



Bureau of Mining Regulation and Reclamation

WASTE ROCK, OVERBURDEN, AND ORE CHARACTERIZATION AND EVALUATION

22 March 2019

Waste rock, overburden, and ore shall be representatively evaluated for its potential to release pollutants to the environment and for its acid generation/neutralization potential pursuant to Nevada Administrative Code (NAC) 445A.396 and NAC 445A.414. The material shall be managed appropriately based on its potential to degrade Waters of the State (WOTS), specific site conditions, and ultimate placement location. Initial characterization results, methods to be utilized for sample collection and evaluation going forward, and proposed actions to mitigate potential acid generation and any other release of pollutants, as warranted, must be included in a Waste Rock Management Plan (WRMP). The WRMP must be submitted with the Water Pollution Control Permit (WPCP) application, pursuant to NAC 445A.396 or as required by the Nevada Division of Environmental Protection (the Division), Bureau of Mining Regulation and Reclamation.

It is the responsibility of the applicant or Permittee to ensure use of a Division-Approved and/or -Certified laboratory; and to request the laboratory use appropriate analytical methods to ensure future data acceptability by the Division. A listing of the Nevada-approved and/or Nevada -certified laboratories may be found on the Division website at <https://ndep.nv.gov/water/lab-certification/info-resources/mining-labs>.

Initial rock characterization data collected during the exploration phase of the project may be used, if appropriate analytical methods are performed or if the Division approves a representative correlation study between the methods used and the Division-approved methods.

An expansion of a pit, underground workings, or other new mining area must be representatively characterized and approved by the Division prior to the onset of mining, because previous characterization may not be applicable for the new area. The samples must be collected within the proposed new mining area and must be chemically and spatially representative (as reasonably possible) of the entire range of materials that will be encountered during mining. If a pit lake is predicted to form after the cessation of mining, samples in close proximity to the final pit wall will be required for characterization and incorporation into the ground water model and pit lake(s) study.

In accordance with NAC 445A.XXX (Definition of waste rock effective 30 August 2018; Number not yet defined), overburden and any other material that is mined as part of the process to reach the ore, but from which a metallic mineral of economic value cannot be extracted at the time that it is mined, are considered to be waste rock, and must be evaluated per the requirements for waste rock in this guidance.

Please review and utilize the Reporting Guidelines at the end of this document to allow the Division to more efficiently review the submittal and subsequently decrease the time required for the issuance of a Water Pollution Control Permit.

SAMPLE COLLECTION

For this evaluation to be meaningful, the sample material must be representative of the entire range of material(s). Characterization must be completed for all the following where applicable:

- a. Waste rock, all geochemically distinct type based on lithology, alteration and mineralization;
- b. Ore:
 - i. Mill grade;
 - ii. Heap leach material;
- c. Tailings, reject or off-spec material;
- d. Ultimate pit wall and pit floor rock;
- e. Pit backfill rock (above and below groundwater rebound elevation*);
- f. Underground backfill (above and below groundwater rebound elevation*):
 - i. Cemented paste backfill (all ingredients separately and combined));
 - ii. Cemented waste rock;
 - iii. Waste rock;
- g. Cap/cover materials (identified site-specific sources).

*The Division may require a minimum vertical distance above or below the predicted groundwater rebound elevation for placement of certain materials.

The following factors must be considered in establishing a representative sampling program:

- a. Sampling density and frequency;
- b. Sample size;
- c. Lithological variation;
- d. Hydrothermal alteration types and extent;
- e. Mineralogical variation;
- f. Extent and variation of sulfide mineralization;
- g. Degree of fracturing;
- h. Degree of oxidation;
- i. Extent of secondary mineralization;
- j. Presence/mass of evaporative mineral precipitates (EMPs) on rock surfaces;
- k. Final disposition (ore, waste, pit wall, pit floor, pit backfill, underground backfill, etc.);
- l. Historical environmental context (e.g., former mine sites with known issues/concerns).

Use of existing or operational samples in rock characterization:

- a. Drill core and/or rock chip samples of ore and waste collected during initial ore body definition may be used for preliminary material characterization. Pulps are acceptable for the Nevada Modified Sobek Procedure and mineralogical analysis. Pulps are not acceptable for Meteoric Water Mobility Procedure and Humidity Cell Tests.
- b. All samples used in the evaluation must be from the volume of rock to be mined or immediately adjacent thereto.

- c. Illustrations must be included using cross-sections showing sample locations relative to the current and proposed mining limits.
- d. During mining (after Division approval), analyses may be required from blast-hole samples that have been sent to the assay lab.
- e. The Division may require all of a portion of the blast-hole materials to be retained and representatively composited, as appropriate, during the quarter for on-going evaluation of waste rock and ore character.
- f. During mining, (after Division approval), sampling may also be required during the quarter from the waste rock dump where material has been placed.

