2 The Proposal

Arafura Resources NL (Arafura[1]) proposes to develop an open cut gold mining operation at Mt Porter, approximately 180 kilometres south-east of Darwin. The proposed operation would run for approximately eight months, scheduled to take place during the regional Dry season in 2007.

The Mt Porter Gold Project is located on the eastern side of Mt Porter (292 metres Australian Height Datum), which is the highest of a series of narrow crested peaks along a north-south trending ridge line. The project area is located 20 km north of the town of Pine Creek, and is accessed by the Frances Creek Road leading to the Frances Creek Mine (Figure 1, p11). The Mt Porter Gold Project lies approximately 20 to 25 km south-east of Kakadu National Park, and 20 km north of the Kakadu Highway that travels to the east of the project into Kakadu National Park.

The project area is on the Mary River West Pastoral Lease PPL815, NT Portion 1630. The project area is within Mineral Lease 23839 which was granted on 2 February 2005. The Mineral Lease encompasses 362.6 hectares.

2.1 Project Timing

Arafura wish to commence mining as soon as all approvals have been obtained. It is proposed to occur over just a single Dry season and is expected to last 7 months. Mining is scheduled be completed before the onset of the Wet season in November 2007

2.2 Mine

The final pit (which is based on the most favourable economic parameters) includes identified resources of 574,000 tonnes at a grade of 2.1 grams per tonne gold and waste rock totalling 2.4 million tonnes.

Approximately 24 hectares of land would be disturbed for the open pit and infrastructure associated with mining operations

The proposed mine would require:

- Construction of one open pit;
- Construction of a waste rock stockpile east of the pit;
- Installation of workshops, explosives magazine and offices; and
- Upgrading of existing roads and tracks for ore haulage.

Ore would be extracted by drilling and blasting, and then transported by haul truck or road train to the Union Reef Mill for processing. Some dewatering of the pit would be required.

There would be no need for construction of separate borrow pits as preliminary studies indicate that material from the upper benches of the open pit would be suitable for this purpose. This waste material would be used to construct the site access road, internal roads, the ROM pad, water storage dams and pads for workshops, stores and offices.

[1] The proponent for the Mt Porter Gold Project is *Arafura Resources NL*.. Martinick Bosch Sell Pty Ltd trading as *MBS Environmental* prepared the Public Environmental Report, Supplement and Further Information submission for, and in consultation with Arafura Resources NL, and acted as point of contact for all EPA Program enquiries relating to the project. In this document both Arafura Resources NL and MBS Environmental are referred to collectively as *Arafura*.

Hazardous substances to be used within the mining operation would be diesel, lubricants and explosives. Diesel and lubricants would be stored in self-bunded tanks complying with Australian Standard AS 1940:2004. The storage, use and disposal of explosives would be in accordance with the *Explosives Act 1999,* the *Explosives Regulations 2003* and manufacturer's guidelines.

2.3 Site Layout

Proposed site layout is presented in Figure 3 (pge.11). Frances Creek Road is proposed to serve as the main haulage route adjoining an access track leading to the project area. Offices, workshops and an explosives magazine would need to be constructed prior to commencement of mining.

2.4 Open Pit and Waste Rock

The pit location is shown in Figure 3 - Site Layout (pge.11).

The natural ground level of the surrounds of the proposed pit is 580 metres RL. The open pit is proposed to cover a surface area of four hectares. The final pit floor would be at about 460 metres RL, making it about 115 metres deep. It is estimated that a total of one million bench[2] cubic metres (2.5 to 3 million tonnes) of material would be excavated from the pit. This would consist of approximately 200,000 bench cubic metres of ore and 800,000 bench cubic metres of waste for a stripping ratio of between 4:1 and 8:1.

Approximately 2.4 million tonnes of waste rock is proposed to be excavated from the pit. Waste rock would primarily be disposed of by construction of an out of pit waste rock stockpile located east of the pit. Waste rock would consist of both oxide rock (non-acid forming) and primary rock (potentially acid forming). An estimated 70 to 75% (1.75 million tonnes) of the waste rock in the pit is oxidised.

The final waste rock stockpile would cover a surface area of approximately 11.85 hectares. Potentially Acid Forming (PAF) material is proposed to be encapsulated within an envelope of the waste rock stockpile and diversion drains would be constructed to minimize the potential of water reaching the PAF material.

[2] Volume measured of rock before being mined.

