October 23, 2016

Discussion Paper on Water Importation to Pigeon Lake

Introduction

There has been much discussion over the past years about the need to import water to stabilize water levels and to "flush" nutrients from the lake. This discussion paper provides some analyses and observations to help shed light on this issue. Calculations are made concerning the amount of nutrients actually leaving the lake at Pigeon Creek in 2013 using the data collected by Alberta Environment (AEP) and ALMS as part of the extensive data collection program that year. In addition, calculations are made of a hypothetical case where 20 cm of water flows over the weir for the entire open-water season. These calculations show that nutrient removal is not significantly impacted by increasing the amount of water flowing out of the lake. This is because the phosphorous cycle in Pigeon Lake is such that only for short periods is the phosphorous concentration at a high level.

An explanation is also provided as to why the lake level varies and does not seem to correlate with the amount of precipitation received in the watershed.

Summary of Data

During the open-water season of 2013, an extensive data collection program was conducted, and the results were presented in an AEP report (Chris Teichreb, *2013 Overview of Pigeon Lake Water Quality, Sediment Quality, and Non-fish Biota*. This report is available on line on the AEP website). The data set included the phosphorous concentration (shown in Figure 1) and the outflow stream flow rate (shown in Figure 2) for Pigeon Creek. With these data, the total amount of phosphorous that was discharged from the lake can be calculated.

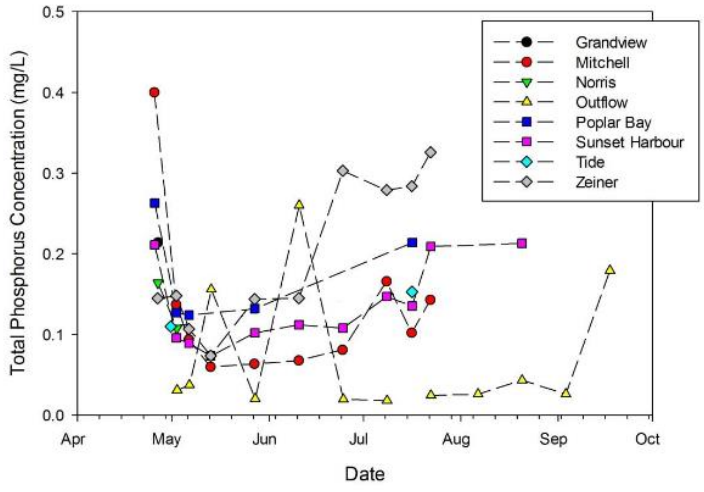

Figure 1: Total phosphorous concentration in inlet and outlet streams (ref. Teichreb 2013 p.30)

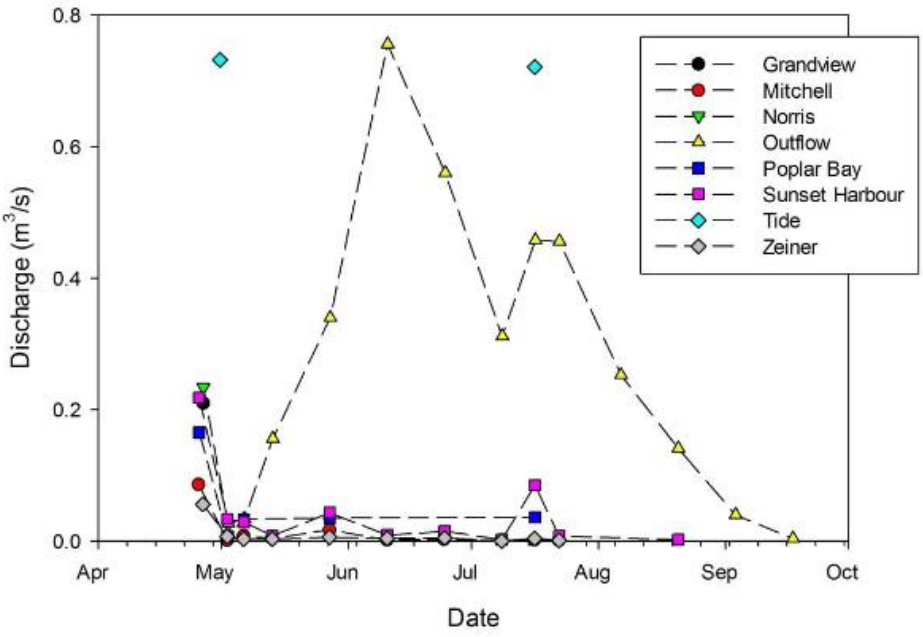

Figure 2: Stream flows (ref. Teichreb 2013 p. 40)

