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# DE BEERS GAHCHO KUÉ WATER LICENCE AMENDMENT TECHNICAL SESSIONS PRESENTATION

Yellowknife (Location TBD)  
May 24, 2018

## TOPIC 3 - EFFLUENT QUALITY CRITERIA FOR AREA 8 AND LAKE N11



## OUTLINE

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- Effluent Quality Criteria (EQC) Methods
  - Seven steps
  - Parameters of interest (POI) for Area 8 and Lake N11
- EQC for Area 8
  - Site-specific water quality objectives (SSWQO)
  - Screening to identify parameters of potential concern (POPC)
  - Mixing zone and dilution factor
  - EQC results
- EQC for Lake N11
  - SSWQO
  - Screening to identify POPC
  - Mixing zone and dilution factor
  - EQC results



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# EQC METHODS



## EQC METHODS

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- Applied the same methods used to set water quality-based EQC in Water Licence MV2005L2-0015
- The methods are based on guidance from AEP(1995) and USEPA (1991)
- The same methods were used to set water quality-based EQC in Water Licence MV2011L2-0004 (Snap Lake Mine) and W2012L2-0001 (the Jay Project)
- The EQC calculations approach reviewed by EcoMetrix (MVRB/MVLWB IR#15; De Beers 2014)
- Seven steps...



## EQC METHODS - SEVEN STEPS

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1. Identify POI (i.e., parameters for which EQC may be developed)
2. Select SSWQO for each parameter
3. Identify POPC using a multi-step screening process
4. Select a mixing zone and dilution factor
5. Calculate EQC for POPC
6. Compare EQC to acute SSWQO to prevent acute toxicity at the final point of discharge
7. Compare EQC to projected discharge concentrations to determine whether the EQC are reasonably and consistently achievable



## EQC METHODS - PARAMETERS OF INTEREST FOR LAKE N11 AND AREA 8

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- Potential List of POI: TDS, Ca, Cl, F, Mg, K, Na, SO<sub>4</sub>, NO<sub>3</sub>-N, NH<sub>3</sub>-N, TKN, TP, DP, total and dissolved Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, Tl, U, V, and Zn
- GNWT-ENR-9
  - Parameters were eliminated from the list of POI because the parameter did not have a toxicity-based guideline
    - Ca, Mg, Na, TKN, and Mn were eliminated from the list of POI
  - Total concentrations of parameters were used in the assessment because total concentrations include dissolved fractions
    - Dissolved phosphorus and dissolved metals were eliminated from the list of POI
- List of POI: TDS, Cl, F, K, SO<sub>4</sub>, NO<sub>3</sub>-N, NH<sub>3</sub>-N, TP, and total Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, Tl, U, V, and Zn

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# EQC FOR AREA 8





## EQC FOR AREA 8 - SITE-SPECIFIC WATER QUALITY OBJECTIVES

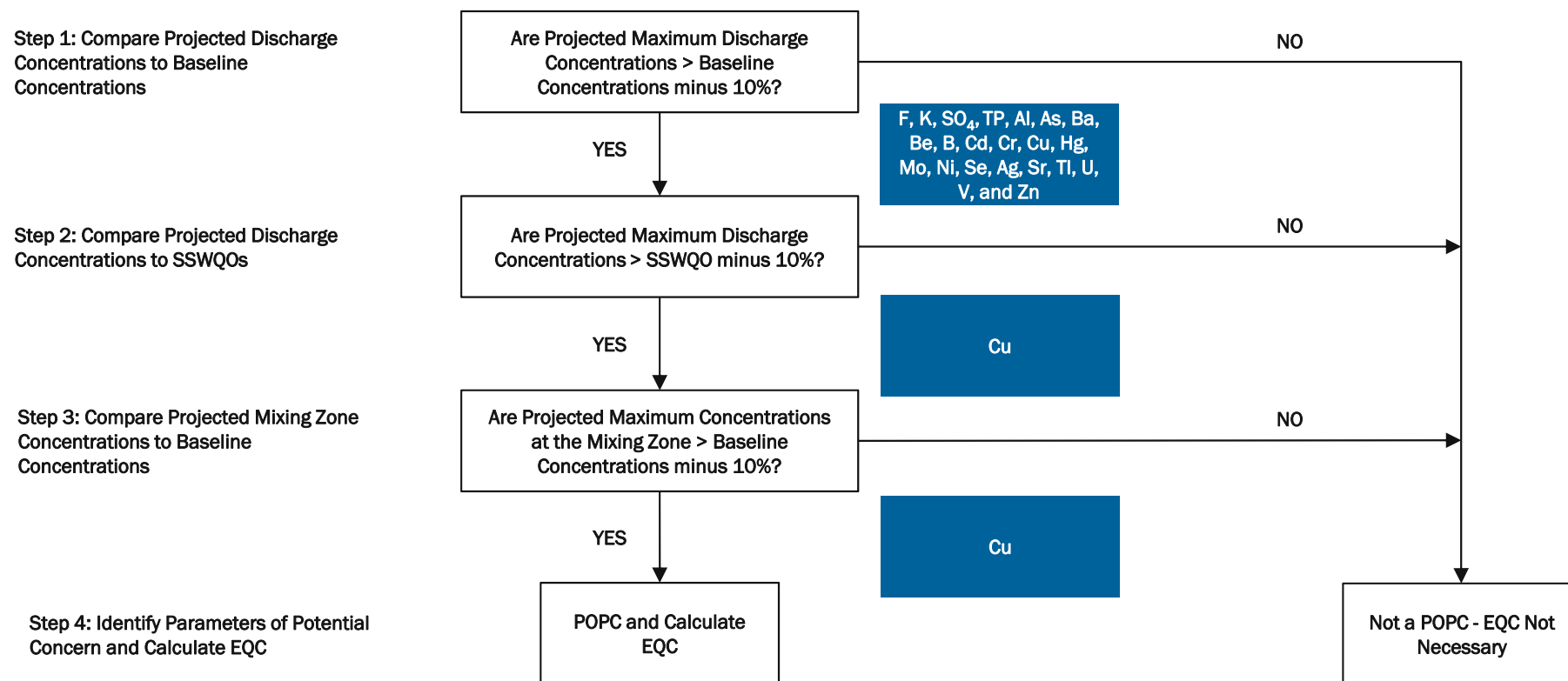
- The SSWQO are the same as those identified in the Reasons for Decision for the Land Use Permit (MV2005C0032) and Water Licence (MV2005L2-0015) applications for the Mine (MVLWB 2014), with the exceptions of:
  - Fluoride
  - Total silver
  - Total strontium