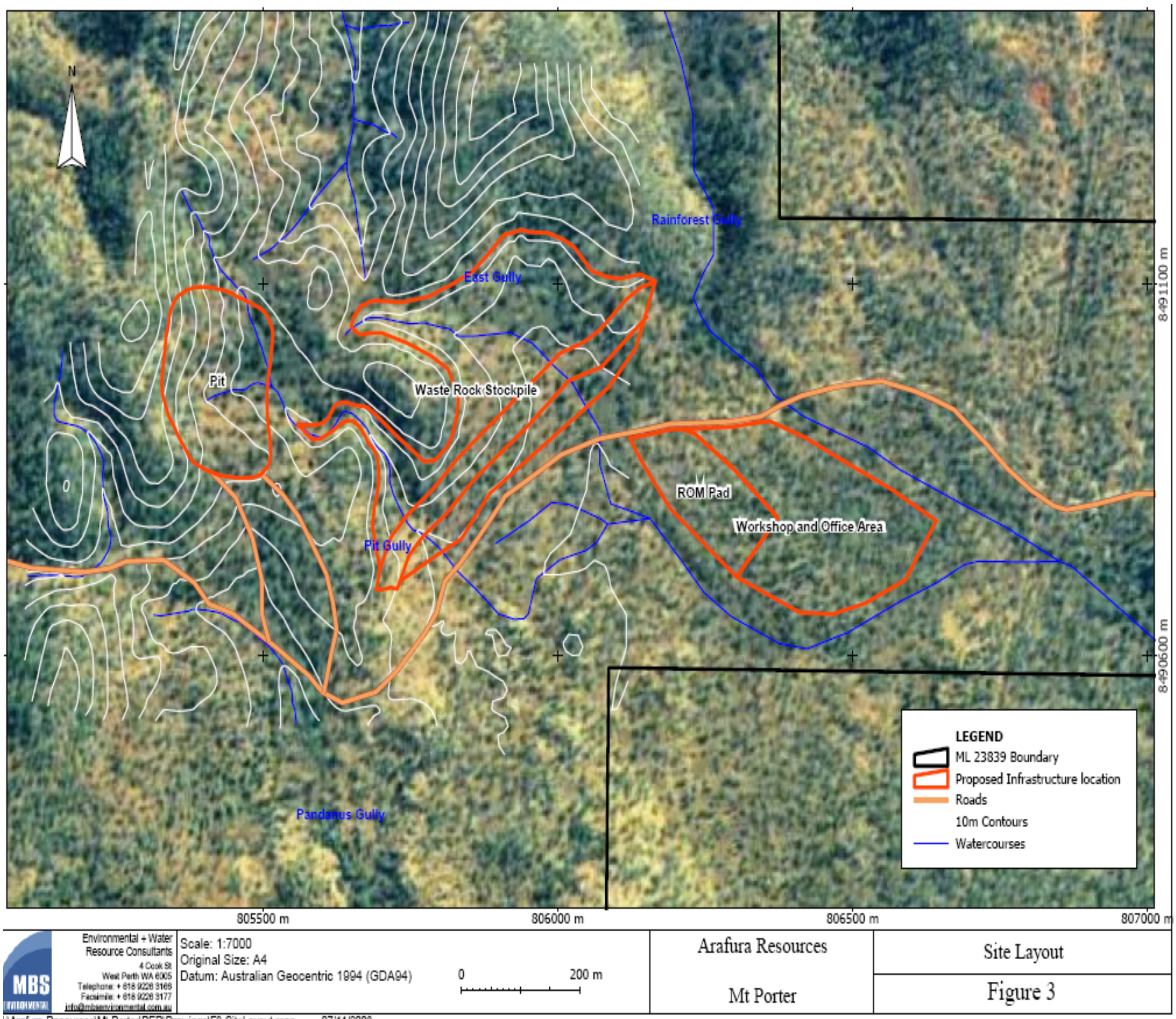

Figure 3 - Site Layout

2.5 Ore Processing

No processing is proposed to be undertaken on site. Ore from the operation is proposed to be transported 15 kilometres to the Union Reef Mill and toll treated. The mill is owned and operated by GBS Gold International

The planned processing at Union Reef Mill is via the GEOCOAT® refractory ore treatment process. The GEOCOAT® process is a standard bio-oxidation process for the treatment of refractory gold ores and concentrates in a heap leach environment, with subsequent recovery of gold through a normal carbon-in-leach (CIL) circuit.

2.6 Water Management

2.6.1 Water Sources and Dewatering

An estimate of 500 kilolitres per day of water would be required for site use. Water requirements for the proposed operations are limited to dust control, equipment wash down and personal use. Dust control would use the most water. It includes spraying of roads, stockpiles and loading operations.

With the project duration planned for the Dry season, quantities of rainwater are expected to be limited.

Temporary earthen dams to store water for site use are proposed to be constructed. Water would be pumped to these dams from the open pit sump and the unnamed bore (used as makeup water if there is insufficient quantity from the open pit dewatering).

Pit inflow water is expected to increase in the final stages of the pit excavation, when the pit is below the standing water level of the unnamed bore. Quantities significantly in excess of the estimated 500 kilolitres per day required for site use would require discharge. The duration of the final stage of the pit excavation below this level is very short and would only be approximately four to six weeks of the eight month project duration. The total volume of surplus water requiring discharge would be approximately 20,000 kilolitres.

2.6.2 Water Diversion

The following water diversion measures are planned for stable construction of the waste rock stockpile:

- Drainage pipes are proposed to be placed along the creek beds, maintaining a preferred drainage path for water from the upper catchments;
- Convex top surface, directing runoff to drains on the outer edge of the waste landform; and
- Diversion drains are proposed to be established around the central zone designated for PAF material. These would be directed to the outer edges of the dump and then redirected back to the main drainage lines.

Other water diversion measures for locations around the mine area include:

- Installation of culverts and / or floodways as required where roads cross watercourses and drains. Water diversion structures would be armoured, where necessary, to reduce the velocity and erosion potential of surface flows; and
- Redirection of surface run-off requiring discharge to the environment to detention basins to remove sediment prior to discharge.

2.7 Infrastructure and Transport

Infrastructure areas would be confined to the south of the access road to avoid impact on the remnant rainforest vegetation community, recently identified by the botanical survey, and to avoid disturbance of watercourses. It are proposed to occupy an area of 8.2 hectares

Much of the mine infrastructure are proposed to be mobile. Mobile infrastructure would include:

Power supply:	Portable generator for the site office and workshop
Site office:	Portable site office and ablution facilities
Workshop:	Sea container equipment store
Fuel storage:	Self bunded tanks or on ground tanks in lined bunded area
Explosives magazine:	Explosives would be stored in a magazine of an approved design.

Existing roads from Pine Creek provide general access to the mine site. Road access to the site from Pine Creek would be about 23 kilometres via the public roads Kakadu Highway (three kilometres) and Mt Wells Road (eight kilometres) followed by 6.5 kilometres of the private Frances Creek Road and 2.7 kilometers on the access track into the site.

Arafura Resources intends to transport ore from the mine for treatment at the Union Reef CIL processing plant, which is located approximately 10 kilometres south-southwest of Mt Porter. The transport route is shown in Figure 1 - Mt Porter Location Plan (pge. 11)

The Mt Porter access road and Frances Creek Road would require considerable earthworks to form them to a standard suitable for use by road trains. Earthmoving activities are planned to start in 2007 at the commencement of the Dry season (April).

2.8 Workforce and Accommodation

Once operations commence, the on-site workforce including mining and haulage operators, would rapidly build up to as many as thirty to forty persons at any one time depending on shift arrangements. It is proposed that mining operations would be scheduled for continuous operation that would comprise a day shift and night shift each of 12 hours duration.

All personnel would reside off-site and commute to the mine site on a daily basis.

2.9 Rehabilitation and Decommissioning

The Mt Porter Gold Project falls within the Mary River West pastoral lease. Prior to commencement of mining, the area was used for pastoral activities. Although no pastoral activities currently occur in the immediate vicinity of the proposed mine site, there is potential for pastoral activities to be restored post-mining.

Areas disturbed by mining and associated activities would be rehabilitated at the conclusion of operations. Waste rock stockpiles would be stabilised and seeded prior to vacating the site. PAF waste material would be encapsulated within the stockpile and water diversion drains are proposed to be constructed to ensure the waste landform is not subject to erosion during the Wet season.

The office and workshop areas and the access road between Frances Creek Road to the mine site are proposed to be rehabilitated after mining operations are completed. The affected portion of the Frances Creek Road would not be rehabilitated. Over time it would revert to the condition it was in prior to mining, i.e. un-maintained public road.

Arafura is committed to carrying out rehabilitation works before the onset of the Wet season. Rehabilitation would be performed in accordance with current accepted industry and public standards and conducted in accordance with Mine Management Plans approved by DPIFM.

