ASSESSING BACKGROUND METALS CONCENTRATIONS IN BC GROUNDWATER

Luca Malaguti, Thurber Engineering Ltd.

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia

Preliminary Findings

Assessing Background Metals Concentrations in British Columbia’s Groundwater

- Groundwater quality data sets (data set A and B) provided to CSAP
- CSAP to assess possibility that some metals concentrations normally found in GW may exceed new Stage 10 CSR standards
- Metals of interest in this report were cobalt, lithium, beryllium and vanadium
- Data sets statistically analysed to identify exceedances within a population
- Omnibus standards considered for drinking water (DW):
  - ✓ Cobalt = 1 µg/L
  - ✓ Lithium = 8 µg/L
  - ✓ Beryllium = 1.5 µg/L (taken as AW Fresh)
  - ✓ Vanadium = 20 µg/L

Luca Malaguti,
M.Eng., EIT

CSAP
Society of Contaminated
Sites Approved Professionals
of British Columbia

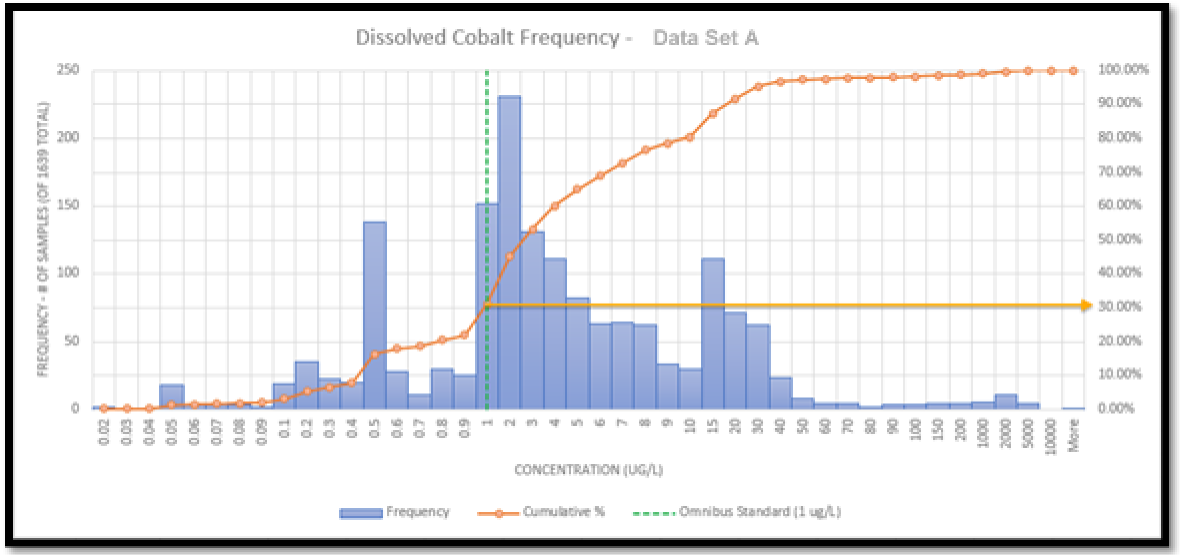
Approach and Methods

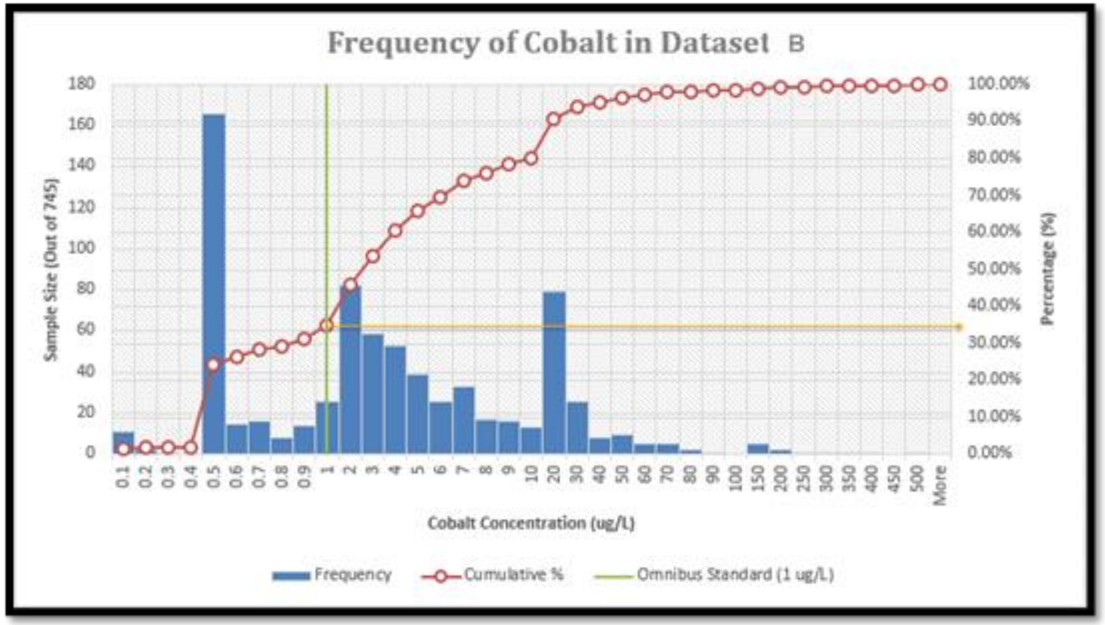
Luca Malaguti, M.Eng., EIT

- Technical Guidance 12 “Statistics for Contaminated Sites” used as reference for analysis
- Data sets showed high variability in spatial and temporal distribution
- Exhibited both normal and lognormal distributions patterns at times
- Data sets analysed with histograms, cumulative probability plots and regression analysis for each metal population of values
- Several concentration values were not detected (i.e., often recorded as less than [“<”] a value)
- Some data values were recorded as less than the MDL, possible false positives removed according to filtering steps
- Five key filtering steps applied based on screening criteria from *Goddard, M.L., 2017* (See Appendix)
- All **data was excluded if** the value was **less than or equal** to the MDL (value ≤ MDL) **AND** if the MDL was **greater than** the Omnibus standard for that specific metal (MDL > Omnibus standard in µg/L)
- In order for a particular the sample value to be excluded, **both statements must be abided**.