| Parameter                     | Proposed | Source             |
|-------------------------------|----------|--------------------|
|                               | SSWQO    |                    |
| Total dissolved solids (mg/L) | 500      | Health Canada 2017 |
| Chloride (mg/L)               | 120      | CCME 1999          |
| Fluoride (mg/L)               | 0.12     | CCME 1999          |
|                               | 1.5      | Health Canada 2017 |
| Potassium (mg/L)              | 41       | Rescan 2012        |
| Sulphate (mg/L)               | 62       | Rescan 2012        |
| Total ammonia (mg N/L)        | 1.78     | CCME 1999          |
| Nitrate (mg N/L)              | 2.93     | CCME 1999          |
| Total phosphorus (mg P/L)     | 0.0109   | Wetzel 2001        |
| Total aluminum (mg/L)         | 0.1      | CCME 1999          |
| Total antimony (mg/L)         | 0.006    | Health Canada 2017 |
| Total arsenic (mg/L)          | 0.005    | CCME 1999          |
| Total barium (mg/L)           | 1        | Health Canada 2017 |
| Total beryllium (mg/L)        | 0.004    | USEPA 2009         |
| Total boron (mg/L)            | 1.5      | CCME 1999          |

## EQC FOR AREA 8 - SITE-SPECIFIC WATER QUALITY OBJECTIVES

| Parameter               | Proposed | Source                       |
|-------------------------|----------|------------------------------|
|                         | SSWQO    |                              |
| Total cadmium (mg/L)    | 0.005    | Health Canada 2017           |
| Total chromium (mg/L)   | 0.001    | CCME 1999                    |
| Total cobalt (mg/L)     | 0.004    | BCMOE 2017                   |
| Total copper (mg/L)     | 0.002    | CCME 1999                    |
| Total iron (mg/L)       | 0.57     | Mean + 2 standard deviations |
| Total lead (mg/L)       | 0.0014   | Mean + 2 standard deviations |
| Total mercury (mg/L)    | 0.000026 | CCME 1999                    |
| Total molybdenum (mg/L) | 0.073    | CCME 1999                    |
| Total nickel (mg/L)     | 0.025    | CCME 1999                    |
| Total selenium (mg/L)   | 0.001    | CCME 1999                    |
| Total silver (mg/L)     | 0.00025  | CCME 1999                    |
| Total strontium (mg/L)  | 10.7     | McPherson et al. (2014)      |
| Total thallium (mg/L)   | 0.0008   | CCME 1999                    |
| Total uranium (mg/L)    | 0.015    | CCME 1999                    |
| Total vanadium (mg/L)   | 0.006    | OMEE 1994                    |
| Total zinc (mg/L)       | 0.03     | CCME 1999                    |

# EQC FOR AREA 8 - SCREENING TO IDENTIFY PARAMETERS OF POTENTIAL CONCERN



## EQC FOR AREA 8 - SCREENING TO IDENTIFY PARAMETERS OF POTENTIAL CONCERN

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- GNWT-ENR-29 - Baseline Concentrations in Area 8
  - “Since the mixing zones are within Lake N11 and Area 8, the Board concludes that the use of baseline concentrations for setting SSWQO and EQC should be made with respect to the specific lake that receives the discharge”
  - De Beers used the mean plus two standard deviations from data collected between 2011 and 2013 in Area 8 to represent baseline concentrations in Area 8
- ECCC-9
  - With respect to the first screening step, if projected Area 7 concentrations are less than baseline concentrations in the receiving environment, then changes to parameter concentrations in the receiving environment would not be expected to be distinguishable from baseline concentrations
  - The first screening step is protective of the receiving environment because it retains parameters in the screening process that have discharge-source concentrations that are greater than baseline concentrations in the receiving environment