The AEP report on the phosphorous budget (Chris Teichreb, *Pigeon Lake Phosphorous Budget,* 2013) calculated the total amount of phosphorous leaving the lake over the study period through Pigeon Creek as 331 kg (ref. Teichreb, ibid, p.18). The cumulative discharge through Pigeon Creek was approximately 38 million m3 (ibid, p 11) during this period. For reference purposes, the total amount of phosphorous in Pigeon Lake during late summer when the phosphorous concentration peaked is calculated to be 34,303 kg (ibid, p 21). Thus, the fraction that was discharged through Pigeon Creek was 331/34,303 or 0.0096, clearly not a significant amount of phosphorous removed. (Note: If the calculation used the phosphorous concentration in the outlet stream rather than that of Pigeon Lake, the amount discharged would be in the order of 100 kg.)

Hypothetical Calculation of Phosphorous "Flushing" with Water Importation

A calculation of the amount of phosphorous removed from the lake through discharge was calculated assuming 20 cm of water was flowing over the weir during the complete open-water season and the discharge water had a phosphorous concentration equal to that present in the lake. To appreciate the significance of this calculation, one must understand that the total phosphorous (TP) in Pigeon Lake has a very low concentration during the winter and at the start of the open-water season. This concentration is approximately 10 mg/m3. For a variety of reasons, this concentration slowly increases to about 40 mg/m3 around the beginning of August and then spikes for the month of August and thereafter starts to decrease. This is fluctuation is shown in Figure 3. Calculated from the weir discharge curves from AEP (shown in Figure 4), with the water level 20 cm above the top of the weir, the flow rate is approximately 0 .7 m3/sec. From these values, the total phosphorous discharged from the lake can be calculated.

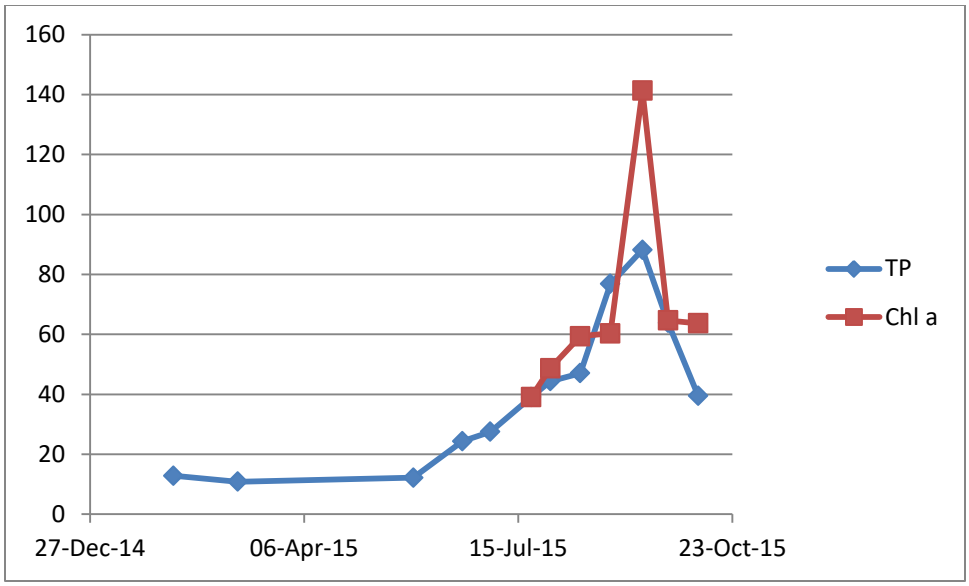

Figure 3. TP variation at Pigeon Lake (recombined sample) (ref. Hutchinson Report on Sediment Analysis)

Month	Flow rate (m3/sec)	Volume (m3)	TP (mg/m3)	Monthly Flux (kg)
April	0.7	1960200	10	20
May	0.7	1960200	10	20
June	0.7	1960200	20	39
July	0.7	1960200	35	69
August	0.7	1960200	80	157
September	0.7	1960200	70	137
October	0.7	1960200	40	78
November	0.7	1960200	30	59
			total mass	**579**

Table 1. Calculation of amount of phosphorous discharged at Pigeon Creek if 20 cm of water flowed over the weir during the complete open water season.

To maintain a steady flowrate over the weir would be a very costly exercise. This calculation shows the fraction of phosphorous removed from the lake's water is 579/34,303 or 0.017. (Compare to the fraction removed from natural flow of 0.0096.)When considering the amount of phosphorous stored in the sediments, the amount removed is negligible.

