterPortal Society (https://albertawater.com/water-yield-streamflow-analysis/alberta-s-water-yield) publish a map of Alberta showing expected surface water yield. Muriel Lake appears to be in an area with an expected yield of 10 to 25 $mm/m^2/y$. So yes, accounting for groundwater input still yields a reasonable value for surface water flow – but at the low end of what would be expected.

Another way to look at the potential contribution of surface water is to look at the difference between precipitation and evapotranspiration. Evapotranspiration is defined as the sum of evaporation and transpiration, i.e. the sum of water lost from the land's surface by evaporation and the use of water by plants. A healthy difference between precipitation levels and the evapotranspiration would support higher levels of surface water runoff. Alberta Environment publish calculated evapotranspiration data for locations around the province, the closest to Muriel Lake being Cold Lake. Evapotranspiration and precipitation data is shown below. Evapotranspiration data was not published for Cold Lake in all years.

| Period | Average Annual Precipitation, mm | Evapotranspiration, mm | Difference, mm | Years of Evap. data |
|---|---|---|---|---|
| 1971-1980 | 459 | 384 | 75 | 6 |
| 1981-1990 | 416 | 357 | 59 | 5 |
| 1991-2000 | 417 | 348 | 69 | 10 |
| 2001-2010 | 380 | 343 | 37 | 9 |
| Average | 418 | 358 | 60 | |

So on average precipitation is exceeding transpiration by 60mm per year but less than 10 mm per year is reaching the lake. This seems low. It seems logical that we should look to see if anything is interfering with surface runoff and if the net runoff can be increased.

Going back to the water balance calculations, which showed an additional input of 9,300 $dam^3$/per year of water would have been required to prevent the lake level from dropping. From a drainage basin area of 276 $km^2$, this is equivalent to an additional 33.7mm of runoff. Given the many hills and bogs in the drainage basin, it is perhaps unreasonable to expect to recover such a high level of runoff. Given the many year period of reduced precipitation, one would expect lake level to drop .

However, the effect of a small increase or decrease in surface runoff is significant. A 1 mm increase in runoff would add 276 $dam^3$ per year, or about 3% of the annual deficit. Over 40 years, this would amount to a change in lake level of 0.16m (0.53 feet).

As the lake level has been declining Muriel Lake has been receiving very little surface runoff – we believe less than 10 mm per $m^2$ per year. This is less than is normal for watersheds in this area of Alberta. This presents both an explanation for why the decline in Muriel Lake's water level has been so extreme, and an opportunity to restore the lake. Water that could have flowed to the lake was held back and evaporated before it could reach the lake. Increasing drainage effectiveness could reverse this and offset the evaporation deficit.

Surface water flow can be impacted by both natural (eg. beaver activity) and anthropogenic activity (man-made activity like roads, culverts, agricultural drainage and irrigation, industrial berms and containment, land-use changes). By examining the drainage basin closely we can find locations where the above may have reduced or impeded surface water flow – and by correcting them, we can increase the flow of water to the lake. In other posts (future) on this website we will show locations where we have found impeded surface water flow, and our efforts to correct this. Also, read about our beaver deceiver project, where we have installed devices so that we can keep creeks flowing through beaver dams, while keeping the beaver dams intact and the beavers happy and healthy.

To fully investigate the effect of surface water disruptions to the lake level and identify where best we could improve drainage we are planning to develop a computer drainage model of the entire Muriel Lake basin, based on Lidar data. This model will identify locations where flow is impeded, and quantify the volumes of water affected. Corrective actions might include installing new culverts, clearing blocked culverts, or re-contouring ditches. Anywhere you see standing water is a potential location to improve drainage! We are currently seeking funding for this project. To help, use the DONATE button on the home page!

TECHNICAL EXPERTISE DISCLAIMER:

This write-up was prepared by members of MLBMS. While some of our members have technical backgrounds, and we believe we have a better than layman's understanding of the science involved, we are **not** professional hydrologists. We have attempted to provide references for all data used. The data and previous studies were made by professionally regulated scientists. We would welcome any constructive comments or identification of any errors we may have made in this analysis.