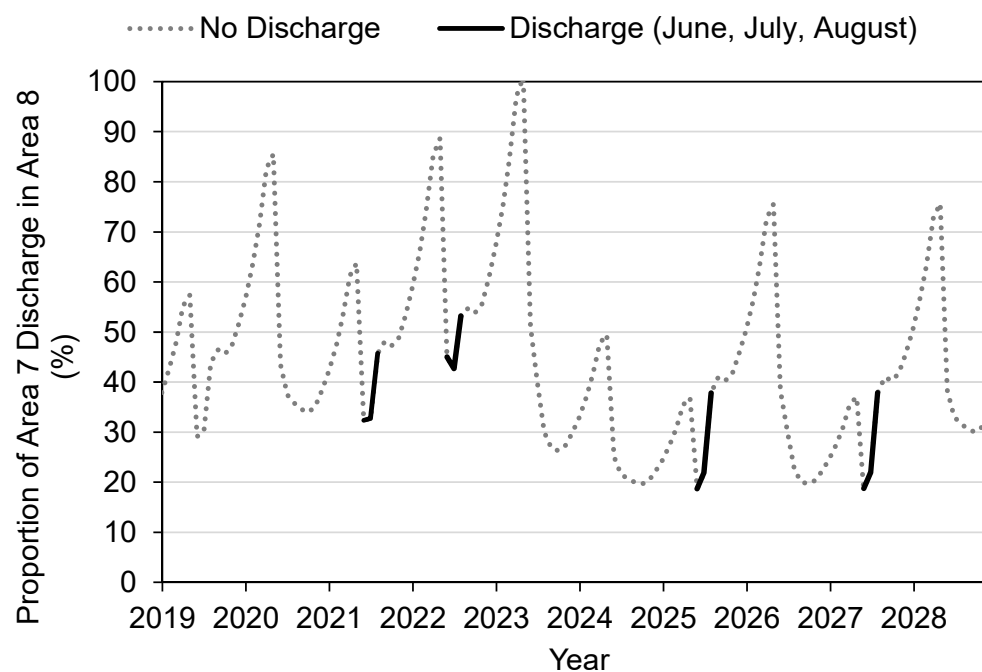
## EQC FOR AREA 8 - MIXING ZONE AND DILUTION FACTOR

| Parameter       | Water Licence MV2005L2-0015 | Proposed     |
|-----------------|-----------------------------|--------------|
| Mixing zone     | 100 m radius                | 100 m radius |
| Dilution factor | 37                          | 90           |

- GNWT-ENR-10 and GNWT-ENR-11
  - The dilution factor for Area 8 has changed from version 2 of the EQC Report (De Beers 2014)
    - Characteristics of the Area 8 diffuser were updated to reflect those in the detailed design report (Golder 2017b)
    - Projected characteristics of the discharge from Area 7 were updated to reflect the most recent Site water quality model results (Attachment 2, Appendix C of the 2018 Water Licence Amendment Application)

## EQC FOR AREA 8 - PROPORTION OF AREA 7 WATER IN AREA 8

- The most important factor affecting EQC is the volume of water discharged to the receiving environment (i.e., from Area 7 to Area 8)
- EQC are calculated under most limiting conditions (i.e., maximum proportion of effluent in the receiving environment)
- Area 8 will contain 100% of the Area 7 discharge during ice-cover conditions in 2023



## EQC FOR AREA 8

| POPC                                | Maximum Average Concentration | Maximum Grab Concentration |
|-------------------------------------|-------------------------------|----------------------------|
| Total copper (mg/L)                 | 0.002                         | 0.003                      |
| pH (pH units)                       | 6.5 to 9                      |                            |
| Total suspended solids (mg/L)       | 15                            | 25                         |
| Total petroleum hydrocarbons (mg/L) | -                             | 5                          |

- ECCC-3 and GNWT-ENR-28
  - De Beers does not propose EQC for faecal coliforms for Area 8

