ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

REPORT NO. 211011

INDEPENDENT MONITOR'S AUDIT OF THE MCARTHUR RIVER MINE FOR THE 2010 OPERATIONAL PERIOD

ENVIRONMENTAL EARTH SCIENCES VIC

REPORT TO THE MINISTER FOR PRIMARY INDUSTRY FISHERIES AND RESOURCES
OCTOBER 2011
VERSION 1

Glaeba (03) Pty Ltd trading as Environmental Earth Sciences VIC
Level 1, 98 Maribyrnong Street, Footscray, VIC 3011 PO Box 2253, Footscray, VIC 3011
P. 61 3 9687 1666 F. 61 3 9687 1844 E. eesvic@eesi.biz
www.environmentalearthsciences.com

EXECUTIVE SUMMARY

This report presents the assessment by the Independent Monitor (IM) of the environmental performance of the McArthur River Mine (MRM) during the 2010 operational period, which extends from October 2009 to September 2010. However, it also includes observations made during a site inspection carried out on 30 and 31 May 2011. This is the fourth consecutive annual report produced by the Independent Monitor.

The environmental performance of the MRM operation is assessed via:

- annual site inspections;
- technical review of data and documentation provided to the Independent Monitor;
- discussions with McArthur River Mine and the Department of Resources (DoR);
- MRM's compliance with commitments made in the annual Mining Management Plan; and
- MRM's efforts to improve on environmental performance each year.

Outcome of MRM compliance assessment
As in previous years, MRM have demonstrated a high level of procedural compliance with their commitments made in the annual Mining Management Plan (MMP). Only one non-compliance was identified in this audit; this relates to a lack of shaping of the surface of the tailings storage facility (TSF) Cell 1 cover. Nine commitments were considered to be incomplete compliances.

Review of the Department of Resources
For this audit, the Department of Resources again provided the Independent Monitor with thorough and appropriate administrative procedures used to check the monitoring and approvals of the MRM operation. Check monitoring of the MRM operation for surface water and groundwater impacts appears to be generally appropriate.

A compliance audit of MRM undertaken by the DoR was also supplied to the Independent Monitor and this audit was reviewed together with two site inspection reports. While the audit and inspections appeared to have been carried out appropriately in line with procedures, the Independent Monitor has made recommendations for more thorough and complete reporting from the DoR.

Outcome of technical audit
Many areas of environmental performance of the operation appear to be improving with each audit. The areas of monitoring considered to have an adequate environmental performance include:

- flora and fauna monitoring both at the mine site and at Bing Bong Port;
- surface water monitoring;
- fluvial sediment monitoring; and
- structural monitoring of the river diversions.

However, there are many more improvements still to be made and many aspects of the monitoring program are considered to be below leading practice standards (DRET, 2011).

Adverse impacts of seepage from the Tailings Storage Facility (TSF) have been detected in Surprise Creek. Seepage monitoring in 2005 and 2007, as well as measurement and modelling during the past year, clearly shows that soluble sulfate, zinc and, potentially, lead and cadmium are seeping into Surprise Creek.

Dust from operations at the run of mine (ROM) pad and crushing plant, and also historically from the TSF, is being expressed in stream sediments in both Barney Creek and Surprise Creek. Both of these chemical inputs from the mining activities have adversely impacted the macroinvertebrates in Surprise Creek. Ongoing action for rectification of dust emissions and seepage from the TSF is strongly recommended.

Other remaining issues that are considered significant and to require immediate action towards rectification include the:

- volume of water stored in Cell 2 of the TSF remains a concern as there is considered to be an extreme risk of embankment failure or overtopping of the spillway;
- visual method for classification of NAF/PAF waste rock is of concern as it poses the potential for misclassification;
- progress of acidification of the tailings and delineation of the treatment options;
- generation of fugitive dust emissions from the PACRIM area, and, to a lesser extent, the Bing Bong Port concentrate storage shed;
- structural integrity of the Bing Bong Port dredge spoil pond walls;
- slow progress of revegetation on the McArthur River diversion; and
- inadequacy of reporting of many routine monitoring programs.

Additional recommendations and issues are identified in the technical review section in the body of this report.

MRM continue to show a genuine willingness to improve their environmental performance and have made efforts to follow up on many of the recommendations made in past Independent Monitor Audit reports. MRM and the DoR are strongly advised to consider all of the recommendations in this report and make concerted efforts to rectify the issues identified.

In 2012 the Independent Monitor will review the performance of the mine operation for the 2011 operational period, and will follow up on the recommendations made in this report.

Project Manager
Laura Boland
Environmental Scientist
Environmental Earth Sciences

Project Director/Internal Reviewer
Philip Mulvey
Senior Principal Scientist
Environmental Earth Sciences

Technical input
Geordie McMillan
Senior Hydrogeologist
Environmental Earth Sciences

Peter Scott
Environmental Earth Sciences
Senior Principal geochemist

Don Still
Principal Hydrologist
Bewsher Consulting

Jorge Alcaino
Environmental Scientist
Environmental Earth Sciences

Dr Bill Low
Principal Ecologist
Low Ecological Services

Angela Stewart
Environmental Scientist
Low Ecological Services

Holger Woyt
Marine Ecologist
Low Ecological Services

Timothy Rowles
Senior Geotechnical Engineer
Knight Piésold

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APPENDICES

1 INTRODUCTION

The McArthur River Mine is operated by McArthur River Mining Pty Ltd (MRM), which is 100% owned by Xstrata PLC. The McArthur River Mine is located in the Gulf Region, Northern Territory, approximately 740 kilometres south-east of Darwin and 45 kilometres south-west of the township of Borroloola (Figure 1).

