Northern Territory Environment Protection Authority

ENVIRONMENTAL ASSESSMENT GUIDELINES

Acid and metalliferous drainage

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Version 1.2

1 Purpose

This Guideline aims to assist Proponents to define the information requirements of an Environmental Impact Statement (EIS) relating to assessment of potential Acid and Metalliferous Drainage (AMD) from mining and mineral processing materials, including waste rock, tailings, low grade ore stockpiles and open pits.

2 Environmental Objectives

Provide sufficient characterisation to enable assessment of whether the proposed mining operation has potential to produce AMD or other contaminants or materials that present risks to the environment or public health.

Prevent, mitigate or manage potential AMD and other contaminants or materials so that they do not cause environmental or human health impacts during mine operations or legacy issues both on and off site after mine closure.

3 Background

Mining activities involve the excavation and disturbance of materials. Where this material is excavated from below the groundwater table (where oxidation is inhibited), and then exposed to air and water it may undergo natural oxidation of sulfide minerals. AMD is a result of the exposure of some sulfide minerals to oxygen and water, resulting in drainage waters that can be acidic and/or have high concentrations of dissolved metals. The drainage produced from the oxidation process may be acidic or neutral, with or without dissolved heavy metals, but always contains sulfate. Sulfidic ore bodies will likely generate sulfidic tailings, although alkaline processing may ameliorate any AMD potential, in the medium or even long-term, in tailings storage facilities.

Discharge of AMD impacted water can impact surface water and groundwater, and threaten ecological processes, potable water supplies and/or irrigation resources. AMD generation can continue long after mining operations are complete and create legacy issues that remain indefinitely and are difficult and possibly prohibitively expensive to treat. An understanding of the characteristics of materials that are to be excavated and disturbed during mining and mineral processing is required to identify environmental characteristics, and handling limitations for the design and operation of any waste rock, dump or tailings storage facility, and subsequent rehabilitation of these facilities.

4 Information Sources

Australian guidelines relevant to AMD include the following:

- Australian Government Department of Industry Tourism and Resources Leading Practice Sustainable Development Program for the Mining Industry Handbooks:
    - Managing Acid and Metalliferous Drainage (2007);
    - Tailings Management (2007);
    - Water Management (2008);
    - Mine Closure and Completion (2006); and
    - Mine Rehabilitation (2006).
- Queensland Department of Environment and Heritage Protection, Assessment and Management of Acid Drainage (1995);
- Northern Territory Minerals Council (Inc.) and the Mines and Petroleum Management Division of the Northern Territory Government, TEAM NT:

Technologies for Environmental Advancement of Mining in the Northern Territory (2004); and

- The International Network for Acid Prevention sponsored the production of the Global Acid Rock Drainage Guide (GARD Guide) intended to summarise best practices and technology to address AMD issues. While the GARD Guide has a decided North American focus, it provides very useful and detailed information on AMD prediction, prevention, and mitigation.

5 Legislative Requirements

Environmental Impact Assessment may involve assessments and approvals in relation to matters regulated under a range of Northern Territory and Commonwealth legislation. Relevant legislation includes that listed below. The list is indicative of matters related to AMD that may require assessment. It is not exhaustive.

Proponents should carefully review projects to determine legislated requirements relevant to particular projects.

The legislation listed has been used in developing these Guidelines.

- *Fisheries Act*
- *Marine Pollution Act*
- *Mining Management Act*
- *Public and Environmental Health Act*
- *Territory Parks and Wildlife Conservation Act*
- *Waste Management and Pollution Control Act*
- *Water Act*

The Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* provides protection for matters of national environmental significance (NES). The NES matters are:

- World Heritage properties;
- National Heritage Places;
- Wetlands of international importance;
- Nationally threatened animal and plant species and ecological communities;
- Internationally protected migratory species;
- Commonwealth marine areas;
- Great Barrier Reef Marine Park; and
- Nuclear actions (including uranium mines).

The EPBC Act webpage has a search tool that helps determine whether NES matters occur in the area of proposed dredging activity. To generate a map and environmental report on the area refer to:

http://www.environment.gov.au/erin/ert/epbc/index.html

6 Limitations

This Guidance is:

- confined to generic matters relating to AMD and does not address more proposal-specific issues that may be of significance;
- not an instrument for predicting outcomes of deliberations by the NT EPA;
- designed to promote a more certain and consistent approach to assessments; and
- intended to apply to proposals prior to the proponent submitting the proposal to NT EPA for environmental assessment.

The Northern Territory Environment Protection Authority (NT EPA) has prepared this document in good faith, exercising all due care and attention, but no representation or warranty, express or implied, is made as to the relevance, completeness or fitness for purpose of this document in respect of any particular user's circumstances. Users of this document should satisfy themselves concerning its application to their situation and, where necessary, seek expert advice.

