



MEMORANDUM

Date: December 08, 2016

File:

**To: Mark Zacharias,
Assistant Deputy Minister
Environmental Protection Division**

Quesnel Lake Water Quality for samples collected August 4, 2014 to August 30, 2016 compared to Drinking Water and Aquatic Life Guidelines

Water samples from Quesnel Lake have been collected by Ministry of Environment (MoE) staff as part of the Ministry's monitoring program with respect to compliance/audit and quality assurance/quality control purposes. This will allow the Ministry to re-affirm Mount Polley Mining Corporation (MPMC) sampling results and determine the state of the water quality in Quesnel Lake. MoE has reported out on these results since the Mount Polley Mine Breach on August 4, 2014. All data and associated maps have been made publically available on the MoE Mount Polley Breach website (<http://www2.gov.bc.ca/gov/content/environment/air-land-water/spills-environmental-emergencies/spill-incidents/past-spill-incidents/mt-polley>).

This memo is to summarize and provide any conclusions in the data from the past two years of sampling data collected. For this memo, water samples collected between August 4, 2014 and August 30, 2016 are reviewed to determine potential impacts to drinking water and to aquatic life. Quesnel Lake sites sampled by MoE include deep lake sites between Cariboo Island and Cedar Point as well as shallow sites around the Hazeltine Creek delta. In addition, summary tables have been included which illustrate data results and exceedances for Quesnel Lake. Please note that this is the final Quesnel Lake memo MoE will be publishing so that more resources can be put towards other areas of the Mount Polley monitoring project (including further monitoring).

The parameters analysed include pH, conductivity, turbidity, total suspended solids, total dissolved solids, total organic carbon, hardness, alkalinity, nutrients, general ions, total and dissolved metals. Samples collected are analyzed by ALS Environmental (previously by Maxxam Analytical) including MPMC samples.

As part of the QA/QC measures taken by MOE, replicate (REP) samples were collected at several sites on Quesnel Lake as well as an equipment blank (BLE), field blank (BLF) and lab blank (BLL) to ensure 10% of the sampling program was quality control. The replicate and lab blank results were within the acceptable percent difference allowed for QA/QC purposes; however in the BLE and BLF, trace readings of some metals were noted (lead, zinc). MOE staff ordered new sampling equipment to rule out the potential for equipment contamination. Minor zinc contamination is still occurring with new equipment, so MoE is continuing to investigate all other sources of zinc introduction (i.e. filtering supplies, DI water, etc.).

An overall assessment of the data from Quesnel Lake from August 2014 up to and including August 2016 results was conducted. Turbidity and copper levels have been the main parameters of concern at these sites with respect to drinking water and aquatic life. Table 1 (below) represents the number of exceedances that have occurred from all MoE sample dates on Quesnel Lake. Table 2 is a summary of exceedances during each sampling season and area (Shallow sites around the Hazeltine Creek delta, and Deep sites) on Quesnel Lake.

Table 1. Number of exceedances for both drinking water and aquatic life guidelines from all MoE sample events from August 4, 2014 to August 30, 2016.

Parameter	Total Sample Events in 2014	Number of DW Exceedances in 2014	Number of AL Exceedances in 2014	Total Sample Events in 2015	Number of DW Exceedances in 2015	Number of AL Exceedances in 2015	Total Sample Events in 2016	Number of DW Exceedances in 2016	Number of AL Exceedances in 2016	
Turbidity	80	28	20	41	1	0	41	0	0	
TSS		n/a	20		n/a	1		n/a	0	0
Total Aluminum		35	n/a		1	n/a		0	0	0
Total Chromium		0	14		0	0		0	0	0
Total Cobalt		n/a	3		n/a	0		0	n/a	0
Total Copper		0	46		0	2		0	0	0
Total Iron		18	14		0	0		0	0	0
Total Lead		0	2		0	0		0	0	0
Total Manganese		12	0		0	0		0	0	0
Total Phosphorus		20	13		1	0		0	0	0
Total Silver		n/a	4		n/a	0		0	n/a	0
Total Zinc		0	11		0	0		0	0	0
Dissolved Aluminum		2	7		0	0		0	0	0

*n/a: no guideline for that parameter

Table 2. Summary of exceedances over time for drinking water and aquatic life guidelines from all MoE sample events from August 4, 2014 to August 30, 2016.