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia

Results - Cobalt

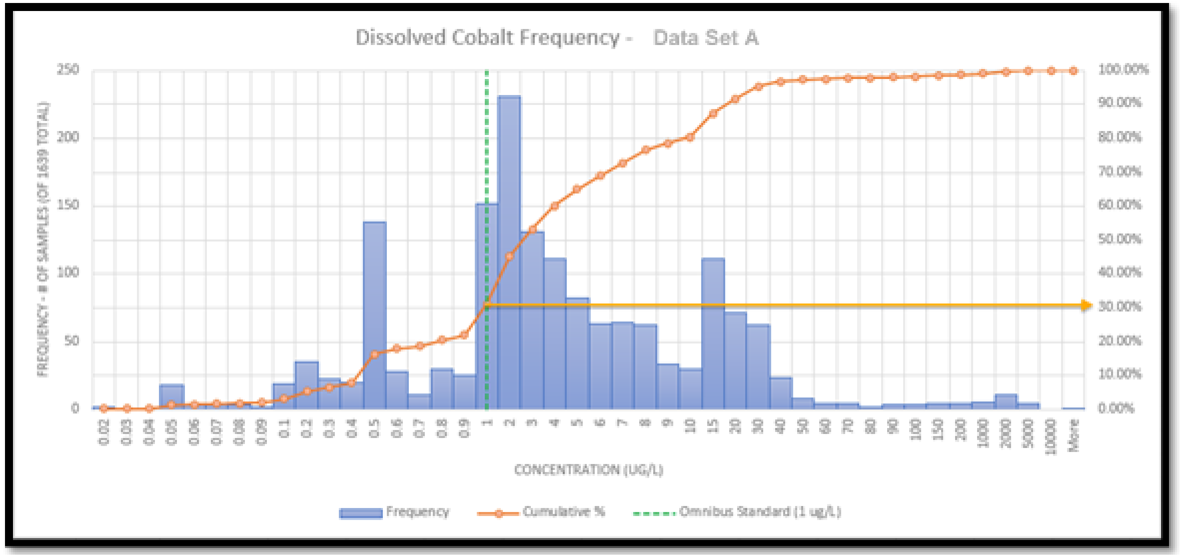


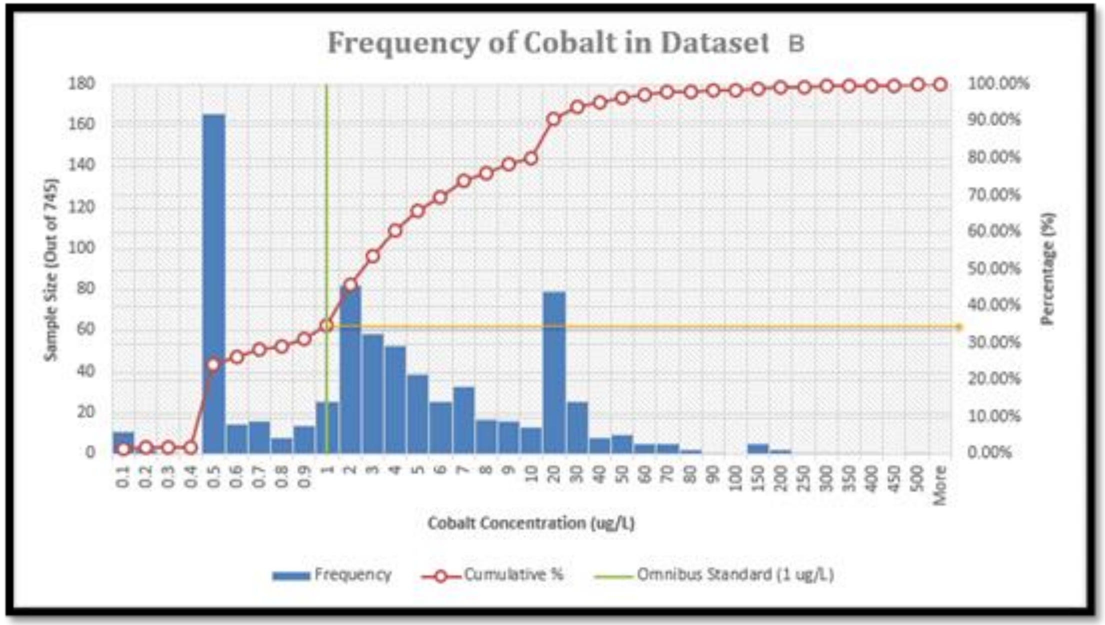


Luca Malaguti, M.Eng., EIT

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia

Results - Lithium





Luca Malaguti, M.Eng., EIT

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia

Results - Discussion

- For Data Set A, circa 96% of the beryllium values and 98% of the vanadium values **did not exceed** the new Omnibus standards of 1.5 µg/L and 20 µg/L, respectively.
- Similarly, for Data Set B, circa 98% of beryllium values and 95% of vanadium values **not exceeding** new standards.
- Cobalt:
  - ✓ In data set A, cobalt has just over 31% of values are below the new omnibus standard. **This means that almost 70% of the cobalt values exceed the standard in this population.**
  - ✓ In data set B, about 35% of values for cobalt were below the omnibus standard, and **most of the population exceeded the standard (c. 65%).**
- Lithium:
  - ✓ In data set A, just under 50% of the lithium values are below the new Omnibus standards, and therefore most of **the lithium values also exceed the new standard**.
  - ✓ In data set B, **lithium has just under 50% of the values exceeding the omnibus standard**.