PLEASE NOTE: If the analytical laboratory is not approved or certified, as applicable, the Division will not accept data for the analyses in question and will require re-testing, re-sampling, and/or re-analysis by a Nevada-approved and/or Nevada-certified laboratory, as applicable, unless the Permittee has received prior Division approval.

A listing of the Nevada-approved and/or Nevada-certified laboratories may be found on the Division website here: <https://ndep.nv.gov/land/mining/regulation/guidance-policies-references-and-requirements> and here: <https://ndep.nv.gov/water/lab-certification/info-resources/mining-labs>

Definition of Nevada-certified vs Nevada-approved

The Lab Certification Branch of the Bureau of Safe Drinking Water manages the Nevada-certified and Nevada-approved methods and procedures.

Nevada-certified is mandatory, enforceable by regulation NAC 445A, certified labs must abide by our regulations and follow State law. Methods and procedures that are certified when meeting all requirements for compliance.

Nevada-approved is for methods that cannot meet the regulatory definition of certified but the Division has approved the methods or procedures based upon review of standard operating procedures and an acceptable on-site assessment and participation in performance evaluation studies where available. Participation of laboratories in a Nevada-approved method is voluntary but the lab must be deemed Nevada-approved for the Division to accept the data. The Nevada-approved methods are the only methods that BMRR will accept for Permitting and compliance unless prior approval has been granted.

CHARACTERIZATION AND EVALUATION PROCEDURE

Multi-Element Spectrographic Analysis per NAC 445A.396.4 (a):

The Division has determined that the minimum requirement for a spectrographic analysis is an analysis for Division Profile I constituents from a Meteoric Water Mobility Procedure (MWMP). Additional spectrographic analyses (e.g. ICP-MS, etc.) may be provided to augment the required characterization data but will not be accepted as the only characterization completed.

Evaluation of Samples for the Potential to Releases Pollutants per NAC 445A.396.4 (b):

- I. Collect representative samples and submit a synopsis of the sampling procedures used.
- II. Required minimum analytical requirements, required for all mining operations except placer operations that do not include crushing, shall include the following: MWMP – Profile I and Acid-Base Accounting (Nevada-Modified Sobek Procedure - Alternative I or II).
- III. If any potentially acid generating (PAG) material will be mined or if a pit lake is predicted to form at the site, the Division will require Humidity Cell Testing (HCT) and a complete mineralogical analysis of all rock/alteration/ mineralization types, both ore and waste. The purpose of this effort is to evaluate the potential for acid generation and identify the specific sulfide and non-sulfide minerals (e.g., pyrite, pyrrhotite, calcite, dolomite, quartz, silica, etc.) that are involved in acid generation, neutralization, and encapsulation. Unless otherwise approved by the Division, HCTs (also known as kinetic testing) are also required if a pit lake will form at the project, because they are necessary for geochemical models. These data must be included as part of the WPCP application.
- IV. Mineralogical analysis shall be performed using the following methods (listed below), as appropriate, by a Nevada-approved laboratory or as approved by the Division.
 - A. XRD – X-ray Powder Diffraction;
 - B. SEM – Scanning Electron Microscopy;
 - C. Petrography (reflected light, transmitted light);
 - D. Division Approval Required before analysis:
 1. XRF – X-ray fluorescence;
 2. EDX – Energy Dispersive X-ray;
 3. NIR – Near Infrared;
 4. MLA – Mineral Liberation Analyzer;
 5. EMPA – Electron Microprobe Analysis;
 6. QEMSCAN - Quantitative Evaluation of Materials by Scanning Electron Microscopy;
 7. Other analysis proposed by Permittee.

The purpose of this evaluation is to guide geochemical understanding of the reactions occurring during testing, such that appropriate geochemical modeling can be completed for the site. Sample selection for pre- and post-kinetic testing should be made in conjunction with site-specific guidance from the Division. Mineralogical characterization must include primary rock-forming minerals (e.g., silicates, carbonates, etc.), hypogene minerals (e.g., pyrite, galena, etc.), and supergene (secondary) minerals (e.g., melanterite, coquimbite, etc.).

