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MEMORANDUM

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Mine Waste Management Limited (MWM) has provided this memorandum to Matakanui Gold Limited for the proposed Bendigo-Ophir Gold Project (BOGP Project). MWM has been engaged to provide advice regarding quality assurance / quality control (QA/QC) of water quality data loaded into the BOGP water quality database. It is recommended that the following issues are considered for QA/QC:

- Quality assurance (QA) of data is required.
- Quality control (QC) including duplicate samples, replicate testing, blanks, and water reference standards should be used.
- Quality assurance of data is required.
- Management of limits of reporting (LOR).
- Ensuring the LOR is appropriate for the potential constituents of concern (PCOC) to confirm whether they are elevated against recommended water quality guidelines.
- Analysis of data to confirm whether further ongoing testing is required if results are consistently lower than the recommended water quality guidelines.

BACKGROUND

An important aspect of ensuring data are suitable and meet the data quality objectives (DQOs) is to undertake QA/QC where:

- Quality assurance (QA) is defined as the system of documented processes and procedures that ensure quality and includes aspects including training, equipment calibration, sampling procedures, and record-keeping.
- Quality control (QC) is defined as the operational activities that confirm the quality assurance methods are functional, and that the information collected is accurate, precise, and properly recorded.

This memorandum provides advice on QA/QC of water quality data once it is entered into the water quality database. It assumed data management processes are appropriate to avoid the input of

erroneous data and that transcription errors are avoided. It is assumed that all chain of custody (COC) forms and certificates of analysis (COA) are stored and are filed in a logical manner to provide proof of data should it be queried.

QUALITY CONTROL

For duplicate samples, replicate testing of the same sample, and inter-laboratory duplicates, a quantitative measure of the variability (or reproducibility of the data) should be undertaken (e.g., precision). Precision should be measured by the relative percent difference (RPD). Note: Small concentration changes at low analyte concentrations (typically defines as <10x LOR) will result in larger calculated variations in precision – the significance of this large change should be considered in the context of the DQOs (e.g., Standards Australia, 2005).

A quantitative measure of the closeness of reported data to the true value is required (e.g., accuracy). One way to determine accuracy of the dataset is to compare the ionic balance of water samples for reference samples and duplicates. This approach provides a larger dataset (rather than one measurement) to consider accuracy.

Recommended QC:

- Calculation of RPD for duplicate samples, replicate samples, inter-laboratory duplicate samples where:

  $$RPD = [(R1 - R2) / ((R1 + R2)/2)] \times 100$$

  Where:

  R1 is sample 1; and

  R2 is sample 2.

- Where a RPD of ≤20% should be used as an indicator for determining appropriate discrepancies between laboratories. A RPD of ≤20% was adopted as:
  - the samples were taken at the same time; and
  - the water samples are expected to be homogeneous.
- Calculation of ionic balance (IB) for duplicate samples, replicate samples, and inter-laboratory duplicate samples where:
  - Measured ion concentrations are first converted to milliequivalents per litre (meq/L):

    $$Meq/L = (C/MW)*V*1000)$$

    Where:

    C is the concentration in mg/L;

    MW is the molecular weight in g/mol; and

    V is the valence of the substance

- Iron and manganese are both assumed to have charge of +2, because the ferrous and manganous species of these elements are the primary water-soluble forms.
- Positively charged ion concentrations are summed to obtain a Cation Sum, and negatively charged ions are summed to obtain an Anion Sum.
- An ionic balance (IB) (Charge balance) is determined by:

$$IB = [(\Sigma Cation\ (meq/L) - \Sigma Anion\ (meq/L)) / (\Sigma Cation\ (meq/L) + \Sigma Anion(meq/L)] \times 100$$

- An Ionic Balance of <10% is considered reasonable.