Luca Malaguti, M.Eng., EIT

Luca Malaguti, M.Eng., EIT

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia

Acknowledgements

A special thanks to Peter Reid and Michael Sloan for putting together the initial data sets A and B, as well as providing key advice in the analysis of data presented here.

This report would like to acknowledge Catherine Schachtel and the help and support of the CSAP staff for providing the time and resources to make this project possible. Also, the Ministry of Environment, most notably Stephen Dankevy, played a key role in putting together the data filtering steps.

Finally, I would like to acknowledge the help and support of Guy Patrick for supervising, and editing the work presented here.

Luca Malaguti, M.Eng., EIT

Appendix

The filtering steps and formulae used in this analysis are described as follows:

1) Remove any sample name that does not correspond to a groundwater borehole or monitoring well (i.e. MW, BH, etc.). Several sample names recorded as *"infl", "eff", "tank", "sump"*, etc. were discarded entirely. The raw groundwater data from each of the data sets was filtered (using filtering/sorting tools in Excel) to only show; a) data with appropriate sample names and b) data from dissolved metals only (i.e. dissolved cobalt values).

2) All values in "mg/L" units were converted to "µg/L" for both the sample value and detection limit. The sample unit column was sorted to identify sequence of value/unit pairs, and multiplied by 1000 in new column with µg/L units (see Excel data sheet). Values with "<" signs in front of a number (i.e. <0.005) were modified to the existing number (i.e. 0.005) in the likelihood that the sample was a false positive or if indeed the value is less than the MDL. This is later accounted for in the next filtering step (i.e. value ≤ MDL).

The formula used for this was:

=IF(LEFT(H3,1)="<",VALUE(MID(H3,2,LEN(H3))),VALUE(H3))

The "If" statement identifies that if a logical test is true, then the mid-value in the cell (excluding the "<") is used. If the test is false, then the value in the cell is used.

3) The third filtering step compares all sample results within a range for a metal with their respective detection limits. All **data was excluded if** the value was **less than or equal** to the MDL (value ≤ MDL) **AND** if the MDL was **greater than** the Omnibus standard for that specific metal (MDL > Omnibus standard in µg/L). In order for a particular the sample value to be excluded, **both statements must be abided**.

The formula used for this was:

=IF(M5<=O5,IF(O5>1,REPLACE(M5,1,4,""),M5),M5)

The nested "if" functions present a logical test within a logical test to identify the above-mentioned comparison between sample result and its MDL. If both statements are true, then the value is replaced with a blank cell, otherwise the initial value is printed as is. The highlighted "1" here is where the Omnibus standard value for each specific metal is entered (i.e. in this case it's the formula for cobalt).

4) The fourth step involves identifying any multiples of the same sample results that have the same name. Many results represented samples acquired from the same location on several occasions over a long time period. These sample values were consolidated: sorted alphabetically while expanding the entire selection, using conditional formatting tool the multiple values were identified and highlighted by cell colour.

The formula used for this was:

=IF(CELL("contents",V3)=CELL("contents",V4),PERCENTILE(W3:W4,0.95),"nodup")

The 95^{th} percentile of each group of duplicates was taken, and the multiple values were then consolidated into one distinct value (the 95^{th}) for that specific sample name. If no duplicate was found, then the formula prints "nodup".

5) Finally, the sample values that survive the filtering steps are rearranged and sorted according to concentration, from smallest to largest. A data analysis tool was used to plot histograms of the data showing frequency against concentration group. The histograms were used to illustrate possible normal/lognormal behavior, and give an idea of the exceedance percentages for each metal. A regression analysis tool was used to plot a normal probability plot of the data (as described in Technical Guidance 12-6 "Choosing a Distribution" of the CSR).

CSAP
Society of Contaminated Sites Approved Professionals of British Columbia