3 Regional Setting

3.1 Climate

The proposed Mt Porter Gold project lies in the tropical monsoon belt of northern Australia. The region experiences hot, humid summers (the ‘Wet season’) and cooler, dry winters (the ‘Dry season’). Average rainfall in the region is 1100 to 1300 mm and falls mainly during the period between October and April. The most significant amounts fall during the months of January to March, when the area is subject to tropical cyclones and associated tropical low pressure systems and monsoon troughs.

3.2 Geology

The Mt Porter gold deposit is located in the Adelaide River-Pine Creek region of the Northern Territory and is hosted by a belt of basement rocks called the Pine Creek Inlier. The Pine Creek Inlier is a province of highly mineralised Archaean and Palaeoproterozoic rocks which extends over a roughly triangular region from near Darwin and Jabiru in the north to Katherine, some 230 kilometres to the south. It contains one of the world's largest and richest uranium provinces and contains about 15% of the world's high grade uranium resources. It is also a significant gold province with well developed infrastructure and services for the mining industry.

The metasedimentary rocks present in the Mount Porter project area belong to the Koolpin Formation of the South Alligator Group. Broadly, the Koolpin Formation is characterised by carbonaceous shales, but in the Middle Koolpin Formation, chloritic sulphidic laminated cherty "shales", with prominently developed chert nodules, ubiquitously present. These cherty units are widely regarded to be silicate facies banded iron formations (BIF).

3.3 Landform and Soils

Topography of the Mt Porter area ranges from about 150 metres AHD along Frances Creek Road in the eastern part of the tenement to 292 metres AHD at Mt Porter in the centre of the tenement. The geomorphology and land systems of the Katherine – Darwin region were described and mapped by Christian and Stewart (1946). The Mt Porter mineral lease contains two land systems:

- Brocks Creek Ridge Land System; and
- Cullen Land System.

The Brocks Creek Ridge Land System is described as consisting of sharp, rocky, north/south ridges, and hills with steep slopes (up to 40 – 60%) to gentle crests that are dissected by watercourses. The Cullen Land System contains topography that varies from rough, rocky granite outcrops to gently undulating country with small areas of flat land. The base rock of this land system is Cullen Granite, which is known to commonly intrude rocks in the Brocks Creek Group from the Brocks Creek Ridge Land System.

3.4 Groundwater

The dominate aquifer system within the proposed mining area is considered to be the meta-sediments of the Koolpin Formation. Permeability in this unit is largely secondary related to fractures, weathering and to a lesser extent, bedding.

The Zamu Dolerite sills form low flow boundaries throughout the site, with groundwater seeps (springs) occurring at the contact between these intrusive units and the Koolpin meta-sediments.

Regionally, the groundwater is typically of low salinity with high levels of bicarbonate and a pH that ranges from slightly acid to slightly alkaline. The fractured aquifers of the study area are characterised by groundwater that rarely exceeds a salinity of 700 milligrams per litre, is high in bicarbonate and contains the cations calcium, magnesium and sodium in proportions tending to be highest in magnesium.

3.5 Surface Water

Overall data from the natural waters indicate that prior to any mining taking place, the 'background' water available to floral and faunal populations is:

- Close to neutral, mainly in the pH range from 6.5 to 7.5;
- Is low in nitrate but may contain relatively high phosphate;
- Contains moderate levels of arsenic, aluminium, copper, lead, thallium, vanadium and zinc plus significant traces of other metals and sulfate; and

Arsenic, aluminium, zinc, copper and iron are present in the soil in significant quantities and may be mobilised if acid drainage was to occur.

3.6 Vegetation and Flora

Dominant vegetation communities for the Northern Territory have been described and mapped by Wilson *et al.* (1990). The vegetation community mapped as being dominant within Mt Porter Gold Project area is described as *Eucalyptus tectifica* and *Corymbia latifolia* Low Woodland with *Sorghum* understorey (Wilson *et al.* 1990). Site specific studies show however that this description by Wilson *et al.* (1990) is not accurate as the dominant Eucalyptus in these parts is actually *Eucalyptus tintinans* associated with *Corymbia dichromophloia* and *E. miniata*, over a tall *Sorghum* grassland understorey (Low Ecological Services, 2005).

The vegetation is relatively homogeneous over the proposed project area with only slight changes in species richness and abundances between habitat units. Five land unit groups were identified within the project area boundaries. All land units are widespread throughout the project area, namely:

1. Ridge Crests and Slopes;
2. Low Hills;
3. Riparian;
4. Low Undulating Plains; and
5. Granite Hills.

3.7 Fauna

A fauna study of the Mt Porter Project area was conducted at the end of the Wet season between April 18th and 24th, 2005. A specific survey was also conducted in June 2006 to determine if Gouldian Finches (*Erythrura gouldiae*) were present during the late breeding season.

Fauna of the Mt Porter area is typical of the Pine Creek region. There were 87 animal species identified, including 41 birds, 26 mammals, 17 reptiles, three amphibians and one fish. No Gouldian Finches were observed in the Mt Porter project area during Survey 2 nor within the Frances Creek survey. Two species of conservation significance were identified during the 2005 Mt Porter survey. These were Orange Horseshoe-bat (*Rhinonicterus aurantius*) and White-striped or Arnhem Sheath-tail bat (*Taphozous kapalgensis*). However, as a result of changes to legislation only the Arnhem Sheath-tail bat (*Taphozous kapalgensis*) remains listed (near threatened under the *TPWC Act* (2000)).

Fauna of Conservation Significance that may occur in the Mt Porter area are presented in Table 1.