QUALITY ASSURANCE

Data should undergo quality assurance processes including graphical analysis to identify outlier/anomalous samples. For projects involving the disturbance of sulfide minerals this should include:

- Comparison of field pH and EC to laboratory pH and EC
- Time series plots of PCOC concentrations to identify outliers with checks against water quality guidelines to identify parameters that are elevated.
- Evaluation of sulfate concentrations versus PCOC concentrations to understand any relationships and identify outlier data (noting sulfate is often correlated with other contaminants at mining operations where sulfide minerals are disturbed).
- Evaluation of pH versus metal concentrations. Assessment of pH can be a useful guide to the reliability of data and if metals remain elevated above typical metal hydrolysis pH values (Table 1) then the data reliability should be considered.
- Comparison of Total N measurements against the sum of nitrogenous compounds (Nitrite-N, Nitrate-N, Ammoniacal-N).

Table 1. Minimum metal hydroxide solubility.

Metal	pH corresponding to minimum metal hydroxide solubility
Ferric iron, Fe^{3+}	~3.5
Antimony, Sb^{2+}	4.2
Aluminium, Al^{3+}	4.5
Lead, Pb^{2+}	6.5
Copper, Cu^{2+}	7.0
Ferrous iron, Fe^{2+}	8.0
Zinc, Zn^{2+}	8.5
Nickel, Ni^{2+}	9.3
Cadmium, Cd^{2+}	10.0
Manganese, Mn^{2+}	10.6

Source: INAP (2014).

When outlier/anomalous samples are identified by the QA process, the first step is to check the laboratory COA and confirm there are no transcription errors (i.e., data not loaded into the database correctly). If the reported data are correct, then the next step is to query the issue with the laboratory requesting the data management procedures are checked and for the sample to be retested. If the results are the same, then another confirmatory sample may need to be submitted. If this is not possible then the data should be presented but not used (unless conservative assumptions are being used), with an explanation of why the data are considered erroneous.

LIMITS OF REPORTING

Limits of reporting (LOR) need to be considered as being suitable or whether lower limits are required. For instance:

- Ensuring the LOR is appropriate for the PCOC to confirm whether they are elevated against recommended water quality guidelines. If water quality guidelines are lower than the LOR, then lower LORs may be required.
- However, consideration should be given to practical quantification limits (PQLs). For instance, the typical LOR for HS^-, Hg, and Ag is often higher than ANZG (2018) guidelines and lower LOR are often not practical.
- LOR need to be clearly recorded in the database noting that LOR can change between laboratories and analytes. Preference is that the '<' symbol is maintained in the database and post processing outside the database (e.g., for analysis purposes) converts this to a number than can be used (e.g., ½ the LOR) with the conversion process clearly explained.

PCOC MONITORING REQUIREMENTS

Generally, if any parameter is within 50% of the adopted trigger limits (e.g., resource consent limits or the ANZG (2018) guideline limits, etc) they are considered potentially elevated and ongoing monitoring is recommended to confirm trends and/or potential hazards. This approach is similar to using 50% of maximum acceptable value (MAV) for drinking water where it is used as a screening level for follow up action (NZ Government, 2022).

If there is a robust water quality database available for a project that includes:

- Multiple sites within the project area to understand typical PCOC concentrations including critical locations;
- Assessment of mineralised and unmineralised areas to understand typical PCOC concentrations;
- Assessment of areas affect by historical mining activities and areas not affected by historical mining activities;
- At least two years of monthly monitoring data[1] (to address seasonality) during different flow regimes (low, median, and high flow);

[1] *ANZG (2018) notes that site-specific guideline values should be based on at least 2 years of monthly monitoring data from an appropriate site: https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/reference-data*

- Trend analysis to confirm no increasing trends for PCOC or high variability of results;
- Evaluation of whether changes have occurred within the catchment that could affect PCOC concentrations;
- Approval of recommended water quality limits by a subject matter expert in ecotoxicity,

then it would be reasonable to cease routine analysis for the PCOC that are > 50% of the recommended water quality compliance criteria for the BOGP (i.e., a MEQ < 0.5). These proposed water quality criteria are provided in Ryder (2025).

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at +64 3 242 0221 or paul.weber@minewaste.com.au should you wish to discuss this memorandum in greater detail.

REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZG) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra.

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