## EQC FOR AREA 8

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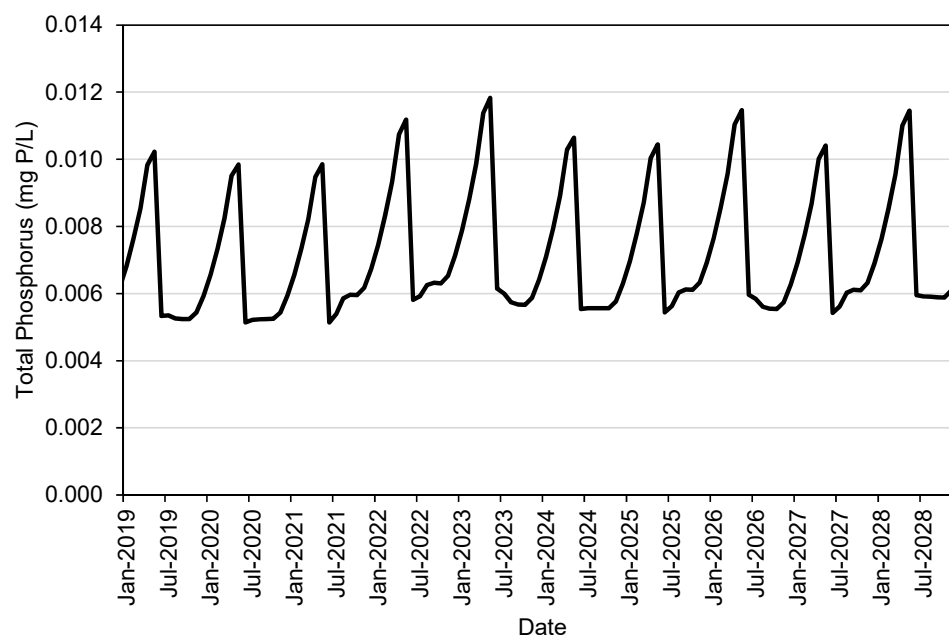
- ECCC-4
  - If water from the WMP is stored in Area 7 as a contingency measure, water in Area 7 would not be pumped to Area 8 for downstream flow mitigation. De Beers would either pump the water in Area 7 back to the WMP or to a pit. If De Beers stores water from the WMP in Area 7, and then wants to discharge that water from Area 7 to Area 8 for downstream flow mitigation, an EQC evaluation report would be prepared and submitted to the MVLWB
- ECCC-12
  - The original EQC developed for Area 8 were based on the possible discharge of water from the WMP to Area 8 in Year 1 of operations for downstream flow mitigation. As sources of water for discharges are not the same, De Beers has requested removal of EQC for TDS, sulphate, nitrate, total phosphorus, and total chromium, molybdenum, nickel, and uranium from the Water Licence for the discharge to Area 8 because these parameters were only considered POPC for discharge from the WMP.
  - Water was never discharged from the WMP to Area 8 for downstream flow mitigation and water from the WMP will not be used for downstream flow mitigation for the remainder of operations



## TOTAL PHOSPHORUS CONCENTRATIONS IN AREA 8

- GNWT-ENR-33

- Three sources of TP loading to Area 8
  - Natural inflows from the Area 8 watershed (5 kg/yr)
  - Proposed discharge from Area 7 (9 kg/yr)
  - Proposed discharge from Lake N11 (6 kg/yr)
  - TP concentrations in Area 8 are projected to be approximately 0.006 mg P/L during the open-water season and peak at approximately 0.012 mg P/L during the ice-cover season
- TP concentrations are projected to exceed the SSWQO of 0.0109 mg P/L for very short periods of time during ice-cover, but concentrations consistently return to concentrations similar to existing conditions during the open water periods
- De Beers has not proposed TP EQC for Area 8



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## EQC FOR LAKE N11



## EQC FOR LAKE N11 - SITE-SPECIFIC WATER QUALITY OBJECTIVES

- The SSWQO are the same as those identified in the Reasons for Decision for the Land Use Permit (MV2005C0032) and Water Licence (MV2005L2-0015) applications for the Mine (MVLWB 2014), with the exceptions of:
  - Fluoride
  - Nitrate
  - Total silver
  - Total strontium

| Parameter                     | Proposed   | Source             |
|-------------------------------|------------|--------------------|
|                               | SSWQO      |                    |
| Total dissolved solids (mg/L) | 500        | Health Canada 2017 |
| Chloride (mg/L)               | 120        | CCME 1999          |
| Fluoride (mg/L)               | 0.12       | CCME 1999          |
|                               | 1.5        | Health Canada 2017 |
| Potassium (mg/L)              | 41         | Rescan 2012        |
| Sulphate (mg/L)               | 41         | Rescan 2012        |
| Total ammonia (mg N/L)        | 2.4        | CCME 1999          |
| Nitrate (mg N/L)              | 2.93       | CCME 1999          |
|                               | 3 to 13.13 | Rescan 2012        |
| Total phosphorus (mg P/L)     | 0.0109     | Wetzel 2001        |
| Total aluminum (mg/L)         | 0.1        | CCME 1999          |
| Total antimony (mg/L)         | 0.006      | Health Canada 2017 |
| Total arsenic (mg/L)          | 0.005      | CCME 1999          |
| Total barium (mg/L)           | 1          | Health Canada 2017 |
| Total beryllium (mg/L)        | 0.004      | USEPA 2009         |
| Total boron (mg/L)            | 1.5        | CCME 1999          |

## EQC FOR LAKE N11 - SITE-SPECIFIC WATER QUALITY OBJECTIVES

- ECCC-5
  - The MVLWB concluded that the SSWQO that were adopted for the Mine are “protective of the designated water uses in Lake N11 and Area 8 as well as downstream areas during operations and that these SSWQO satisfy the intent of Suggestion 1 of EIR 0607-001”
  - As a result, De Beers maintained the SSWQO for total cadmium of 0.005 mg/L in the amendment application