Table 1: Species of Conservation Significance that may occur in the Pine Creek Area

Common Name	Scientific Name	Status	Species sited at Mt Porter	Species sited at Frances Creek
***EPBC Act* Protected Matters Database**				
Red Goshawk	*Erythrotriorchis radiatus*	Vulnerable	No	No
Gouldian Finch	*Erythrura gouldiae*	Endangered	No	No
Partridge Pigeon (eastern)	*Geophaps smithii smithii*	Vulnerable	No	Yes
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	Vulnerable	No	No
Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus nudicluniatus*	Critically Endangered	No	No
Northern Quoll	*Dasyurus hallucatus*	Endangered	No	No
Melville Cicadabird	*Coracina tenuirostris melvillensis*	Migratory	No	No
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Migratory	No	No
Derby White-browed Robin	*Poecilodryas superciliosa cerviniventris*	Migratory	No	No
Rufous fantail	*Rhipidura rufifrons*	Migratory	No	No
Oriental Plover	*Charadrius veredus*	Migratory	No	No
Oriental Pratincole	*Glareola maldivarum*	Migratory	No	No
Little Curlew	*Numenius minutus*	Migratory	No	No
Magpie Goose	*Anseranas semipalmata*	Overfly marine area	No	Yes
Fork-tailed Swift	*Apus pacificus*	Overfly marine area	No	No
Great Egret (White Egret)	*Ardea ibis*	Overfly marine area	No	Yes
Cattle Egret	*Ardea ibis*	Overfly marine area	No	No
Rainbow Bee-eater	*Merops ornatus*	Overfly marine area	No	Yes
Freshwater Crocodile	*Crocodylus johnstoni*	Listed	No	Yes
Salt-water Crocodile	*Crocodylus porosus*	Listed	No	No
***TPWC Act* 2000**				
Orange HorseshoeBat	*Rhinonicterus aurantius*	Near Threatened	Yes	Yes
Arnhem Sheath-tailed Bat	*Taphozous kapalgensis*	Near Threatened	Yes	Yes

3.8 Existing Social Environment

3.8.1 Aboriginal Heritage

A 2005 Archaeological survey of the Mt Porter area found the area to be rich in archaeological sites and material with 21 sites being recorded within the present development area. Five sites were accorded a high archaeological significance and it was recommended that these be avoided by the development and protected from any or further disturbance or damage. Seven sites were accorded medium significance and need to be avoided wherever possible, but could be disturbed following permission from NRETA and further archaeological study including the collection of all surface artifacts. Nine sites were found to be of low significance and should be avoided wherever possible but could be disturbed following permission from the Minister for Natural Resource, Environment and Heritage.

3.8.2 Native Title

Mining Lease 23839 is subject to a Native Title Claim DC01/06 made by the Northern Land Council on behalf of the Wagiman, Warai and Jawoyn native title groups. In December 2004 an agreement was reached between Arafura Resources NL, the Northern Land Council and the Northern Territory Government for the Mt Porter Gold Project. The agreement addressed the concerns of the Native Title groups with respect to Aboriginal site and heritage protection, employment opportunities, mine site rehabilitation, and financial compensation when mining commences.

3.8.3 Social Environment

The Mt Porter project area is 20 kilometres north of Pine Creek, which is the nearest population centre. Pine Creek is on the Stuart Highway between Darwin and Katherine. Pine Creek district covers an area of 400 square kilometres and has a population of about 500 people, of which 10% are Aboriginal (ABS, 2002).

Major industries in the district include agriculture (beef and cattle), mining and tourism. Tourism sites feature the unique landscape, Aboriginal heritage, and flora and fauna in the world heritage listed Kakadu National Park, 50 kilometres north-east of Pine Creek.

4 Environmental Impact Assessment

4.1 Introduction

The main purpose of this Environmental Assessment Report is to determine if the proposed project can proceed without unacceptable environmental impacts. It does this by identifying all relevant potential environmental impacts and evaluating the feasibility and likely effectiveness of environmental safeguards put forward by the proponent.

Elements of the proposal initially suggest it has low potential to cause significant environmental impacts. This is suggested by:

- The current proposal containing mining operations to within one Dry season, thus removing requirements for management of stormwater runoff during active mining;
- The locations of the mine and waste rock dump being located at the head of the catchment. The open pit is within 50 metres of the summit of Mt Porter and the waste rock dump 50-100m downslope of the pit;
- The one existing spring above the waste rock dump appears to be minor, ephemeral and unlikely to support significant aquatic ecosystems. Removal of a dolerite sill within the pit is suggested as likely to disconnect the spring from its source aquifer, and move the discharge point to the pit;
- The proposal is not situated in a town drinking-water catchment;
- Groundwater aquifers in the area appear to be of low yield and potentially disconnected due to the complex nature and geology of the region;
- Surface waters of the area contain moderate levels of arsenic, aluminium, copper, lead, thallium, vanadium and zinc plus significant traces of other metals and sulphate. It may contain aluminium and iron in colloidal suspension;
- The Pine Creek area has been heavily mined since the 1870s, and is thus already highly disturbed at many nearby locations;
- The proposal involves removal from the site of the bulk of the potentially acidic material, as ore; and
- No chemical processing or crushing of ore is to occur on-site;

Based upon the above, Arafura's view has been that the project is relatively low risk and therefore the detail and extent of information provided in the PER, Supplement and additional information reflects this view. The proponent has argued against submitting requested information stating that it is not necessary for the project's assessment. Instead it has deferred the provision of the information to the approval process. It is the EPA Program's view that this demonstrates a lack of understanding of the purpose of the environmental impact assessment process for the Northern Territory, that is, a process that has been established to inform the approval processes on the environmental acceptability or not of a proposal. Accordingly, the lack of detail provided by the proponent has increased the risk setting of the proposal as some of the key assumptions outlined above have not been demonstrated through appropriate studies.

The EPA Program is reasonably confident that mining at the site can be managed in an environmentally appropriate manner, however there are a number of key areas that require further work prior to the commencement of any mining activity under the *Mining Management Act* for the development or operations of the proposal. These include the following:-

(1) A reassessment of the estimates of acid and metallifererous drainage that may reasonably be expected from the project. This will require a re-assessment of the geochemical data provided and provision of adequate information defining the porosity of the oxide material proposed as an encapsulant so that leaching characteristics can be better defined.

(2) Design and implementation into the proposal of mitigation structures and strategies to rehabilitate low level Acid and Metalliferous Drainage from the Waste Rock Dump;

(3) A demonstrated understanding of the extent of connectivity between deep and shallow aquifers and surface flow areas (including waterholes and Nellie Creek) to better determine the true amount of waste water, including potential seepage from the stockpiles, that may be entering the riparian environment;

(4) Specify and develop appropriate local watercourse trigger values. These must be determined in reference to the declared beneficial uses of the Mary River and be based upon representative background water quality data; and

(5) Production of closure criteria and additional rehabilitation monitoring programmes that provide a wider range of information against which those closure criteria may be cross-referenced.

4.2 Waste Rock Management

Approximately 2.4 million tonnes of waste rock is proposed to be excavated from the pit. Waste rock would primarily be disposed of by construction of an out-of-pit Waste Rock Dump (WRD) located ~100m east of the pit. Waste rock would consist of both oxide rock (relatively non-acid forming) and primary rock (potentially acid forming). An estimated 70 - 75% (1.75 million tonnes) of the waste rock in the pit is oxidised (see Characterisation, s 4.2.1.3).