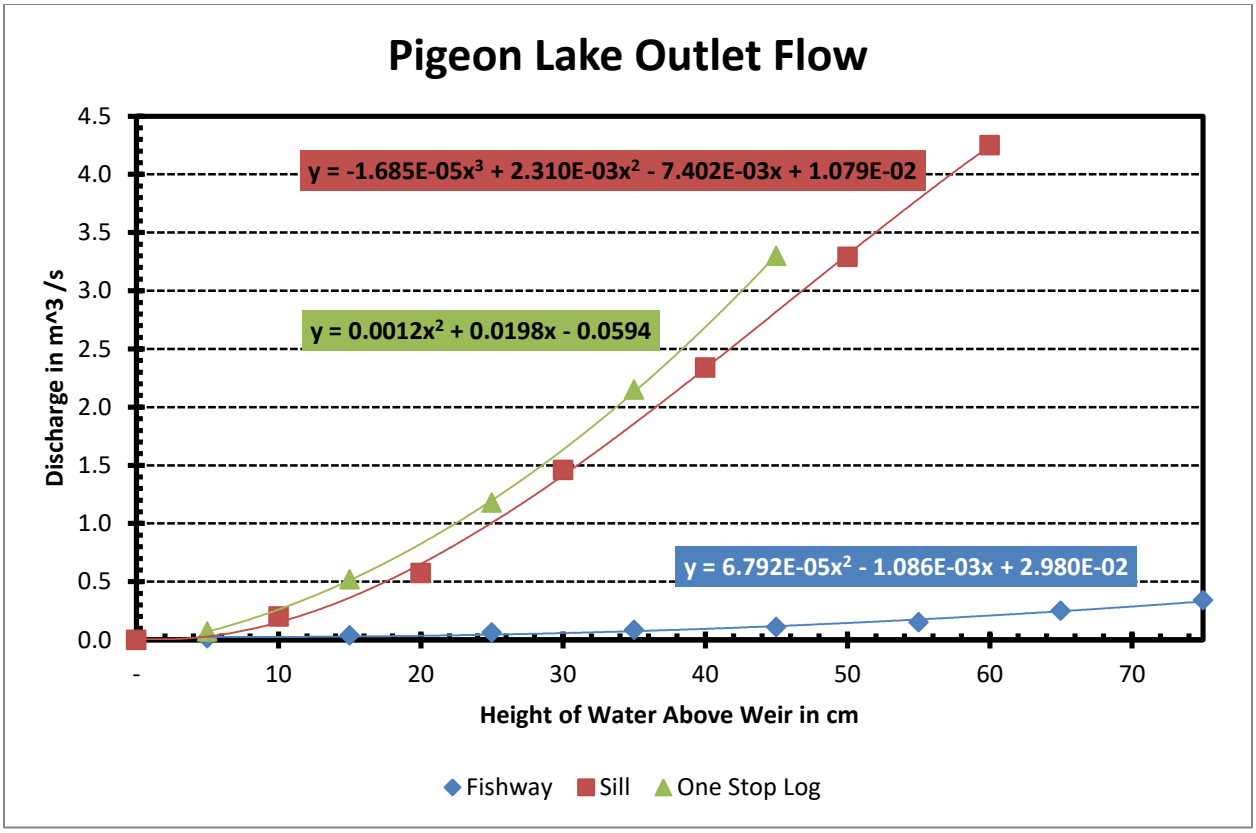

Figure 4. Pigeon Lake Weir discharge curve

Sourcing Water at the Brazeau Dam

Since it is a requirement of AEP that any water imported into Pigeon Lake would have to be fully treated, it has been suggested that using the Brazeau Dam as a source would be more economical as the water would not be polluted and would not require treating. Further, since the Brazeau Dam is at a higher elevation than Pigeon Lake, the assumption is that water could simply flow down a pipeline between the two locations without the need for pumping. The requirement from AEP for full treatment of water stems from two factors: differing water characteristics (elevated suspended solids, metals, etc.) and non-native species (biota not present in Pigeon Lake). While it may be true that the water in the Brazeau Dam has not been impacted by similar contaminants as in the North Saskatchewan River, the Brazeau Dam is part of a completely different ecosystem from that of Pigeon Lake. Introducing elements from a different ecosystem has always caused unforeseen problems and would no doubt be troublesome for Pigeon Lake. Examining the proposal to have water flow freely from the Brazeau Dam to Pigeon Lake without pumping reveals serious problems. The elevation of the Brazeau Dam when at maximum water level is 965 m above sea level (ASL) whereas Pigeon Lake is at 850 m ASL. The seasonal variation in lake level is about 15 m with the typical low water level being 950 m ASL. This 100 m difference would seem to indicate that water could flow along a pipeline without mechanical assistance. But besides the pressure drop associated with the flow of water in a pipe, which would seriously impact the natural flow rate through that pipe, the simple fact is that water cannot flow uphill. A pipeline can “siphon” water over a small hill; approximately 25 feet (> 8 m) higher than the inlet of the pipeline, if the pipe is

