PAF & AMD Management Procedure
Environment

1 Purpose and Scope

This procedure specifies the operational environmental requirements relating to the management of Potentially Acid Forming (PAF) and Acid and Metalliferous Drainage (AMD) at the Roy Hill Project. This procedure applies to all personnel involved in activities at the Mine, Rail and Port operations that affect PAF and AMD management.

1.1 Background

AMD has traditionally been referred to as 'acid mine drainage' or 'acid rock drainage'. At some sites, near-neutral but metalliferous drainage can be just as difficult to manage as acid water. There are sites where acid generation has been adequately neutralised by natural mineral assemblages, effectively stripping the water of toxic metals, but leaving a highly saline leachate.

AMD can display one or more of the following chemical characteristics:

- Low pH (typical values range from 1.5 to 4);
- High soluble metal concentrations (such as iron, aluminium, manganese, cadmium, copper, lead, zinc, arsenic and mercury);
- Elevated acidity values (such as. 50–15,000 mg/L $CaCO_3$ equivalent);
- High (sulfate) salinity (typical sulfate concentrations range from 500–10,000 mg/L; typical salinities range from 1,000–20,000 µS/cm);
- Low concentrations of dissolved oxygen (such as less than 6 mg/L); and
- Low turbidity or total suspended solids (combined with one or more of the above).

Key indicators of AMD presence include:

- Red coloured or unnaturally clear water;
- Orange-brown iron oxide precipitates in drainage lines;
- Death of fish or other aquatic organisms;
- Precipitate formation on mixing of AMD and background (receiving) water, or at stream junctions;
- Poor productivity of revegetated areas (such as waste rock pile covers);
- Vegetation dieback or soil scalds (such as bare areas); and
- Corrosion of concrete or steel structures.

At Roy Hill, the potential for metalliferous drainage has been investigated by Soil Water Consultants (2010), which identified that, whilst some metals occur in relatively high concentrations in the solid phase (above the ecological investigation limit), they are typically strongly held on the soil particles or in the crystal mineral structure and therefore not available to leaching solutions, even under highly acidic conditions. Therefore, the waste materials to be mined will have a low potential to generate metalliferous drainage when disturbed.

Roy Hill has conducted further peer reviews of PAF/AMD to ensure all risks are understood. The most recent review identified that Alunites, Nammuldi Waste Zone and the Roy Hill Shale require further static and kinetic testing.

2 Procedure

2.1 Management Actions

2.1.1 Identification of PAF/AMD

1. Sample for sulphur and other metals known to cause AMD (arsenic, selenium, manganese etc.) during resource drilling programs.
2. Interrogate the Roy Hill Geodatabase to produce histograms (with associated univariate statistics) of "S" hits of over 0.1% for the major lithologies to be produced during open-pit mining.
3. Prepare cross-sections displaying the down-hole profile of sulphur (arsenic, selenium, manganese etc.) for the mine-waste-zones (i.e. exclusive of ore-zone), together with geology, pit-shell and pre-mining watertable.
4. Develop a specific PAF/AMD management plan, if PAF/AMD material has been identified to be disturbed, to ensure all environmental impacts are proactively managed.
5. Conduct detailed resource definition drilling within mining areas that identifies hits of sulphur and other metals known to cause AMD.
6. Develop accurate "ore block" model highlighting PAF and ACM materials to identify PAF/AMD material during ongoing mining activities and ensuring basal blanket material is identified.
7. Testing the acid formation potential of tailings in line with the Tailings Operating Manual.
8. Ensure all PAF material is placed into the appropriate mine plans and schedule so it is placed into future backfilled pits within the saturation zone (i.e. pit floor) with minimal rehandle.
9. Ensure Acid Consuming Material (ACM), for example calcrete, is selectively mined and stockpiled for treatment of mined AMD material.