Initially oxide material stripped from the upper benches of the pit would be used in establishing the Run-of-Mine (ROM) pad, site office, access roads and mine access areas. Additional oxide material would then be set aside for later use in capping the potential acid forming material in the WRD.

4.2.1 Waste Rock Dump (WRD)

The final waste rock dump would cover a surface area of approximately 11.85 hectares. Potentially Acid Forming (PAF) material is proposed to be encased in clay within the WRD. Diversion drains and a convex top to the WRD would be constructed to minimize the potential of stormwater reaching the PAF material.

The waste rock dump is to lie across the head of the catchment of two gullies: East Gully and Pit Gully (see Figure 3, pge.15). Pit Gully contains an existing ephemeral spring in its upper reaches, above the final crest level of the waste landform. East Gully has no observed springs. Drainage from the spring and from each of the limited upper catchments (see Figure 4, pge.25) would be redirected around the upper contours of the waste landform, leading to rock armoured spillway structures on the side of the stockpile. A drainage pipe is to be buried under the WRD along each of the present creeklines to maintain a preferred drainage pathway for any groundwater infiltration into, or seepage from the WRD. PAF material is to be deposited in the southern flank of the dry East Gully and above the spur between the two valley fingers. If required, lime would be added to the PAF material to minimise potential for acid generation.

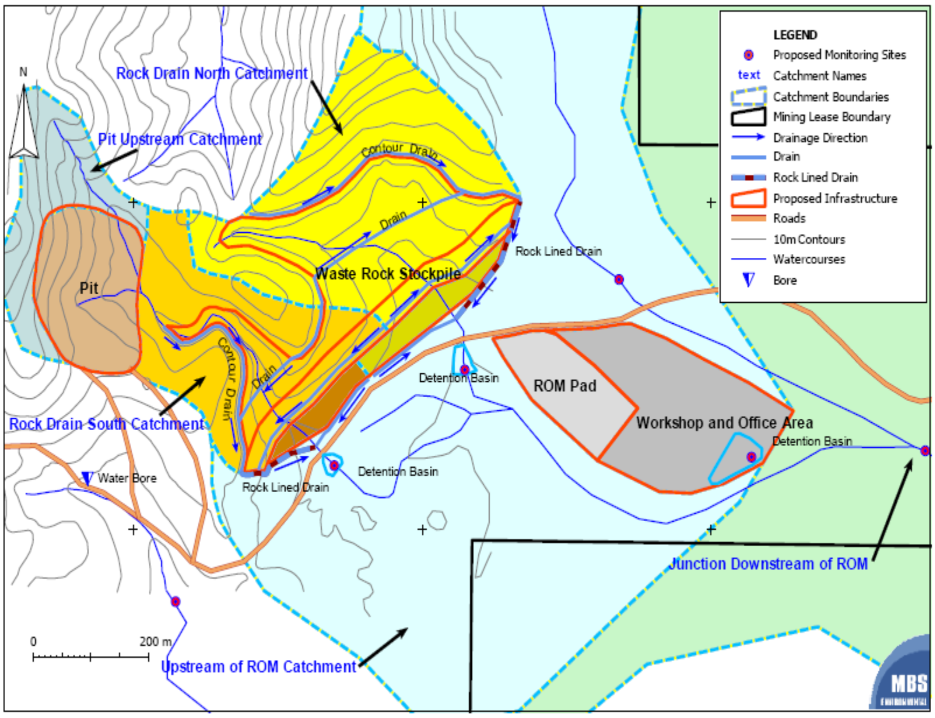

Figure 4 - Water Management Measures and Monitoring Locations

Ultimately the whole waste rock stockpile would be capped with oxide waste relocated from a temporary stockpile to provide a cover layer as a barrier to ingress of water.

Depending on topsoil availability from the pit and WRD footprints, approximately 100mm of topsoil is proposed to be spread over the top of the WRD. This is to be stabilised by scarification and sowing with seed from local native flora species.

4.2.1.1 Waste Rock Dump – Potential Issues

The potential for acid and metallifererous drainage[3] developing from the waste rock dump represents the principal risk of the proposal. This risk extends to the potential for

[3] Acid and Metalliferous Drainage (AMD) has traditionally been referred to as 'acid mine drainage' or 'acid rock drainage'. In this document the term AMD recognises that not all problematic drainage related to the oxidation of sulfides is acidic. 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:

- vegetation dieback or soil scalds (such as bare areas);
- death of fish or other aquatic organisms;
- 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 CaCO3 equivalent);
- high (sulfate) salinity (typical sulfate concentrations range from 500–10,000 mg/L;
- typical salinities range from 1000–20 000 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;
- 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); and
- corrosion of concrete or steel structures.

(DITR (2007))

contamination of ground or surface waters and subsequent impacts on downstream ecosystems. As mentioned in section 4.1 above, the location and limited nature of the proposal suggested a low risk setting. However, concerns raised in comments have suggested potential flaws in Arafura's approach to preventing occurrence of Acid and Metalliferous Drainage (AMD).

4.2.1.2 Waste Rock Dump – Cover

Arafura presented calculations indicating roughly 675,000 cubic metres of oxide waste would be extracted from the pit. Approximately 25,000 m^3 of clay was estimated to be required to line the PAF cell (1m thick floor, 5m walls, and compacted 3m on top). Arafura expects that suitable quantities of suitable quality clay would be able to be found from within the weathered dolerite sills in the upper zone of the pit.

No chemical testing has been carried out on these clays to confirm their suitability for use as lining clay. The clay must be tested to determine its response to the aggressive chemical nature of the metal salts that would be generated in the WRD. Chemical adsorption such as sodium can significantly change the clay structure over time. This would substantially increase permeability and seepage into the PAF material. Dispersive clay testing results should have been included in the PER.

In the further information submission Arafura provided details of the proposed PAF cell liner, including minimum target permeabilities of 1×10^{-7} m/sec and thicknesses of the clay. Modelling suggested surface water infiltration would take at least 1 year to penetrate the PAF cap if target permeabilities were attained. Modelling was presented as conservative as it was based upon an assumption of a constant hydraulic head. The EPA Program considers that such modelling may be conservative initially, but may become an underestimate of permeability with time.

TeamNT (2004) notes experience worldwide indicating that there is inevitably some loss in cover performance in the 5 to 10 year period after construction, and that it may be prudent to place more conservative specifications on the initial design. For example, if the design specification for hydraulic conductivity produced from modelling calculations is 10^{-8} m/s then perhaps the construction specification should be set at 10^{-9} m/s, to allow for imperfections in construction and changes in material properties. The 10^{-7} m/sec maximum water transmission rate targeted by Arafura is quite permeable compared to what is achievable with high quality clays, suggesting that the minimum 3m thickness is required to compensate for the lower clay quality. NLC commented on the PER that the permeability of oxide materials is generally high in relation to clays, suggesting an explanation for the higher permeability estimates used.