completely free of air. Attempting to induce unaided flow in a pipeline over an elevation difference greater than this amount will only draw a vacuum and flow will not occur. The topography between the two locations is such that there are many hills are present in the 100 km distance between the two locations with elevations gains greater than 958 m ASL, which would prevent any flow from occurring (Figure 5). Hence, without pumping, a pipeline from the Brazeau Dam is not a workable idea.

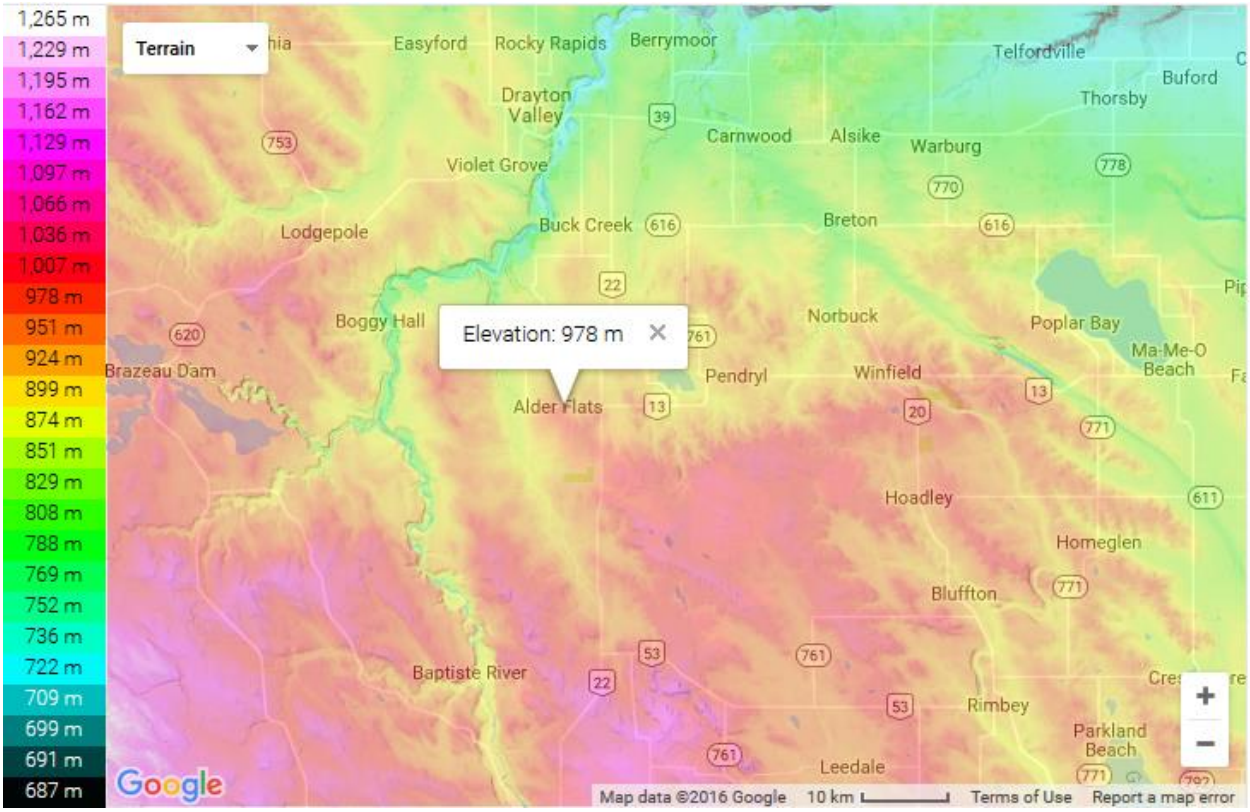

Figure 5. Topographic map showing elevations between the Brazeau Dam and Pigeon Lake

Conclusion

The calculations presented show that the amount of phosphorous that will be discharged (or flushed) from Pigeon Lake, even with a sustained flow of water over the weir, is relatively very small, especially when the vast store of nutrients in the sediments is considered. This is primarily because of the fact that Pigeon Lake's water has a very low phosphorous concentration during most of the year with that concentration rising for the period when significant algae blooms occur. Therefore, it can be concluded that importing water to Pigeon Lake would not be a feasible method of improving the water quality of the lake.