2.1.2 Disposal of excavated PAF materials

1. Extraction of the ore without disturbing the PAF/AMD material should occur, where practicable, through the use of alternative mining techniques (including surface miners and small digging appliances).
2. Alternative mining techniques should restrict the risk of blasting operations disturbing the underlying shale material.
3. In the case that PAF material has been excavated, the material will require disposal. The material needs to be isolated from oxygen and water to reduce the likelihood that the PAF material will oxidise and produce acid drainage.

4. The PAF material will need to be encapsulated with ACM and inert material that prevents infiltration of stormwater and exposure to atmospheric conditions.
5. All PAF/AMD material mined should be preferentially placed immediately to an in-pit store and covered with a basal blanket of calcrete. The location should be as such that it will be eventually within the future saturation zone (preferably the pit floor).
6. Where the immediate placement of PAF/AMD material within the future saturation zone, cannot be achieved then the following shall occur:
   - A temporary store shall be created close to the final disposal pit to reduce double handling;
   - A basal-blanket of calcrete would likely need to be employed upon which the reactive mine-wastes are placed. Bunding around the perimeter of this basal-blanket would be needed for the containment of runoff generated from the pile of reactive mine-wastes during episodic, intense wet-spells;
   - Surface water formed in the temporary store should be left to evaporate unless there is a structural integrity risk to the store;
   - Reactive materials shall be rehandled once in-pit backfill opportunities are available. The material must be placed within the future saturation zone; and
   - It is undesirable for any PAF/AMD to remain in above ground Waste Rock Dumps at closure due to the increased environmental management techniques required (infiltration control for secure isolation of the PAF units and erosion control, so that the PAF units do not become exposed over time).

2.2 Training and Awareness

1. Specific PAF/AMD training shall be given to the Mine Geology Team and Operations to ensure PAF/AMD material is avoided or handled correctly by the Roy Hill Geology Team.
2. Annual toolboxes topics covering PAF/AMD identification and AMD environmental impacts will be held by the Roy Hill Environment and Geology Teams for Roy Hill Operations Team.

2.3 Monitoring Actions

1. Superintendent Hydrogeology is responsible for regular water quality monitoring of down gradient groundwater bores for increasing trends of AMD indicators (pH, SO_4, Cl, HCO_3 (if pH > 6), acidity (if pH < 5), Mn, Mg, Ca, and Fe).
2. The Superintendent Orebody Modelling and Superintendent Rehabilitation Mine are responsible for conducting ongoing static and kinetic testing to further understand the PAF/AMD risks associated with Alunites, Nammuldi Waste Zone and the Roy Hill Shale.
3. Superintendent Metallurgy is responsible for testing the acid formation potential of tailings in line with the Tailings Operating Manual.
4. Superintendent Rehabilitation (or delegate) is responsible for monitoring the placement of PAF/AMD materials within permanent backfilled pit locations.

2.4 Incidents, Audits and Inspections

1. Superintendent Rehabilitation Mine is responsible for regularly inspecting temporary aboveground PAF/AMD material stores.
2. Superintendent Mine Geology is responsible for inspecting in-pit geology to ensure PAF/AMD materials are not being disturbed, where possible.
3. All non-compliances with this procedure are to be reported as an incident in accordance with the Incident Reporting and Investigation Procedure (100RH-0000-HS-PRO-2004).

2.5 Contingency Actions

1. If PAF/AMD material is disturbed then basal-blanket of calcrete would likely need to be employed upon which the reactive mine-wastes are placed.
2. All disturbed PAF/AMD material must be placed back into backfilled pits in the saturation zone (preferably pit floor).

2.6 Reporting Requirements

1. Incident, compliance and audit reporting must occur in accordance with the Incident Reporting and Investigation Procedure (100RH-0000-HS-PRO-2004).
2. Locations of Identified PAF materials and incidents recorded in GIS and included in Annual Environmental Report to Department of Mines and Petroleum (DMP) and Department of Environment Regulation (DER).