7 Investigation

An investigation is required to identify the presence of sulfides and other potential contaminants in material to be mined and processed and, if present, to define their nature, abundance and distribution. The stages should include:

1. Desktop assessment (e.g. geology, hydrology, bore logs);
2. Sampling;
3. Laboratory testing and analysis; and
4. Reporting, including an appropriate management plan.

7.1 Desktop Assessment

Prediction of the geochemical nature of various materials to be mined and processed from a site should commence during the exploration phase of any project. Some information that should be available from the exploration program includes:

- Sulfide content;
- Determination of sulfide types (many but not all sulfides generate acid);
- Presence or absence of carbonates (minerals that consume or neutralise acid); and
- Presence of other potential contaminants, or potentially contaminating process chemicals.

An example of geological information that is relevant to AMD prediction and can be gathered by mine geologists during their exploration programs is presented in Chapter 5 of the GARD Guide (Table 5-2) as listed below:

Geologists Observations and Logging of Core for AMD Analysis

Important data relevant to the prediction of AMD can be gathered during the core logging process. Much of this information is already collected by or can be obtained by interviewing exploration geologists.
Quantitative Data:
Visual sulfide content (primarily pyrite) with an estimate of accuracy
Visual carbonate content with an estimate of accuracy
Semi-Quantitative Data:
Mineralogy, grain size, mode of occurrence of sulfides
Mineralogy, grain size, mode of occurrence of carbonates
"Fizz" reaction of carbonates (strong, weak, none - powdered and unpowdered)
Extent of oxidation, if any, of rocks
Presence of gypsum, barite, graphite or siderite
RQD or other tests of rock competence
Limit of oxidation and supergene zones
Presence of water (depth to water table)
Rock hardness/competence
Qualitative Data:
Presence of secondary sulfate minerals and identification where possible
Weathering or slaking potential (unusual observations such as rapid oxidation or
weathering) in core as recovered or after storage
Potential for breakage along fracture planes and for preferential exposure of sulfides and/or carbonates

Presence of coating on sulfides and carbonates
Potential problems in collecting samples for analysis and testing (e.g., core loss, concentration of holes near ore versus waste, lack of core at depth, difficulty visually segregating different geological units, differences in specific gravity, biasing by sulfide/carbonate stringers, etc.)
Observations at outcrops of deposit (sulfide/carbonate content, extent of weathering, staining, coatings, etc.)
Presence of staining or precipitation in streams or seeps draining the deposit

The desktop assessment should result in the production of a conceptual site model describing potential release, transport, and fate of any AMD waters, or any otherwise contaminated water, or dust, from the mine site, identifying possible sources, pathways, and receptors.

7.2 Sampling

The information required must show that the site has been characterised through sufficient investigations and include the sampling method. This is a critical phase and sufficient samples should be taken to accurately characterise the nature, distribution and variability of critical parameters for each material type, including waste and ore samples. The following information should be provided:

- Details on selection of samples (drill core, drill cuttings, etc.), method of sample collection, and length of time samples have been stored and storage conditions. Ideally, cores and chip samples collected during initial exploration programs should be stored in a cool, dry environment to minimise any weathering before testing;
- Total sulfur and total metals and salts for a representative suite of samples from all rock types and process materials;
- The number of samples will be project-specific and sampling intensity will depend on a number of factors including:
    - Geological variability and complexity in rock types;
    - Information and experience from adjacent or geologically comparable mine sites;
    - Potential for significant environmental or health impacts;
    - Size of the operation;
    - Relative costs;
    - Statistical requirements to ensure samples are representative; and
    - Volume of each waste rock type, ratio of waste to ore and mining method.

7.3 Laboratory Analysis

A geochemical testing program should be performed on samples of mine waste and ore (or simulated tailings) to determine current and potential long-term geochemical characteristics of the materials. There are a number of prediction tests that can be used to determine the reactivity of materials and the likely composition of seepage waters, and these can be divided into two basic types –static and kinetic.

7.3.1 Geochemical Static Tests

Geochemical static tests are simple, rapid and relatively inexpensive to carry out. All tests measure readily soluble constituents of mine materials and provide a snapshot in time of a material's environmental physicochemical properties and stability. They include:

- pH;
- Electrical conductivity;
- Total Sulfur;
- Acid Neutralisation Capacity (ANC);
- Acid Base Accounting (ABA);
- Net Acid Production Potential (NAPP);
- Net Acid Generation (NAG);
- Multi-element composition; and
- Mineralogy, including total metals and salts.

7.3.2 Kinetic Tests

Kinetic tests are used to confirm the findings of the static tests and predict long-term weathering rates. Both acid generation and metal leaching can be evaluated through kinetic testings. They involve controlled simulated weathering under laboratory conditions to mimic oxidation reactions or on-site conditions. Kinetic tests, including humidity cells and column leach tests can take a long time to provide meaningful results and must be designed and operated correctly to simulate field exposure conditions. An appropriately qualified and experienced person should be involved with the supervision and interpretation of kinetic test results.