No permeability testing has yet occurred of the available clay material, to confirm it is of a suitable grade, although Arafura has committed **(**Commitment S13)[4] to include this testing as part of the detailed landform design in the MMP. Attaining the target permeabilities in practice is thus yet to be demonstrated, and would be subject to suitable materials actually being available and on site quality control standards being adhered to when the clay compaction process occurs. Given the uncertainties with attaining suitable low permeability ratings for oxide materials, testing for the actual attainable permeabilities using the oxide material should have been carried out early in the cap design process. This current lack of testing suggests the current cap designs may in fact be invalid. If testing demonstrates that the oxide material is unsuitable as a PAF cell liner, the use of an alternative source of high quality clay or synthetic liner would need to be examined, given uncertainties existing with returning PAF material to the pit (see section 4.2.1.7 for discussion). (Significant design changes such as these may re-trigger assessment under the *Environmental Assessment Act*).

For a compressed clay liner to act as an impermeable barrier to oxygen penetration it needs to be maintained at >85% moisture content. Permeability to oxygen increases exponentially

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[4] Commitments are summarised at Appendix 1.

below a 85% moisture threshold (TeamNT 2004, p55). The proposed 100mm overlying layer of topsoil would not maintain such deeper moisture concentrations through much of a Northern Territory Dry season. TeamNT (2004,Ch.4)) describes currently understood best practice in design of WRD covers suitable for the NT climate. It recommends at least 2m of growth medium and topsoil be placed over the compacted clay liner, to store sufficient Wet season moisture in deeper layers to maintain the required 85% saturation of the clay liner (see **Figure 5**, pge.27).

The 2m deep growth medium also:

- Facilitates establishment of a vegetation cover;
- Is deep enough to prevent termite intrusion into the underlying clay cap;
- Provides sufficient depth for root development in plants larger than grasses;
- Provides a moisture reservoir for vegetation; and
- Provides a conservative physical protective barrier for the PAF clay cell liner against erosion.

In the cover design presented by Arafura, the clay layer is relatively exposed to weathering with only 100mm of topsoil cover. This thin topsoil layer would quickly allow underlying clay layers to undergo drying / wetting cycles with associated contraction / expansion and development of increasing lines of weakness. This has the potential to lead to cracking and development of preferential flow pathways, leading to high permeability into the underlying waste during the wet cycle. Seepage and oxidation would then increase, resulting in leachate drainage from the base of the dump throughout the year.

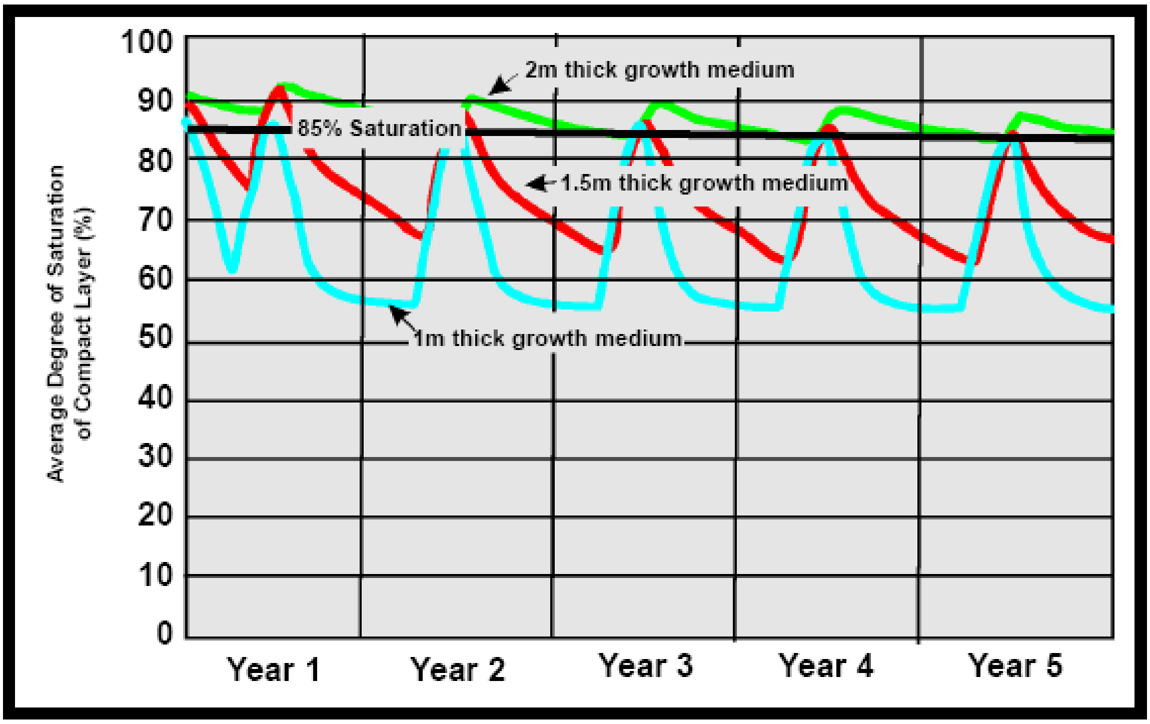

Figure 5 -Effect of growth medium thickness on % saturation of compacted clay layer (from TeamNT2004, p.55)

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Arafura's design of the PAF cell with a 3m thick compressed clay roof would also provide some of the cover features mentioned above, but would be less suitable as a growth medium for the proposed vegetation cover, due to the shallow growth medium and lack of moisture holding capacity.

Tree root penetration is still a topic of current research. A cover system is not a typical soil profile and the behaviour of tree roots (compared with that in natural terrain) remains to be fully defined. However, the deeper the growth medium, the less of an issue this would be. In general, tree roots track moisture, and only grow more deeply to locate water. When the growth medium is too thin (too little moisture stored through the Dry season) then the roots would likely penetrate the compacted clay layer and potentially compromise its integrity (TeamNT 2004, p56).

The upper oxide material, providing it has been proven benign, may make an ideal deeper growth medium, especially if it is well graded. Even if the waste does not initially have the optimum particle size distribution, altering the design or energy factors of the blasts during mining may produce a much better suited cover material.