3 Accountabilities

Unless otherwise specified, the following roles are accountable or responsible for the activities outlined in this procedure.

Role	Responsibility
General Managers	Accountable for ensuring that resources are available to support the implementation of this procedure where it is relevant to their area of responsibility
Managers	Accountable for the implementation of this procedure where it is relevant to their area of responsibility
Superintendents	Responsible for the implementation of this procedure where it is relevant to their area of responsibility
Environment Team	Responsible for review and update of this procedure

Table 1: Accountabilities

4 Abbreviations

Abbreviation	Definition
ACM	Acid Consuming Material
AMD	Acid Mine Drainage
ARD	Acid rock Drainage
DER	Department of Environment Regulation
DMP	Department of Mines and Petroleum
GIS	Geospatial Information System
NAF	Non-acid Forming
PAF	Potentially Acid Forming

Table 2: Abbreviations used in this procedure

5 Definitions

Term	Definition
Acid Consuming Material	Material that has the capacity to reduce the acidity due to it alkaline properties.
Acid Mine Drainage (AMD) and Acid rock Drainage (ARD)	Low pH drainage derived from materials with an insufficient capacity to neutralise the acidic products of sulphide and elemental sulphur oxidation and the dissolution products of acidic minerals.
Acid Neutralising Capacity (ANC)	A general term for a sample's or a material's capability to neutralize acidity.
Block Model	A three dimensional model of the distribution of ore and waste materials based on their geological composition.
Calcrete	Naturally formed $CaC0_3$ that can be used to neutralise acids
Kinetic test	Procedure used to measure the magnitude and/or effects of dynamic processes, including reaction rates (such as sulfide oxidation and acid generation), material alteration and drainage chemistry and loadings that result from weathering.
Lithology	A soil or rock type defined by a distinct set of physical and mineralogical characteristics.
Metalliferous drainage	A form of Acid and Metalliferous Drainage (AMD), characterised by near-neutral pH, elevated heavy metal concentrations, high sulfate salinity.
Operational Environmental Requirements	A plan, procedure or work instruction that must be complied with.
Potentially Acid Forming (PAF)	Material that has the geochemical properties to produce acidic leachate.
Static test	Procedure for characterising the physical or chemical status of a geological sample at one point in time. Static tests include measurements of mineral and chemical composition and the analyses required for Acid Base Accounts.
Waste Rock	Rock with insufficient amounts of the economically valuable elements to warrant its extraction, but which has to be removed to allow physical access to the ore. Waste rock is typically blasted into smaller particles to allow its removal by truck and shovel.

Table 3: Definitions

6 References

Document number	Title
000RH-0000-EN-PLN-0003	Rehabilitation Management Plan
100RH-0000-HS-PRO-2004	Incident Reporting and Investigation Procedure
Department of Industry, Tourism and Resources - 2007	Managing Acid and Metalliferous Drainage
Department of Mines and Petroleum - 2009	Acid Mine Drainage
SMEC - 2009	Roy Hill Acid Mine Drainage Management Plan
Soil and Water Consultants - 2010	Soil and Waste Characterisation
Graeme Campbell and Associates - 2014	Review of Previous Geochemical Investigations for Mine-waste Management and Closure Planning & Suggested Approach for Follow-up Testing

Table 4: References

Note that up-to-date environmental documents should be accessed from the e-Care Roy Hill intranet portal to ensure that the current version is being used.

7 Review

This Procedure is to be reviewed as follows:

- Following the grant of or modification to relevant approvals;
- Annually; or
- As a result of findings or actions identified through inspections, audits and incident reporting.

Reviews are to examine the appropriateness of this Procedure, taking into consideration corporate, system and compliance requirement changes since the last review was undertaken.