"*Kinetic leach tests need to operate for at least 6 months, and typically 12 to 24 months, before sufficient data are available for effective interpretation of the AMD characteristics of a material.*"

7.4 Report

Report should include:

- Information on the regional geology of the site, including the lithology identified and the volumes that will be mined;
- Number of samples collected from each identified lithology;
- Geochemical testing methodology utilised; and
- Metal leaching characteristics.

Based on the above information waste management criteria should be defined and a block model developed. A waste management plan should also be developed which

includes a mine waste schedule, handling procedures and storage locations for both operational and closure phases. The detailed long-term closure options for storage of PAF and otherwise contaminating wastes and the management of potential AMD and other potential contaminants would also be addressed.

8 Management Strategies

Appropriate management strategies must be detailed in the EIS, to show how potential AMD and other potential contamination would be prevented, mitigated or managed.

These could include:

- Minimising disturbance;
- Segregation, encapsulation, burial and isolation of wastes with a potential to contaminate;
- Appropriate cover designs to minimise oxygen and/or water ingress into the stored wastes;
- Chemical amelioration;
- Pyrite removal; and
- Collection and treatment of AMD or otherwise contaminated water, when prevention has not been possible.

For specific management options it would be appropriate to discuss:

- Waste material management and impoundment principles should be described, addressing surface configurations, wall/pad designs and construction, estimated flood heights and provisions for extreme rainfall and flood events, erosion protection, subdrainage and collection sumps.
- Details should be provided of any liners proposed for storage facilities on site, including ore stockpiles, waste rock dumps, tailings storage facilities, sediment ponds and spent heap leach material.
- Detailed operational guidelines should be developed, integrating potential AMD and other potential contaminant management practices into daily operating activities.
- Designs selected for all storage facilities should be described and justified, with emphasis on the prevention or mitigation, rather than treatment of potential impacts.
- The oxygen and water permeability of all waste storage facilities should be predicted and supported, and likely oxygen diffusion and water percolation rates calculated.
- Vertical and horizontal permeability data through the geological strata underlying the proposed waste storage facilities should be established, to enable appropriate design and construction.
- Construction quality control for waste storage facilities should be developed and operational guidelines detailed that integrate potential AMD and other potential contaminant management practices into daily operating activities.
- The capacity of the underlying geology to neutralise any acid and/or metalliferous seepage outputs should be estimated and supported.

- The final mined landform, rehabilitation and revegetation plans and long-term closure options for the management of potential AMD and other potential contaminants should be described.

9 Monitoring

A program is required to monitor the performance of measures to prevent and mitigate potential AMD and other potential contaminants, together with descriptions of the monitoring components, and including the following:

- Monitoring of geochemical and geotechnical characteristics of placed waste;
- Recording of the placement of different waste types, as planned;
- Monitoring the bioaccumulation of metals or other identified parameters in aquatic fauna downstream of the waste storage facilities;
- Monitoring of surface and groundwater quantity and quality upstream and downstream of the waste storage facilities, in such a way as to provide early detection of oxidation, AMD, and generation and transport of other contaminants, together with trigger levels and management actions in the event that these are exceeded; and
- Monitoring the performance of final covers.

10 Closure Planning

Geochemical and geotechnical characterisation of waste materials must be carried out prior to project approval to a sufficient level of detail to develop a workable closure plan. This is fundamental to effective closure planning. For existing operations, this work should start as soon as possible. Characterisation of waste materials should include the identification of materials with potential to produce acid, metalliferous or saline drainage, dispersive and sodic materials, as well as benign materials intended for use in mine rehabilitation activities.

11 Further Information

These guidelines have been produced to provide relevant parties with NT specific information. For more information, please contact:

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12 References

Australian Government Department of Industry Tourism and Resources Leading Practice Sustainable Development Program for the Mining Industry Handbooks: http://www.ret.gov.au/resources/resources_programs/lpsdpmining/handbooks/Pages/default.aspx

- Managing Acid and Metalliferous Drainage (2007);
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- Water Management (2008);
- Mine Closure and Completion (2006); and
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International Network for Acid Prevention, 2009. Global Acid Rock Drainage Guide GARD Guide: http://www.gardguide.com/

Northern Territory Minerals Council (Inc.) and the Mines and Petroleum Management Division of the Northern Territory Government, 2004. TEAM NT: Technologies for Environmental Advancement of Mining in the Northern Territory: Toolkit: http://www.nt.gov.au/d/Minerals_Energy/Content/File/Forms_Guidelines/TEAM_NT_Toolkit.pdf

Queensland Department of Environment and Heritage Protection, 1995. Assessment and Management of Acid Drainage: http://www.ehp.qld.gov.au/land/mining/pdf/tech-guidelines-env-management-mining-b-12.pdf