The table below summarizes the minimum required analysis for mineralogical analysis:

Scenario	Minimum Required Analysis Unless Otherwise Approved
PAG Material	XRD, SEM
PAG Material and Pit Lake	XRD, SEM, optical Petrography (pre and post HCT for all)
Pit Lake and no PAG Material	XRD

- V. The potential to release pollutants shall be evaluated by the MWMP, ASTM International E2242-13, or the most recent version, “Standard Test Method for Column Percolation Extraction of Mine Rock by the Meteoric Water Mobility Procedure”. The extract shall be analyzed for the Division Profile I list of parameters, plus any other parameters/constituents required by the Division on a site-specific basis, (e.g., radio-chemical analysis). In the instance of characterization being completed for pit-lake modeling, the extract shall be analyzed for the Division Pit-Lake Characterization Analytical Profile (Profile I plus Profile III), located on the Division website <https://ndep.nv.gov/land/mining/regulation/guidance-policies-references-and-requirements>. Extraction and analyses must be performed by Nevada-approved and Nevada-certified laboratories, respectively.
- VI. If solution does not percolate through the column, or the material is fine-grained (i.e., tailings, sludge, etc.), see guidance document entitled “Meteoric Water Mobility Procedure Bottle Roll Extraction Option”, located on the Division website <https://ndep.nv.gov/land/mining/regulation/guidance-policies-references-and-requirements>, or Appendix XI of ASTM E2242-13.
- VII. Reporting requirements for the MWMP are located on the Division website, <https://ndep.nv.gov/land/mining/regulation/guidance-policies-references-and-requirements>. This information is required for all MWMP extractions and must be included with all analytical reporting.
- VIII. The potential for acid generation shall be evaluated in accordance with the following testing procedures:
- A. **Static Testing** – also known as Acid-Base Accounting (ABA)
1. Determine Acid Neutralization Potential (ANP) following the most recent version of the Nevada-Modified Sobek (NMS) Procedure located on the Division website, <https://ndep.nv.gov/land/mining/regulation/guidance-policies-references-and-requirements>;
 2. Determine Acid Generation Potential (AGP) by Alternative I or II below, please see the most recent version of the *Nevada Modified Sobek (NMS) Procedure* for more details, summary is provided below:

Alternative I

Determine total sulfur content using LECO-type furnace. All sulfur is assumed to be acid generating. Convert sulfur content to AGP in tons calcium carbonate (CaCO₃) per 1,000 tons material (T/kT) by multiplying percent total sulfur by 31.25. Determine ANP per Section 3.2.3 of the most recent version of the NMS Procedure.

Additional Nevada Requirements

- a) Divide ANP by AGP to determine ratio. If ANP/AGP ratio is less than 1.2, the material is considered potentially acid generating (PAG) and the Division requires sulfur speciation per Alternative II below followed by recalculation of ANP/AGP ratio;
- b) If ANP/AGP ratio is greater than or equal to (\geq) 1.2, no sulfur speciation per Alternative II is required;

Alternative II

Determine the Potential Acid Generating Sulfur content in accordance with procedures described in the most recent version of the NMS Procedure. Convert percent Potential Acid Generating Sulfur to AGP in tons CaCO_3 per 1,000 tons material (T/kT) by multiplying by 31.25. Determine ANP/AGP ratio.

For Sulfur Species that returns a value below the reporting limit (RL) shall be reported quantitatively by listing the RL value preceded by the "<" symbol and the value to be used in the calculations shall be zero.

Reporting requirements for the NMSP are found on page 9 of the NMSP.

B. Kinetic Testing – also known as HCT

1. Scenarios for Kinetic Testing

- If the ANP/AGP ratio is ≥ 1.2 , the Net Neutralization Potential (NNP, or ANP – AGP) is greater than 20 T/kT, and the MWMP extract analysis does not indicate exceedances of Division Profile I reference values (RV) or background for any parameters and no pit lakes will form at the project, then no kinetic testing will be required.
- If a pit lake will form at the project, kinetic testing is required unless otherwise approved by the Division.
- If MWMP analysis indicates exceedances of Profile I RV or background, even though ANP/AGP ratio is ≥ 1.2 and NNP > 20 , kinetic testing may be required, if necessary to define chemical release functions (e.g. groundwater modeling, pit lake modeling). Contact the Division for further details/discussion.
- If ANP/AGP ≥ 1.2 , but NNP < 20 T/kT, kinetic testing may be required. Contact the Division for further details/discussion.
- If ANP/AGP ratio is < 1.2 , kinetic testing is required, unless previously approved otherwise by the Division.

Note: Federal land management agencies, (e.g., U.S. Bureau of Land Management (BLM), U.S. Forest Service) may have different ANP/AGP and NNP limits and requirements. The Division concurs with the use of the most conservative ANP/AGP and NNP limits applicable to the particular mining operation.

ASTM E1915, Net Carbonate Value (NCV) – The NCV method is currently not approved by the Division. Any use of this method will be supplementary to, not in place of, the analyses required by the Division.

Static testing and kinetic testing, as applicable, is required for ore, waste rock, and tailings evaluation but not for metallurgical ore recovery.

The Division has incorporated NNP and MWMP data as criteria for HCT selection to ensure evaluation of samples for the potential to release neutral mine drainage. Neutral mine drainage is characterized as neutral pH and high metals and has a high potential to degrade the waters of the State.