Differential settlement is an important factor that must be addressed as part of the design process. The higher the dump, the greater the potential for consolidation. Arafura's WRD would reach a maximum 20-25m depth. Arafura has proposed a final top slope on the WRD of 1:300 to minimise stormwater erosive power. Achieving these shallow slopes for any length of time while the WRD undergoes settlement appears challenging, and is likely to result in pooling of stormwater on top of the WRD due to subsidence, or erosive loss of topsoil due to an excessive compensatory slope. Differential settlement of only a few decimetres could lead to loss of the cover's water-shedding design.

Deluge rainfall events characteristic of the Northern Territory may fully saturate even a 2m growth medium. Drainage contours of the underlying clay liner over the PAF cell should be considered, to discourage sub-surface ponding after such events. Ponding risks water infiltration into the PAF cell.

Intense storm events also characteristic of the Northern Territory have high erosive capacity. The surface of any cover must be protected to prevent gully erosion and loss of the growth medium layer over time. Protection from erosion could be assisted by the addition of a rock mulch layer, as well as the proposed vegetation cover. Erosion risks causing high sediment loads, direct exposure and degradation of the WRD-PAF cell liner and AMD.

Conclusions

Competency of the proposed design of the cover has not been demonstrated in respect to:

- **Demonstrated impermeability of cover materials;**
- **Long –term integrity of the PAF cell cap with respect to maintaining an ability to minimise potential for AMD formation; and**
- **Ability of the cover to maintain a vegetation cover and prevent erosion.**

4.2.1.3 Waste Rock Characterisation

Arafura stated that in 1998, 17 samples were lodged for Acid Rock Drainage [AMD] determination. The samples were composite drill hole samples and included material now considered to be "ore". At least ten samples included fresh sulfidic material from beneath the oxide zone. Since more than 50% of these samples were non-representative of the wastes to be mined by Arafura, additional waste characterisation studies were undertaken.

From within the oxide zone 35 diamond drill core samples were analysed to determine geochemical properties. No fresh rock waste samples were tested, as almost all fresh rock to be mined from the pit would be ore. Samples were chosen to cover all waste rock types and total sulphur content levels. Sample density over the rock types was not even, so does not indicate relative final quantities. The 35 samples comprised four separate rock type groupings:

(1) **Dolerite sills**. Two samples, both low in sulphide content with traces of carbonate material. Both were found by Arafura to be non acid forming (NAF).

(2) **Carbonaceous siltstone-banded iron formation.**
Twenty-four samples. Generally dark-grey, black to dark-brown, massive, with rare thin well bedded intervals, sometimes with thin chloritic beds. Very rare millimetre thick layers of oxidised sulphides at less than 19 metre down-hole depth with traces of fresh bedded sulphide through to 26 metres. Occasional fine wispy quartz veins mostly less than one centimetre thick.

The twelve samples from the surface to about 19 metres were all NAF. The remaining samples between 19 and 26 metres (deepest sample supplied) were PAF including the three of PAF-[High Capacity] ranking.

All the significantly PAF material (PAF and PAF-[High Capacity], mainly 150 – 250 kgH_2SO_4/tonne) contains carbonaceous siltstone-BIF with visible sulphides. This material represents 2-3% of the total waste rock or 48,000 to 72,000 tonnes. Arafura states that this PAF material contains a moderate content of pyrite and potential to produce in the order of 200 kg H_2SO_4/tonne. Because of its blocky texture, acid generation is suggested to be extremely slow. Where the wastes have high carbon content, oxidation rates may be slowed further. The material is black in colour.

(3) **Felsic dyke samples**
Three samples, two PAF-[Low Capacity] (3.0 and 3.2 kilograms H_2SO_4 per tonne), one NAF. The NAF sample has relatively high sulphate-Sulphur and high Acid Neutralising Capacity (ANC).

(4) **Chloritic-cherty banded iron formation**.
Six samples, all very low in sulphide content and all NAF.

4.2.1.3.1 Adequacy of Sampling

Best practice waste characterisation (TeamNT, 2004) suggests a minimum suite of tests be applied to the full range of waste lithotypes, to include: acid-base accounting, neutralising curve characterisation, Net Acid Generation (NAG) and mineralogy assessments. The use of multiple techniques would give a greater degree of confidence in the predicted properties of materials tested, over the longer period.

Additionally acid leaching alone may not remove all sulfides. More complex testing such as acid ferric leaching would remove a much more representative amount of sulfides.

Arafura's testing program applied NAG testing (Non-barium sulphate; sulphate-Sulphur not determined), and testing for ANC, NAPP, NAG and HCl/HNO_3/$HCLO_4$ soluble Sulphur. Relative to best practice recommendations, the testing regime could be considered inadequate.

TeamNT (2004) recommends appropriate sampling density as a general rule is to test a minimum of 100 samples per significant geologic unit as a first pass. This would equate to 400 samples, instead of the 52 (17 + 35) offered by Arafura.

The NLC expresses concern over the interpretation of acid drainage analyses presented in Appendix 3 (s3 p.5). Arafura criticises EGI's 1998 results, saying *"there are substantial differences between NAG and NAPP[5] values in Table 1. These values should be identical if all sulfur converts to sulfuric acid and all ANC is derived from carbonate minerals*". Arafura had concluded that a large proportion of the sulphur is non-acid producing and some Acid Neutralising Capacity may not be derived from carbonate. The NLC considered the proponent's conclusion to be incorrect, because they considered NAG and NAPP values should be different. The NLC stated that a NAG test utilizes hydrogen peroxide to react only with sulfur in a sample while NAPP values are derived from tests that extract all acids. Research work had shown that NAG test samples with >1% sulfur may lead to underestimation of acid forming potentials[6]. NLC was thus suggesting that Arafura's assumption could result in underestimation of acid forming potential of the Mt Porter waste rock.

Due to its black coloration PAF material is stated to be relatively easily recognisable, which would facilitate segregation of the material for storage in a PAF cell. The EPA Program considers though that the black shale material should still be routinely subject to appropriate chemical categorisation during the construction and placement period in the WRD.

The EPA Program is concerned that the wastes under the seasonal groundwater may have been far less oxidised than the waste nearer to surface. There is clear indication that these waste rocks types possess very high acid generating potential. The number of samples in this area may have been less than two from the total number of samples. The assessment of leachate/seepage quality was also based on a sub-sample of 5, selected from the initial 35 samples. The EPA considers the number of samples too low in high-PAF rock types to adequately represent their impact upon final seepage. Error bounds for predictions are not described in the PER. The EPA Program therefore questions the statistical validity of the sampling regime used to predict the final leachate seepage water.

There are also concerns that the transitional rock has not been adequately characterised. This is of concern due to the potential for PAF material to be present and not accounted for. The PER did not provide details on the further identification of transitional rock during mining.