	2014				2015				2016			
	Late summer		Fall		Spring		Late summer		Spring		Late Summer	
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Turbidity	D, A	D, A	D, A				D					
TSS	C, A	C, A	A									
Total Aluminum	H	H	H				H					
Total Chromium	A	A	A									
Total Cobalt		C	C									
Total Copper	C, A	C, A	A		C	A						
Total Iron	H, A	H, A	H, A									
Total Lead	C	C										
Total Manganese	H	H	H									
Total Phosphorus	D, A	D, A	D, A				D					
Total Silver		C	C									
Total Zinc	C	C	C									
Dissolved Aluminum	D, A	D, C, A										

Shallow: 0.5-15m, Deep: >15m

*D: BC Drinking Water Quality Guideline Exceedance

*H: Health Canada Drinking Water Quality Guideline Exceedance

*C: Chronic Aquatic Life Guideline Exceedance

*A: Acute Aquatic Life Guideline Exceedance

A summary of all drinking water and aquatic life exceedances up to August 2016 can be seen in Table 4 and 5 (below), respectively. Many of the exceedances were in the first few weeks prior to the breach during the August 4 – late August period in 2014.

The following parameters have exceeded drinking water guidelines in Quesnel Lake: turbidity, total phosphorus, total aluminum, total iron, total manganese and dissolved aluminum. The exceedances in total metals were typically found at lower depths, where they bind to particles. However since October 2014 there have been no drinking water exceedances (except for turbidity, total aluminum and total phosphorus on Sept 1/15 at Quesnel Lake near Hazeltine Creek New Path). The manganese drinking water guideline is based on aesthetic effects relating to staining and taste, not direct health effects. Elevated nutrients can affect the drinking water treatment process or lead to algal blooms, which also can affect water quality.

There have been several aquatic life guideline exceedances in Quesnel Lake including turbidity, total suspended solids, total chromium, total cobalt, total copper, total iron, total lead, total phosphorus, total silver, total zinc and dissolved aluminum. While total metals concentrations may exceed aquatic life guidelines, the much lower concentrations of the dissolved form of these metals indicates that the high levels are associated with particulates and may not be as bioavailable as dissolved metals, thus decreasing the risk to aquatic life in Quesnel Lake. By the spring of 2015, total copper levels declined and remained below the chronic aquatic life guideline (except for two exceedances in April and September 2015). More importantly the dissolved form of copper, or the portion that is more bioavailable, was lower and staying relatively constant. Table 3 compares the total copper levels in Quesnel Lake from 2014 to 2016. This table shows that total copper levels in 2015 were a little higher throughout the entire water column around spring overturn when the lake had mixed, but have been consistently lower in the surface waters since the spring of 2015. It is natural for bottom waters to contain slightly higher levels due to settling of particles over time.

Table 3. Total copper values at surface and bottom at Quesnel Lake at Hazeltine Creek Deep Station from August 12, 2014 to August 30, 2016.

Date	Total copper surface (0.5m)	Total Copper Bottom (99m)
August 12, 2014	0.54 µg/L	217 µg/L (at 60m)
September 4, 2014	1.56 µg/L	121 µg/L (at 65m)
April 23, 2015 (Spring Overturn)	1.99 µg/L	2.01 µg/L
September 1, 2015 (Late summer)	0.5 µg/L	1.22 µg/L
April 25, 2016 (Spring Overturn)	0.58 µg/L	1.56 µg/L
August 30, 2016 (Late Summer)	0.5 µg/L	1.18 µg/L

Depth profiles were also conducted during the sampling events and data was collected for dissolved oxygen, temperature, pH and conductivity at every meter from surface to bottom for all sample dates. Dissolved oxygen levels at depth in the summer months remained the same throughout the water column. No hypoxia has been observed in Quesnel Lake at any of the MoE sampling sites. Total phosphorus, which can increase lake productivity, was elevated between August and October 2014 and then returned below water quality guidelines except for one spike in Sept 2015 (note that this was near shore at Quesnel Lake at Hazeltine Creek, New Path). This settling process explains why results of many parameters are slightly higher at depth in the lake during the summer. During fall overturn, the lake mixes and the parameters become more uniform throughout the water column.

