E-mail (dated 8 February 2018) to Dr. K.J. Reimer, Chair, IEAC from:

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Re: Northern Contaminants Program (NCP) Monitoring Program

The NCP long-term monitoring program has remained virtually unchanged since it was first implemented in 2005. Since then we have been annually monitoring the same set of indicator species at the same locations using the same methods to ensure that we have the most robust temporal datasets that we can afford to collect. One the main keys to success of the program is that we've been able to stick with it for so long.

The only thing that has changed is the suite of contaminants that is measured on an annual basis. This has expanded to include chemicals of emerging concern like brominated flame retardants, fluorinated surfactants and organophosphate flame retardants. We have found that the Arctic environment can respond quite quickly to global emissions, so it has been important to maintain annual monitoring for these compounds in order to detect the inflection in the trend, which in most cases has gone from increasing to decreasing over the course of 1-3 years. In some cases we have gone back to archived samples to reconstruct the trend.

We have decreased the analytical frequency from annual to biennial for legacy POPs, primarily the dirty dozen, for which we have clearly established decreasing trends across all indicators. In most cases for these compounds the trends have leveled off likely reflecting the fact that primary sources are no longer important and we are now into the longer term process whereby they are being gradually removed from the environment through natural processes.

We continue to monitor mercury on an annual basis without being able to measure any consistent trend across all indicators and locations, although I think it's safe to say that we are starting to see a leveling off from the large increases that have been observed since industrialization.

I'm not sure you really asked for this, but here are some of my thoughts on monitoring:

- As was outlined in the report that I shared with you a number of years ago, it is very important to reduce to the greatest extent possible any sources of uncertainty or variability in the data. Obviously this means the analytical laboratory must be producing the best possible data with a robust QAQC program in order to demonstrate data quality. Regular participation in an interlaboratory QAQC programs, such as the NCP/AMAP QAQC program, is also important. Other sources of variability in the data should also be controlled by collecting samples at consistent locations, using consistent methods, and at a consistent time of year. This is particularly important for biota. All of the potential co-variables that influence contaminant levels in biota should be collected along with contaminant concentrations. This may include length, age, body condition, sex, and stable isotopes of carbon and nitrogen, which provide information about trophic position and feeding regime (benthic/pelagic). We are also seeing the

increasing use of fatty acids and metabolomics to gain even more information, though these are being explored more from a research perspective than regular monitoring.

· Sample size is an important determinant of statistical power and can be used to a certain extent to mask variability in the data. This was discussed quite a bit in the earlier report from Macdonald. We decided that the optimum sample size for our program was 10 based on diminishing returns in statistical power versus increasing analytical costs, which for us far outweigh the cost of collection. For mercury we upped our sample size to 20 due to the low costs of analysis.

· A monitoring program is usually (ought to be) designed to test a certain hypothesis, which in the case of the NCP is that contaminant trends in the Arctic will follow global emissions patterns. This needs to be considered in the design of the monitoring program to ensure that you are not only measuring the trends, but that you can also evaluate what is driving the trend, i.e. test the hypothesis. In the case of Lake Melville this will obviously have to do with impacts from hydro development. What is increasingly challenging for us, and will likely be for you too, is teasing out other potential drivers, including climate change. We recognize at the NCP that we don't fully understand all the climate driven environmental processes that affect contaminant cycling, including bioaccumulation/magnification, and therefore we maintain a research program that is designed to complement and inform the interpretation of our monitoring program. I think this type of mixed monitoring and research approach will be critical for Lake Melville.

A few years ago we had a consultant do a statistical analysis of the monitoring data for a set of 6 contaminants. Colin Macdonald, who prepared the monitoring design report back in 2005, did the analysis. He did a very thorough analysis of all the time trend data using a statistical program called PIA that was developed for AMAP by Anders Bignert from Sweden. I think Colin's assessment of the monitoring program is a bit pessimistic. He looks at statistical power to assess whether the program is achieving its monitoring objective – the monitoring objective is statistically based and described in the monitoring Blueprint as " the detection of a 10% change over 10–15 years, to detection of a 5% change over a 10–15 year period with a power of 80% and confidence level of 95%. " When looking strictly at statistical power it would appear that only a small number of datasets actually have the power to detect a trend, however, what this analysis discounts is that fact that many significant trends were measured despite lower statistical power. My interpretation, and I've discussed this with a number of scientists, is that if you are able to measure a statistically significant trend then by definition you dataset is powerful enough to detect that trend, even though it might not have the power to detect a weaker trend. Hopefully that makes sense. The report is attached. It was based on this report that we decided to reduce the analytical frequency for legacy POPs.