The EPA Program is also concerned that the soil water leaching testing undertaken may over dilute leachate and this was not corrected within the method as discussed in the PER. The results therefore may not accurately represent the likely impacts of the operation of the WRD or other treatment systems such as the sediment ponds. This adds further uncertainty to the understanding of the true impacts of this proposal.

Therefore, while the pit is small to medium in size and may represent a low risk according to the proponent, the final waste rock dump may constitute a long term risk, particularly to water quality in the small streams and groundwater in the immediate vicinity of the site. The small catchment above the mine will reduce any potential for dilution of AMD.

4.2.1.3.2 Potentially Acid Forming - Low Capacity

Arafura states that PAF [Low Capacity] rock (less than five kilograms H_2SO_4 /tonne) is difficult to recognise and would report as oxide waste. Oxide waste is proposed to be used in construction of the roads, ROM pad, site office, and mine access areas, with the remainder to be deposited in the waste rock dump without the protection of compressed clay capping.

The EPA Program considers that any material which would positively increment acid production should be managed as PAF, and recommends more extensive characterisation to differentiate this material and encase it.

[5] NAPP – Net Acid Producing Potential
[6] AMD Test Handbook, AMIRA Project P387A-Prediction and Kinetic Control of Acid Mine Drainage

Arafura has committed (C.9.2.2b) to conduct further testing of PAF material. Whether this testing would be carried out on material reporting as oxide waste is unclear. Such testing to clearly define areas of PAF [Low Capacity] material prior to their removal from the pit would facilitate more appropriate segregation and reduction of its potential to cause acidic drainage issues from within 'oxide' waste deposition areas.

Arafura states that the upper ~20m of the pit, representing a large percentage (70-75%) of the waste rock, is already oxidised, and hence cannot be a source of significant sulfidic oxidation and acid generation. Although this level of oxidation is significant, the recognised presence of pockets of PAF [Low Capacity] material within the oxide layers shows oxidation is not complete.

4.2.1.3.2.1 Neutral Drainage

Mineral and salt products of the oxidation process may still be present in the oxide rocks, as well as minerals not requiring acidic conditions to dissolve. Such solutes have potential to cause non-acidic seepage problems for downstream ecosystems where accumulating processes are active.

An assessment of potential neutral drainage can be made by assessing the leachate from Net Acid Generation, but this was not undertaken. Therefore the PER did not contain any assessment of neutral drainage. The EPA Program considers this an essential component of a valid waste rock characterisation approach.

Conclusions

- **The EPA Program questions the adequacy of the sampling regime in terms of sampling numbers, and distribution as well as the breadth and rigor of the subsequent testing program.**
- **Accordingly, the EPA Program has concern about the conclusions of Arafura in relation to the proposal, particularly as this has informed their design and subsequent management of the WRD as well as their decision to use the waste rock for road base; and**
- **The EPA Program is concerned that Arafura does not understand the full potential of the WRD's impact to the receiving environment.**

4.2.1.4 Chemical Neutralising Potential

The waste rock dump has not been designed to achieve chemical neutralisation of the seepage from PAF material. In relation to the PAF material, the WRD is designed to use the NAF material purely as physical structure to support and isolate the PAF cell. There appears to be little material with acid neutralising capacity available within the waste rock characterised from the site.

If neutralizing material is to be incorporated within the PAF design as a passive barrier style system, the details of this design were not provided within the PER. For a passive barrier to be designed correctly the barrier should be designed to absorb all predicted acid generated and an additional "safety factor" to represent inaccuracy in the waste rock characterisation and exact chemical reaction speeds in the passive system.

Arafura argues that high elemental carbon content in a proportion of the waste rock would reduce oxidation of the high sulfide content present in those rocks. The NLC commented that the basis for the interpretation may be incorrect, as evidence gathered from monitoring of porous dump waste rock structures within the wider region (e.g. Rum Jungle and Woodcutters) indicates that carbonaceous content does not inhibit acid formation.

Arafura admits that the concept only applies to the oxidation of sulfides away from exposed rock surfaces, where oxygen is slowed from reaching internal rock structures. Oxidation of sulfides on exposed surfaces of waste rock or pit walls would not be slowed. Waste rock would still have relatively high surface areas available for oxidation of sulfides to occur, after the rock has been broken up and transported, by blasting, digging, loading and dumping. The potential for Acid and Metallifererous Drainage (AMD) potential would still be high.

Conclusion

The design of the WRD needs to represent best practice and account for all management contingencies.

4.2.1.5 Waste Rock Dump –Groundwater levels

One of the most common causes of failure in rehabilitation designs for waste storage facilities has been a tendency to treat them as structures isolated from their physical position within the landscape Only when they are intimately linked to the surrounding physical environment can effective and sustainable rehabilitation strategies be developed.

Figure 6 - water table 'moving' into the waste facility

Factors historically often not accounted for in cover design include the mounding of the water table and of the water table 'moving' from the existing topography into the waste facility (TeamNT, 2004).

Arafura have acknowledged (Supp. s3.8) that groundwater mounding due to capillary rise in the landform may occur. Mounding was predicted to be in the order of five metres above existing groundwater levels, but without explanation of the basis of the estimate. The design position of the PAF cell is proposed to be further raised '… at least five metres above the highest predicted mounding level, at approximately 205 metres AHD'. This estimate was based upon the standing water level of 190m AHD in the unnamed bore, ~200m away.

The lack of groundwater data and modelling creates uncertainty in predicting future WRD groundwater levels due to a lack of understanding of current groundwater patterns. It is unclear from information presented whether current estimates of future WRD groundwater levels by Arafura are accounting for the surrounding water table moving into the WRD, as groundwater levels return after pit de-watering, post mining.

Description or analysis has not been presented of the effects of the return of groundwater to the area post dewatering, and predicted effects of groundwater quality around and in the pit and WRD structures.

Consequences of the lateral infiltration of groundwater into the WRD are that a significant proportion of waste rock would be seasonally inundated and drained. Soluble salts and minerals would be leached from the dump, any remaining (non-segregated) PAF material would be oxidized, and the groundwater aquifer would be incrementally acidified (AMD), further mobilising oxidation products (metals, salts). Depending on the correctness of Arafura's predictions regarding future WRD groundwater heights (based on very limited data), the PAF cell may become seasonally inundated. If PAF liners and passive barriers are intersected by seasonal groundwater the effectiveness of the acid control system would be reduced. Downstream expressions of affected aquifers (springs) would have altered water quality.

Conclusion

There is a lack of demonstrated understanding of the connectivity between groundwater and surface flow areas and consequently the potential for impact on the integrity of the acid control system contained in the WRD.