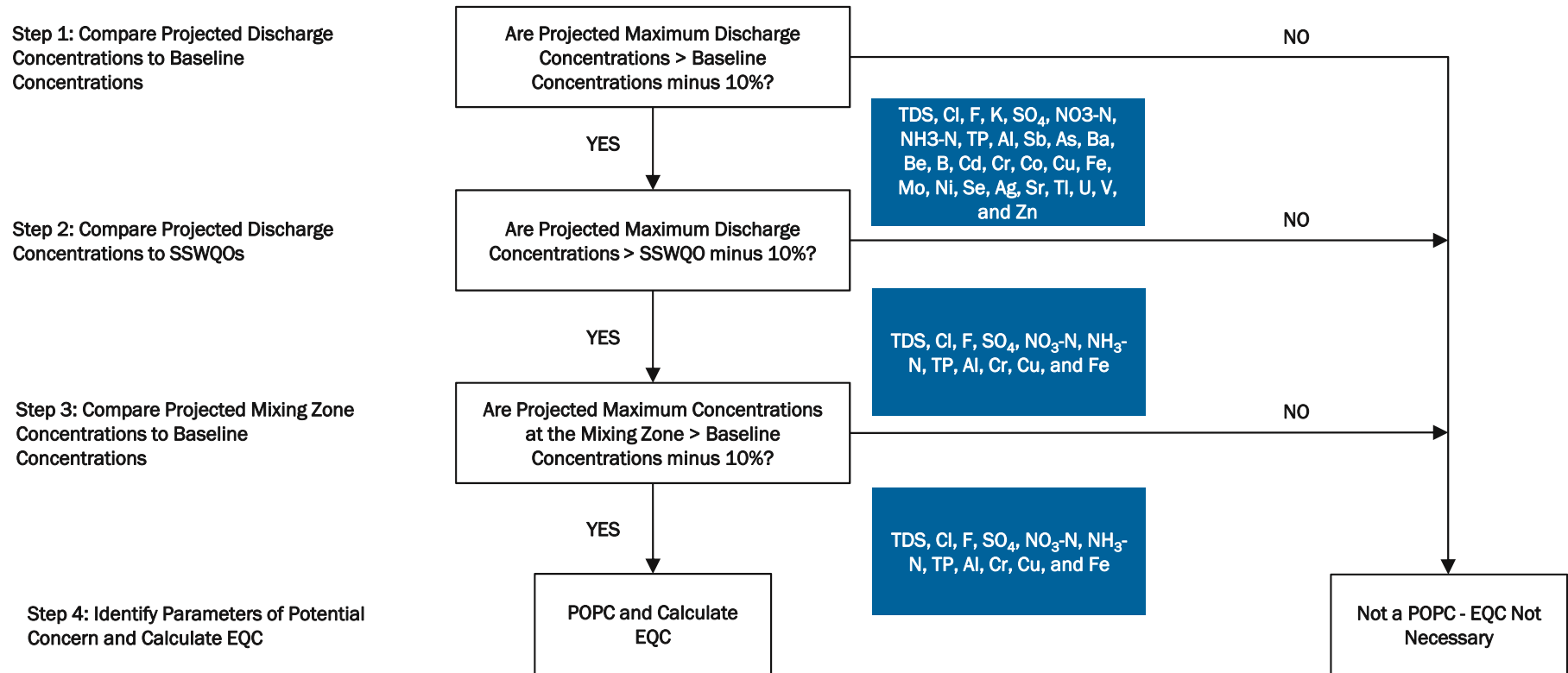
| Parameter               | Proposed | Source                       |
|-------------------------|----------|------------------------------|
|                         | SSWQO    |                              |
| Total cadmium (mg/L)    | 0.005    | Health Canada 2017           |
| Total chromium (mg/L)   | 0.001    | CCME 1999                    |
| Total cobalt (mg/L)     | 0.004    | BCMOE 2017                   |
| Total copper (mg/L)     | 0.002    | CCME 1999                    |
| Total iron (mg/L)       | 0.57     | CCME 1999                    |
| Total lead (mg/L)       | 0.0038   | Mean + 2 standard deviations |
| Total mercury (mg/L)    | 0.00004  | Mean + 2 standard deviations |
| Total molybdenum (mg/L) | 0.073    | CCME 1999                    |
| Total nickel (mg/L)     | 0.025    | CCME 1999                    |
| Total selenium (mg/L)   | 0.001    | CCME 1999                    |
| Total silver (mg/L)     | 0.00025  | CCME 1999                    |
| Total strontium (mg/L)  | 10.7     | McPherson et al. (2014)      |
| Total thallium (mg/L)   | 0.0008   | CCME 1999                    |
| Total uranium (mg/L)    | 0.015    | CCME 1999                    |
| Total vanadium (mg/L)   | 0.006    | OMEE 1994                    |
| Total zinc (mg/L)       | 0.03     | CCME 1999                    |