On December 1, 2015, MPMC began discharging into the Hazeltine Creek channel which enters Quesnel Lake at depth. The Ministry of Environment has collected field profile information over the diffusers as well as field profiles and water quality sampling at the edge of the 100m initial dilution zone (IDZ). This data can be seen in the respective data tables that go with this memo under site QUL-58. No measurements taken at the edge of the IDZ since the discharge was initiated have exceeded the Aquatic Life or Drinking Water Quality Guidelines.

MoE will continue to investigate and monitor the water quality of Quesnel Lake; it will be sampled bi-annually going forward. MoE will continue to determine and address any potential impacts to drinking water and aquatic life. As noted above, MPMC will also be monitoring Quesnel Lake and their data can be found at this website: <https://www.imperialmetals.com/our-operations-and-projects/operations/mount-polley-mine/overview>.

Sincerely,

Deborah Epps, MSc., R.P.Bio.
Section Head, Provincial Water Quality
Ministry of Environment

Table 4. Drinking Water Exceedances from August 4, 2014 to August 30, 2016 for Quesnel Lake.

Location	Parameter	Date	Depth (s)
Quesnel Lake at Hazeltine Creek Delta	Turbidity, Total Phosphorus, Total Aluminum	August 4, 2014	0.5m
Quesnel Lake at Hazeltine Creek Confluence	Turbidity	August 4, 2014	8 and 15m
	Total Aluminum	August 4, 2014	0.5, 8 and 15m
	Total Iron	August 4, 2014	15m
Quesnel Lake at Mouth of Hazeltine Creek	Total Aluminum	August 5, 2014	0.5m
	Total Aluminum	August 6, 2014	0.5m
Quesnel Lake between Raft Creek and Hazeltine Creek	Turbidity, Total Phosphorus, Total Aluminum	August 7, 2014	0.5m
Quesnel Lake at Cariboo Island Shelf	Turbidity, Total Aluminum	August 12, 2014	30m
Quesnel Lake at Hazeltine Creek Deep Station	Turbidity, Total Phosphorus	August 12, 2014	36, 45 and 60m
	Total Aluminum, Total Manganese	August 12, 2014	45 and 60m
	Total Iron	August 12, 2014	45 and 60m
	Turbidity, Total Aluminum, Total Phosphorus, Total Iron, Total Manganese	August 22, 2014	36, 60 and 80m
	Turbidity	September 4, 2014	25, 30 and 65m
	Total Aluminum	September 4, 2014	9, 30 and 65m
	Total Phosphorus	September 4, 2014	9, 25, 30 and 65m
	Total Iron, Total Manganese	September 4, 2014	30 and 65m
Quesnel Lake West Arm Green Buoy Deep Station	Turbidity, Total Aluminum, Total Phosphorus, Total Iron, Total Manganese	August 13, 2014	40, 60 and 90m
	Dissolved Aluminum	August 13, 2014	90m
Quesnel Lake East of Cedar Creek	Total Aluminum	August 13, 2014	8m
Quesnel Lake at Hazeltine Creek New Path	Turbidity, Total Aluminum, Total Phosphorus, Dissolved Aluminum	August 16, 2014	7.5m
Quesnel Lake at Hazeltine Creek Site A	Turbidity, Total Phosphorus	August 20, 2014	0.5, 9, 20 and 27m
	Total Aluminum, Total Iron	August 20, 2014	9 and 27m
Quesnel Lake at Hazeltine Creek Site B	Total Phosphorus	August 20, 2014	0.5m
Quesnel Lake at Hazeltine Creek Site C	Turbidity, Total Aluminum, Total Phosphorus, Total Iron	August 20, 2014	8 and 24m
	Total Manganese	August 20, 2014	8m
Quesnel Lake at Southeast Corner of Mitchell Bay	Total Phosphorus	August 22, 2014	25m
Quesnel Lake at Hazeltine Creek New Path	Turbidity, Total Phosphorus	September 1, 2014	0.5m
	Turbidity, Total Aluminum, Total Phosphorus, Total Iron	September 4, 2014	9m
	Turbidity, Total Phosphorus	September 11, 2014	12m
Quesnel Lake at Hazeltine Creek between sites A and B	Turbidity, Total Aluminum, Total Phosphorus, Total Iron, Total Manganese	October 2, 2014	10 and 15m

Table 5. Aquatic Life exceedances from August 4, 2014 to August 30, 2016 for Quesnel Lake.