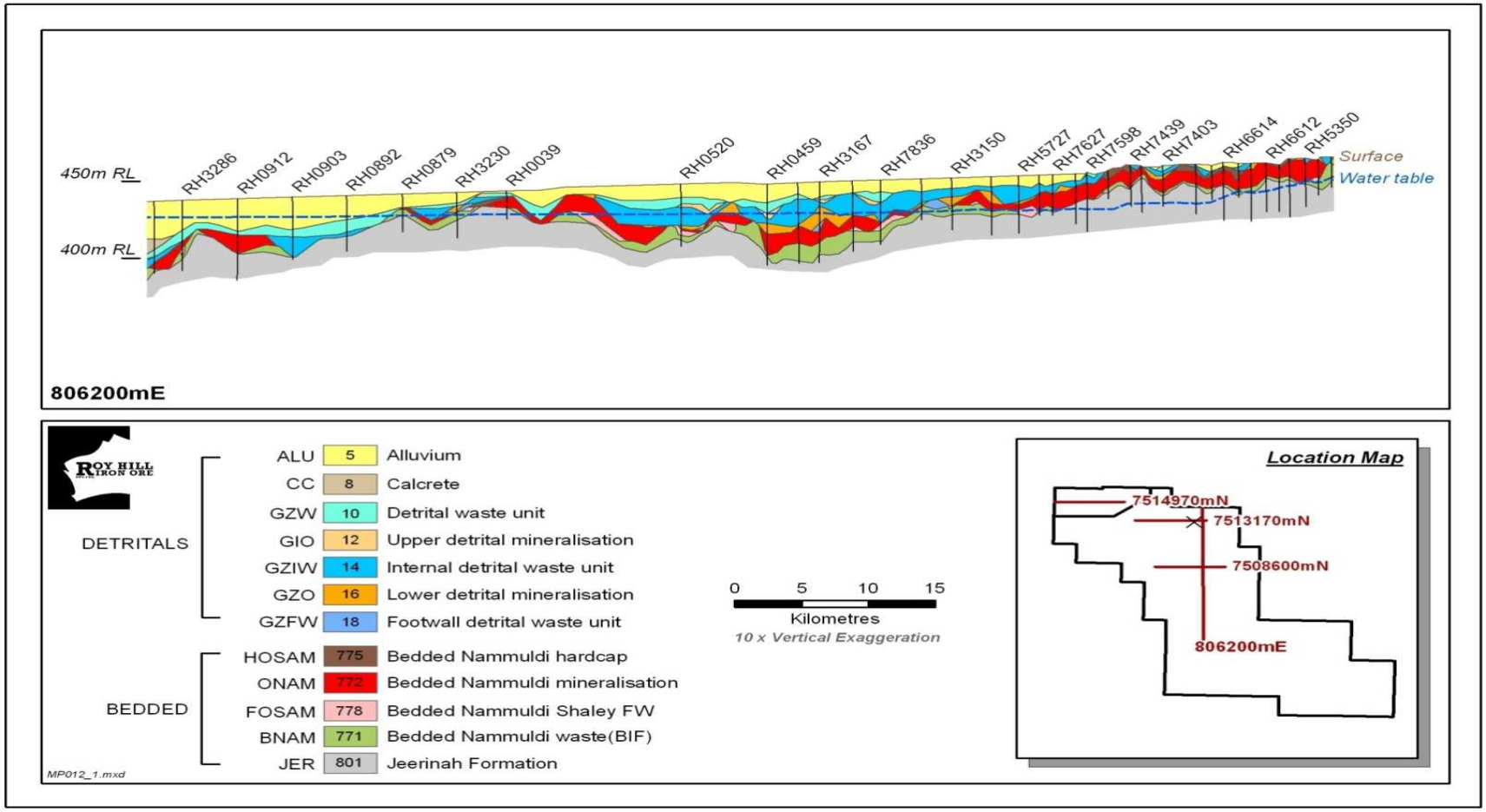

Figure 1: Modelled stratigraphy in Mine project area - north-south section