## EQC FOR LAKE N11 - HARDNESS-DEPENDENT SITE-SPECIFIC WATER QUALITY OBJECTIVES

- ECCC-6 and MVLWB-14
  - Hardness-dependent SSWQO for sulphate, copper, and nickel were calculated using the baseline hardness concentration of 9 mg/L as CaCO<sub>3</sub> in Lake N11 (Table 2-2)
  - Hardness-dependent SSWQO for nitrate was calculated using the projected whole-lake average hardness concentrations in Lake N11 (Table 2-2)
  - The EQC calculated for nitrate using the CCME WQG and the hardness-dependent SSWQO with a baseline hardness concentration in Lake N11 are not projected to be reasonably and consistently achievable for the proposed discharge from the WMP to Lake N11 in Years 3 and 4 of operations

| Hardness (mg/L as CaCO <sub>3</sub> ) | Hardness-based SSWQO for Nitrate (mg N/L) | CCME WQG for Nitrate (mg N/L) |
|---------------------------------------|---|-------------------------------|
| 5                                     | 1.17                                      | 2.93                          |
| 10                                    | 1.17                                      | 2.93                          |
| 15                                    | 1.73                                      | 2.93                          |
| 20                                    | 2.27                                      | 2.93                          |
| 25                                    | 2.81                                      | 2.93                          |
| 26                                    | 2.91                                      | 2.93                          |
| 27                                    | 3.02                                      | 2.93                          |
| 28                                    | 3.13                                      | 2.93                          |
| 29                                    | 3.23                                      | 2.93                          |
| 30                                    | 3.34                                      | 2.93                          |

# EQC FOR LAKE N11 - SCREENING TO IDENTIFY PARAMETERS OF POTENTIAL CONCERN



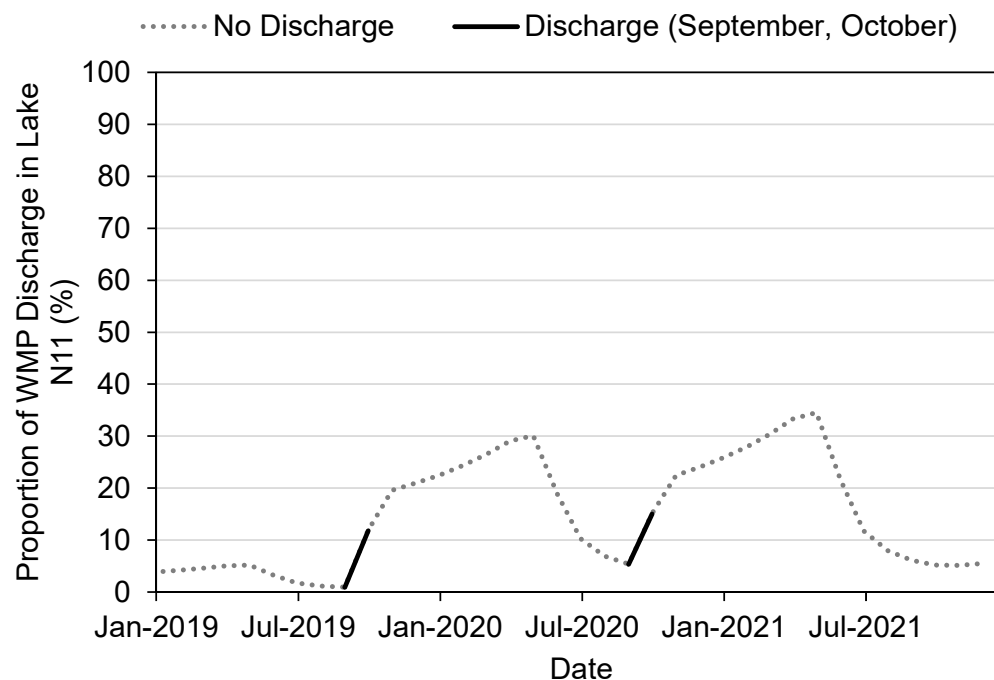
## EQC FOR LAKE N11 - MIXING ZONE AND DILUTION FACTOR

| Parameter       | Water Licence MV2005L2-0015 | Proposed     |
|-----------------|-----------------------------|--------------|
| Mixing zone     | 200 m radius                | 200 m radius |
| Dilution factor | 40                          | 35           |

- GNWT-ENR-10 and GNWT-ENR-11
  - The dilution factor for Lake N11 has changed from version 2 of the EQC Report (De Beers 2014)
    - Characteristics of the submerged diffuser in Lake N11 were updated to reflect the as-built drawings (Golder 2017a)
    - Projected characteristics of the discharge from WMP were updated to reflect the most recent Site water quality model results (Attachment 2, Appendix C of the 2018 Water Licence Amendment Application)

## EQC FOR LAKE N11 - PROPORTION OF WMP WATER IN LAKE N11

- The most important factor affecting EQC is the volume of water discharged to the receiving environment (i.e., from the WMP to Lake N11)
- EQC are calculated under most limiting conditions (i.e., maximum proportion of effluent in the receiving environment)
- Lake N11 will contain 34.5% of the WMP discharge during ice-cover conditions in 2021





## EQC FOR LAKE N11

| POPC                      | Water Licence MV2005L2-0015   |                            | Proposed                      |                            |
|---------------------------|-------------------------------|----------------------------|-------------------------------|----------------------------|
|                           | Maximum Average Concentration | Maximum Grab Concentration | Maximum Average Concentration | Maximum Grab Concentration |
| Chloride (mg/L)           | 160                           | 320                        | 300                           | 515                        |
| Fluoride (mg/L)           | 0.15                          | 0.30                       | 1.5                           | 3                          |
| Sulphate (mg/L)           | 150                           | 300                        | 100                           | 155                        |
| Nitrate (mg N/L)          | 10                            | 20                         | 20                            | 30                         |
| Total ammonia (mg N/L)    | 10                            | 20                         | 6                             | 10                         |
| Total phosphorus (mg P/L) | 0.03                          | 0.06                       | 0.022                         | 0.03                       |
| Total aluminum (mg/L)     | 0.1                           | 0.2                        | 0.23                          | 0.35                       |
| Total chromium (mg/L)     | 0.002                         | 0.004                      | 0.002                         | 0.005                      |
| Total copper (mg/L)       | 0.003                         | 0.006                      | 0.004                         | 0.007                      |
| Total iron (mg/L)         | 0.4                           | 0.8                        | 0.6                           | 1                          |