2. Kinetic Testing Protocol

The Division minimum test protocol requirements for HCT are:

- a. Testing protocols (ASTM D5744-13, Option ‘A’, or the most recent approved method). Each test shall continue for a minimum of 20 weeks. **Tests shall not be terminated without Division approval**; if public lands will be affected, federal land management agency approval may also be required.

Test protocol calls for weekly cycles composed of three days of dry air (<10% Relative Humidity (RH)) and three days of water-saturated air (~95% RH) pumped up through the sample, followed by a leach with water on day 7.

Although a test duration as short as 20 weeks may be suitable for some samples, research indicates that test durations well beyond 20 weeks are commonly required depending on the objectives of the test and the test results. Identified test protocols contain specific criteria to determine when tests may end. The determination as to the timeframe for test termination must be made using site-specific considerations such as leachate quality and the consumption rates of acid-generating and acid-neutralizing material. Analytical results shall be submitted to the federal land manager and the Division periodically, the frequency of submittal shall be based on discussion with the applicant. However, Division approval must be obtained prior to terminating each test.

- b. All HCT extractions shall be performed by a Nevada-approved laboratory. All extract analyses shall be performed by a Clean Water Act (CWA) Nevada-certified laboratory.

- c. Minimum Sampling Requirements

- i. Weekly unfiltered sampling and analysis for:

1. Oxidation/reduction potential (mv);
 2. pH (standard units (SU));
 3. Specific conductance ($\mu\text{S}/\text{cm}$);
 4. Alkalinity;
 5. Acidity when pH <5.0 SU ;
 6. Sulfate;
 7. Iron (total, ferric, and ferrous if pH <5.0 SU or iron (total) >0.6 mg/L; otherwise, only iron (total) is required);

8. Dissolved calcium and magnesium.
 - ii. Filtered extracts per the method will be digested and analyzed during weeks 0, 1, 2, 4, and 4-week extracts thereafter (i.e., weeks 12, 16, 20, 24, 28, 32, etc.) for total dissolved concentrations of the Division Profile I or Profile-IR, as applicable, parameters.
 - iii. Final results reported shall include a Division Profile I or Profile-IR, as applicable, analysis of the final leachate.
 - iv. ANP/AGP analysis of the leached material using a LECO-type analysis as specified above may be required depending on HCT results.
 - v. Mineralogical analysis via appropriate methods, (see above) is also required for any PAG material characterized as part of a pit-lake study.

Effective 1 August 2013, any analyses that are submitted to the Division (or BLM) for characterization, permitting, or compliance must be performed by a Nevada-approved and/or Nevada-certified laboratory, as appropriate.

All laboratories performing mining-specific preparation methods and analytical procedures not explicitly covered under the CWA may be subject to approval by the Division pursuant to Nevada Revised Statutes (NRS) 445A.428. All laboratories performing analytical procedures that are explicitly covered under the CWA programs must be certified by the Division per NRS 445A.428. These requirements are a condition of the WPCP.

REPORTING GUIDELINES

To increase the efficiency of the Division's review of characterization data, please use the following guidelines for reporting characterization data.

Please include in your submittal:

1. A summary table of MWMP test results sorted by rock type.
2. A summary table of the static test results sorted by rock type.
Table should include the following columns: Sample Name, Rock Type (based on lithology, alteration, and mineralization), Paste pH, ANP, AGP, (Alt I or II), ANP/AGP, NNP. If Alt II was used, label the sulfur speciation types as required in the most recent update of the Nevada Modified Sobek Procedure.
3. HCT analyses provided in a reviewable format, including weekly results (Part VIII.B.2.a above) and Profile I or Profile-IR, as applicable, analyses (Parts VIII.B.2.b and VIII.B.2.c above) in Excel file format. Within the data file, include the progressive week number and the corresponding extract sample date.
4. Map displaying the sample locations in plan view. Display rock type (based on lithology, alteration, and mineralogy), pit shell and/or underground extents (proposed and current if applicable), and cross section locations.
5. Cross-sections of the characterized areas displaying: existing ground surface, pit shell and/or underground extents (proposed and current if applicable), location of samples (ABA and HCT), rock types, faults.
6. A table showing the percent each rock type will make up in each waste rock dump and the percent of each rock type that will be left exposed in the walls/floor of each mine pit and/or underground workings (before and after any backfill is placed including in-pit waste rock facilities).
7. All analyses provided must be accompanied with the laboratory quality control and quality assurance documentation (Electronic copy consistent with WPCP Part II.E.5.)
8. If any supplemental data in addition to the required characterization was completed, please include all test results in a reviewable format and electronic copy consistent with WPCP Part II.E.5. (e.g. Total Metals, blasthole data)

While the Division will accept other formats for presenting the characterization data, presenting the information as mentioned above will aid in the timely review of the Water Pollution Control Application.