Lake Level Variations Explained

Pigeon Lake, as is the case with most other prairie lakes in Alberta, has a normal fluctuation in elevation of about 1.3 m. Since there is no significant amount of extraction of water from this lake, the variation is

entirely associated with variations in the weather, mainly precipitation. Strange as it may seem, there is no strong correlation between lake level and amount of rainfall in any year. There is, however, a strong correlation between the fluctuations in lake level and the five-year rolling-average precipitation. This can be understood by considering the discharge and recharge of the groundwater system. In the first year of a drought, with low precipitation, the lake level is maintained somewhat by the flux of groundwater to the lake. The lake is really the surface expression of the groundwater system, and it receives a constant flow of water from the groundwater system. As the drought continues, the level of the groundwater drops and the support it gives the lake diminishes. As a consequence, the rate of decline in level of the lake increases. The opposite effect occurs when the drought ends. During the first year of heavy rains, most of the water recharges the groundwater rather than flowing into the lake. As a result, the lake level does not increase as might be expected. Only after a few years of high precipitation does the lake level start to increase.

A comparison of the rolling-average five-year precipitation to the lake level is shown in Figure 6.This five-year rolling-average precipitation correlation to lake level fluctuations has also been seen on other Alberta lakes.

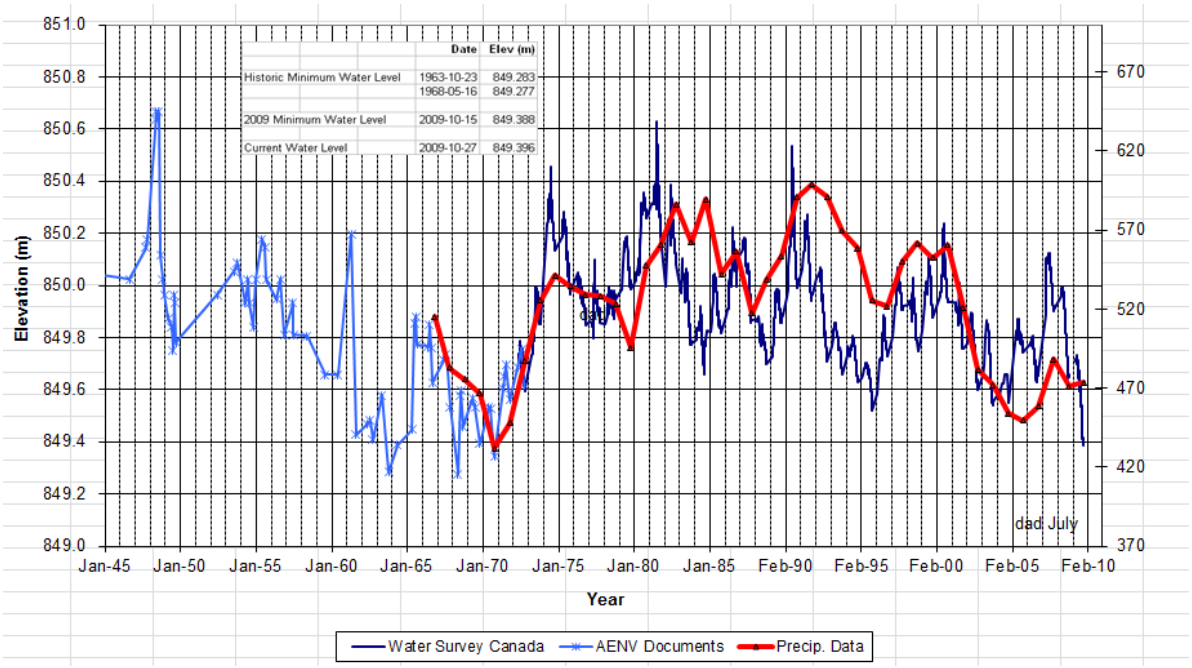

Figure 6. Comparison of variation in Pigeon Lake elevation to rolling average 5-year precipitation

This discussion paper is intended to provide answers to the many questions received on possible improvements to the water quality in Pigeon Lake. Please provide any comments or suggestion to the author.

Don Davidson

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