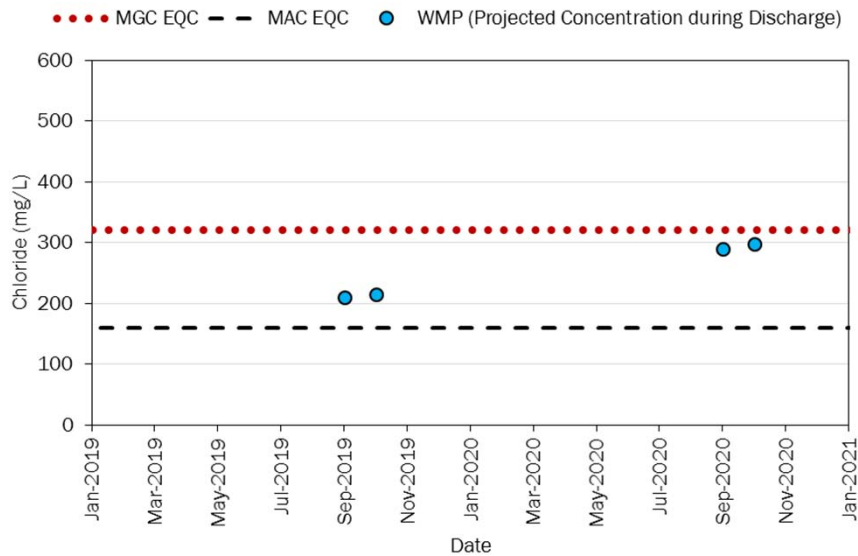
## EQC FOR LAKE N11

| POPC                                | Water Licence MV2005L2-0015   |                            | Proposed                      |                            |
|-------------------------------------|-------------------------------|----------------------------|-------------------------------|----------------------------|
|                                     | Maximum Average Concentration | Maximum Grab Concentration | Maximum Average Concentration | Maximum Grab Concentration |
| Total molybdenum (mg/L)             | 0.3                           | 0.6                        | -                             | -                          |
| Total nickel (mg/L)                 | 0.09                          | 0.18                       | -                             | -                          |
| Total uranium (mg/L)                | 0.06                          | 0.12                       | -                             | -                          |
| pH (pH units)                       | 6.5 to 9                      |                            | 6.5 to 9                      |                            |
| Total suspended solids (mg/L)       | 15                            | 25                         | 15                            | 25                         |
| Total petroleum hydrocarbons (mg/L) | -                             | 5                          | -                             | 5                          |

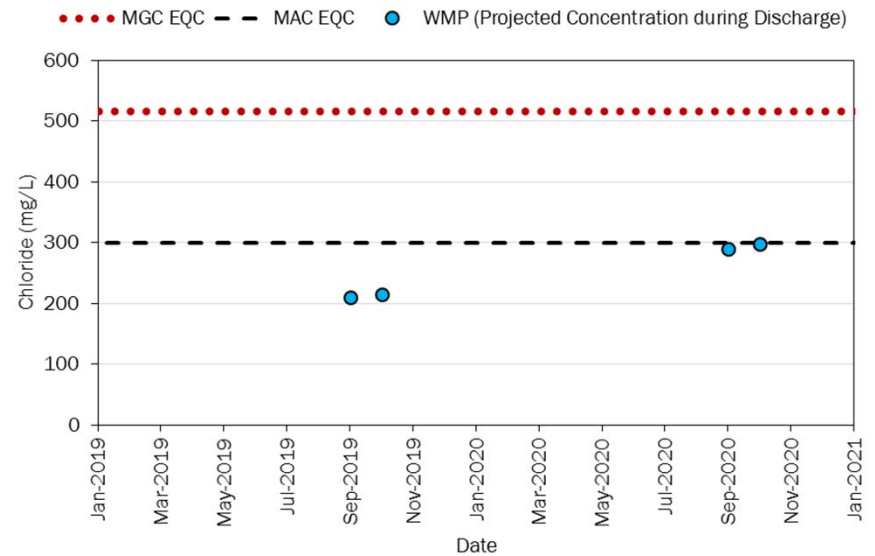
- ECCC-3 and GNWT-ENR-28
  - De Beers does not propose EQC for faecal coliforms for Lake N11