Location	Parameter	Date	Depth (s)
Quesnel Lake at Hazeltine Creek Delta	Total Copper	August 4, 2014	0.5m
Quesnel Lake at Hazeltine Creek Confluence	Turbidity, Total Suspended Solids	August 4, 2014	15m
	Total Copper	August 4, 2014	0.5, 8 and 15m
	Total Lead	August 4, 2014	8m
	Total Copper	August 16, 2014	17.5m
Quesnel Lake at Mouth of Hazeltine Creek	Total Copper	August 5, 2014	0.5m
	Total Chromium, Total Copper	August 6, 2014	0.5m
Quesnel Lake between Raft Creek and Hazeltine Creek	Total Copper, Total Phosphorus	August 7, 2014	0.5m
Quesnel Lake at Hazeltine Creek New Path	Total Copper	August 12, 2014	10m
	Turbidity, Total Suspended Solids, Total Copper, Dissolved Aluminum	August 16, 2014	7.5m
	Turbidity, Total Suspended Solids, Total Copper, Total Iron, Total Phosphorus	September 4, 2014	9m
	Total Copper	September 11, 2014	0.5 and 12m
	Total Suspended Solids, Total Copper	September 1, 2015	0.5m
Quesnel Lake at Southeast Corner of Mitchell Bay	Total Suspended Solids	August 12, 2014	25m
	Total Copper	August 22, 2014	25m
	Total Copper	August 26, 2014	11 and 25m
Quesnel Lake at Cariboo Island Shelf	Total Copper	August 12 2014	30m
Quesnel Lake at Hazeltine Creek Deep Station	Turbidity, Total Suspended Solids, Total Copper	August 12, 2014	36, 45 and 60m
	Total Cobalt, Total Phosphorus	August 12, 2014	60m
	Total Chromium, Total Iron, Total Zinc, Dissolved Aluminum	August 12, 2014	45 and 60m
	Turbidity, Total Chromium, Total Copper, Total Iron, Total Zinc	August 22, 2014	36, 60 and 80m
	Total Suspended Solids	August 22, 2014	36 and 80m
	Total Silver	August 22, 2014	80m
	Turbidity, Total Suspended Solids, Total Chromium, Total Iron	September 4, 2014	30 and 65m
	Total Copper	September 4, 2014	9, 25, 30 and 60m
	Total Phosphorus, Total Zinc, Dissolved Aluminum	September 4, 2014	65m
	Total Copper	April 23, 2015	90m
Quesnel Lake West Arm Green Buoy Deep Station	Turbidity, Total Suspended Solids, Total Chromium, Total Copper, Total Iron, Total Phosphorus, Total Zinc, Dissolved Aluminum	August 13, 2014	40, 60 and 90m
	Total Cobalt, Total Lead	August 13, 2014	90m
	Total Silver	August 13, 2014	60 and 90m
Quesnel Lake at Hazeltine Creek Site A	Turbidity, Total Suspended Solids, Total Phosphorus	August 20, 2014	9 and 27m
	Total Copper	August 20, 2014	0.5, 9, 20 and 27m
Quesnel Lake at Hazeltine Creek Site B	Total Copper	August 20, 2014	0.5m
Quesnel Lake at Hazeltine Creek Site C	Turbidity, Total Suspended Solids, Total Copper, Total Phosphorus	August 20, 2014	8 and 24m
	Total Chromium, Total Lead, Total Zinc	August 20, 2014	8m
Quesnel Lake East of Cedar Creek	Total Copper	August 20, 2014	0.5 and 8m
	Total Copper	August 26, 2014	0.5m

	Total Copper	September 11, 2014	0.5 and 8m
Quesnel Lake Hazeltine Outlet at Log Booms	Total Copper	September 3, 2014	0.5m
Quesnel Lake at Hazeltine Creek between Sites A and B	Turbidity, Total Suspended Solids, Total Chromium, Total Copper, Total Iron, Total Phosphorus	October 2, 2014	10 and 15m
	Total Cobalt, Total Silver, Total Zinc	October 2, 2014	10m