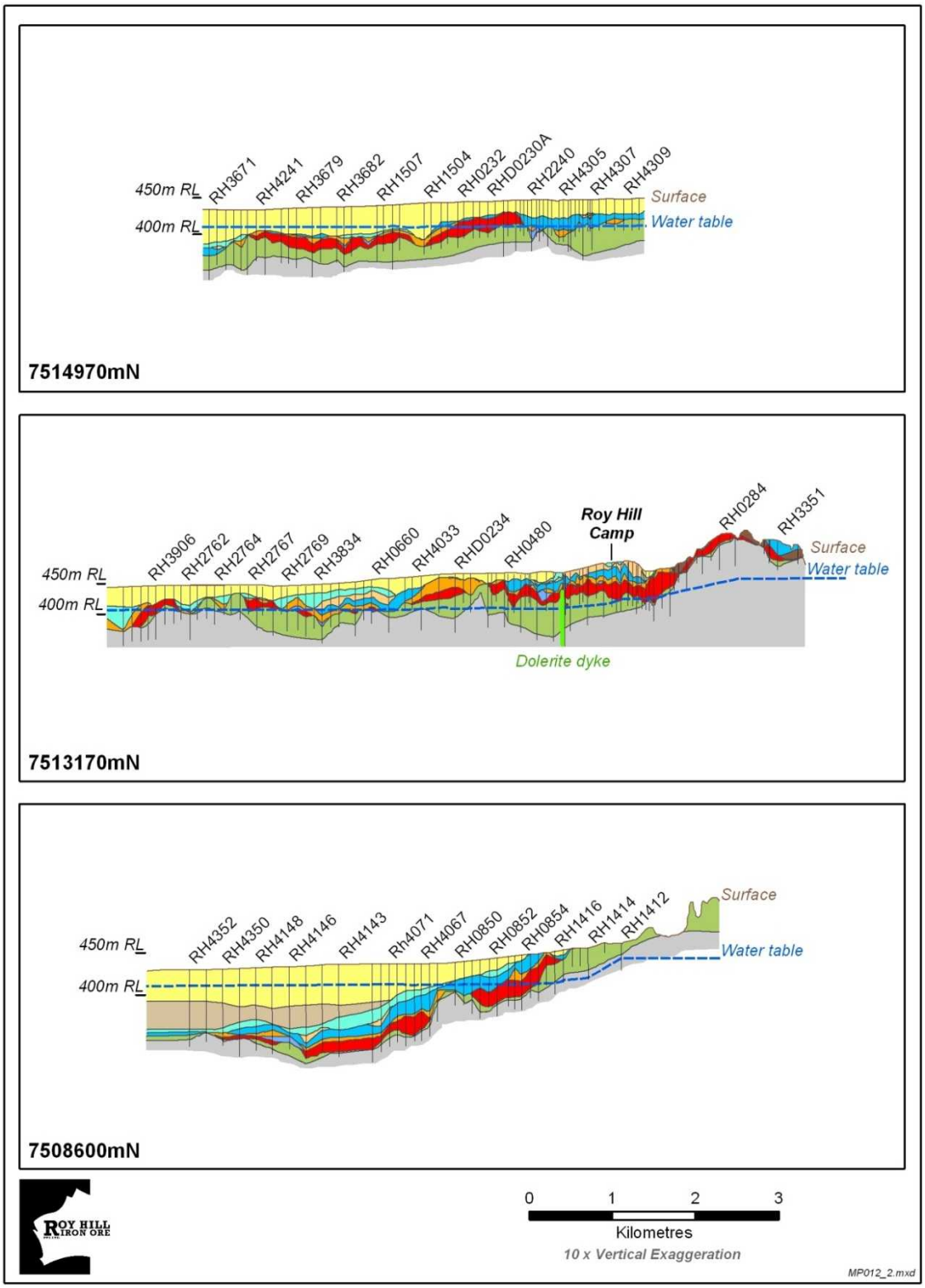

Figure 2: Modelled stratigraphy in Mine project area - east-west sections