# EQC FOR LAKE N11 - CHLORIDE

a) EQC in Water Licence MV2005L2-0015

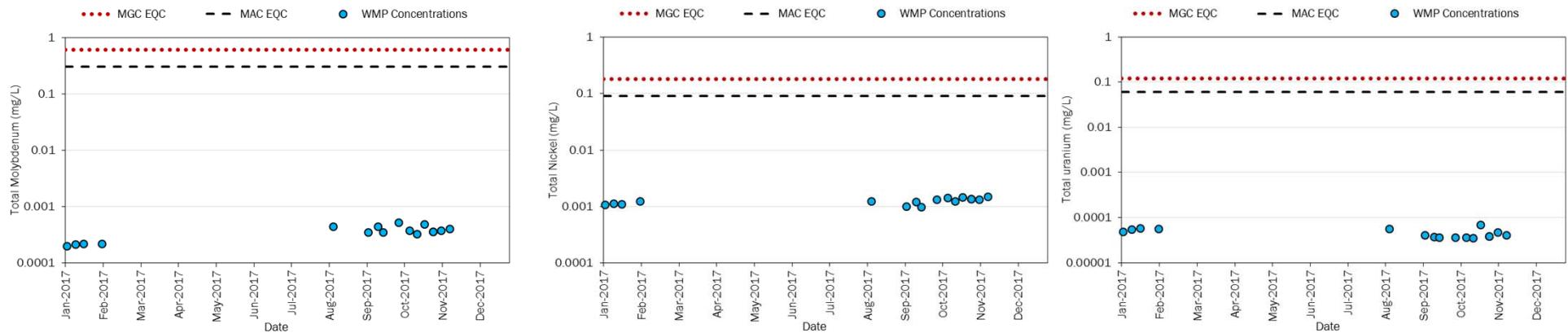


b) Proposed EQC



- GNWT-ENR-12, GNWT-ENR-21 (total aluminum), GNWT-ENR-23 (total copper), GNWT-ENR-24 (total iron)
  - The water quality model outputs results on a monthly timestep
  - The maximum average concentration EQC of 160 mg/L is projected to be exceeded (Figure a)
  - The maximum average concentration EQC of 300 mg/L is required (Figure b)

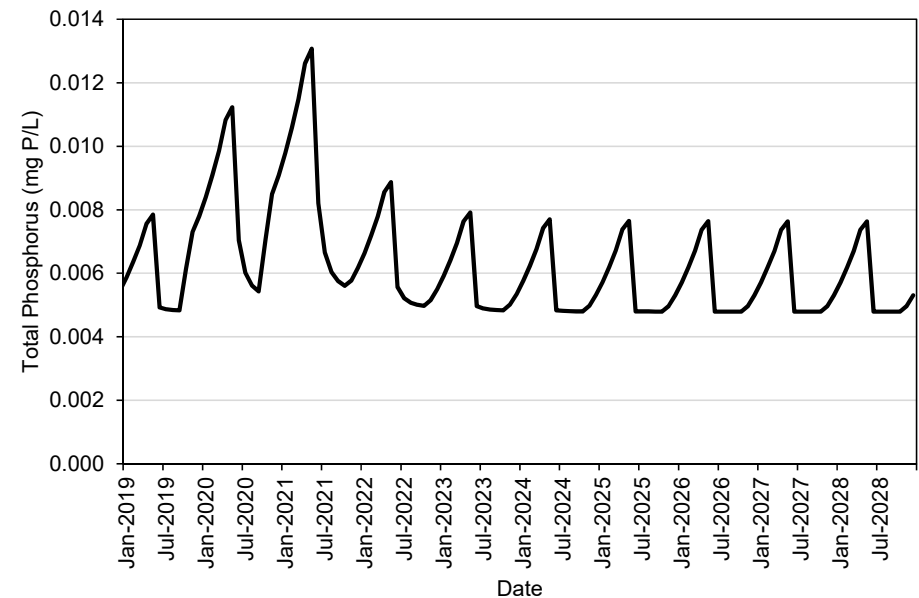
## EQC FOR LAKE N11 - TOTAL MOLYBDENUM, NICKEL, AND URANIUM



- GNWT-ENR-25, GNWT-ENR-26, GNWT-ENR-27 and ECCC-12
  - Total Mo, Ni, and U were not retained in version 2 of the EQC Report (De Beers 2014)
  - Total Mo, Ni, and U were added to the list of POPC that required EQC by the MVLWB because of uncertainties in water quality model predictions (MVLWB 2014)
  - Based on monitoring data in the WMP, it is not necessary to retain total Mo, Ni, and U as a POPC that requires EQC in the Water Licence
  - De Beers currently monitors a full suite of parameters during discharge from the WMP to Lake N11

## TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE N11

- GNWT-ENR-20
  - There are two sources of TP loading to Lake N11
    - Natural inflows from the Lake N11 watershed (100 kg/yr)
    - Proposed discharge from the WMP (58 kg/yr and 73 kg/yr)
    - TP concentrations in Lake N11 are projected to increase
- TP concentrations in Lake N11 are projected to exceed the SSWQO of 0.0109 mg P/L for a very short period of time during the ice-cover season
- With the cessation of discharge from the WMP to Lake N11, TP concentrations are projected to decrease to concentrations below the SSWQO
- De Beers has also proposed a reduction in the TP MAC EQC and MGC EQC from 0.03 mg P/L to 0.022 mg P/L and from 0.06 mg P/L to 0.03 mg P/L



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**THANK-YOU**