McArthur River Mining has been developing one of the largest known zinc-lead-silver deposits in the world since 1995, whence the ore bodies that make up the deposit have been mined through underground operations. In 2006, MRM was granted permission to operate the mine as an open-cut. The mine site layout is shown in Figure 2.

1.1 Regulatory and other requirements of this audit

As part of the approval for open-cut mining operations, a variation was made to the Conditions of Authorisation No 0059-02 for mining leases MLN1121, MLN1122, MLN1123, MLN1124, MLN1125, MLN1126 and MLN582, pursuant to section 38(2) of the NT *Mining Management Act*. This variation included the provision of an Independent Monitor under Schedule 2 of the Authorisation 0059-02. The Independent Monitor is required to:

- monitor the environmental performance of the Mine by reviewing:
  - environmental assessments and monitoring activities undertaken by the operator;
  - environmental assessments and monitoring activities undertaken by the Department; and
- report to the Operator and the Department any urgent issues requiring investigation and reporting.

It is the role of the Independent Monitor to consider key indicators of environmental performance including, but not limited to, the following:

- adherence to statutory commitments;
- effectiveness of environmental risk management systems;
- appropriate and effective monitoring procedures, including air, water, waste, structural, biological and sediment monitoring;
- spatial data management including GIS management, manipulation, representation and presentation of data;
- water management, including: surface water and groundwater modelling; solute transport models; discharge conditions; catchment water balance modelling; water quality, and water treatment technologies and options;
- hydrologic and engineering assessments relating to the river diversions;
- geochemistry, geomorphology and structural integrity design and reports for major infrastructure such as the river diversions, tailings storage facility (TSF), overburden emplacement facility (OEF), run of mine (ROM) pad, and Bing Bong Port dredge spoil;
- closure criteria, progressive rehabilitation planning and costing, and ecological reconstruction assessments including the implementation, monitoring and management of rehabilitated landforms and the river creek diversions; and
- progressive improvements to all of the above.

Source: Google Image 2009

0 50 100 150 200 250

Scale in Kilometres

Source: Google Maps Australia

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Title: **Locality Map**

Location: **McArthur River Mine and Bing Bong Port, Northern Territory**

Project: **Independent Monitor 2010 Operational Period**		**Job No: 210011**
Project Man: **GM**	**Scale: As shown**	**Figure 1**
Drawn By: **PF**	Date: **August 2011**	

Photo: Independent Monitor 1 June 2011

Source: MRM MMP 2009/2010

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **MRM Site layout**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	Figure **2**
Drawn By: **PF**	Date: **August 2011**	

The Independent Monitor is not required to review mine safety or social issues in the McArthur River region arising from the operation of the mine.

The timeframe of the audit was focussed on the period from October 2009 to September 2010, which is referred to herein as the '2010 operational period'. It must be noted however, that the audit has also taken into account limited relevant information, data and observations that are more current than the 2010 operational period.

1.2 Objectives

The objectives of the Independent Monitor Audit are to:

1. review the environmental assessments and monitoring activities undertaken by MRM;
2. review environmental assessments and audits undertaken by the DoR;
3. report to MRM and the DoR any urgent issues requiring investigation and reporting; and
4. provide an annual audit report to the Minister for Primary Industry, Fisheries and Resources that:
    - o assesses the environmental performance of MRM operations; and
    - o recommends improvement measures to increase environmental performance.

1.3 Audit scope

The scope of works required to complete the audit comprised the following components:

- review of the MRM monitoring data, management systems, and assessments undertaken during the 2010 operational period via. These are reviewed through:
    - o a statutory compliance assessment;
    - o a technical review of data and procedures;
    - o a site inspection and
    - o interviews with personnel;
- annual update of the Independent Monitor's risk assessment and gap analysis relating to the MRM operation;
- review of environmental audits, assessment, management systems, and environmental monitoring undertaken by the Department of Resources pertaining to the 2010 operational period;
- community consultation and presentations; and
- the provision of this annual report to the Minister for Primary Industry Fisheries and Resources regarding the environmental performance of MRM operations.

The following approach has been applied throughout the audit process:

- the Independent Monitor does not collect data in additional to that provided by MRM or the Department of Resources;
- the intention of this audit is to identify and discuss issues that the Independent Monitor considers to be of significant environmental risk, or represent a significant inadequacy in environmental performance; and

- issues of lower environmental risk may be assessed and discussed within subsequent audits periods.

Each year, the Independent Monitor selects a number of areas on which to focus for technical review. Many of these areas are in response to recommendations for improvement from the previous audit and others are new areas on which the Independent Monitor considers it significant to focus. In this audit, the primary areas focussed upon included, but were not limited to:

- the performance of the tailings storage facility (TSF), particularly in terms of:
  - excess water storage in TSF Cell 2;
  - current and likely future seepage migration from TSF Cell 1 into Surprise Creek;
  - geochemical assessment/hazard classification of tailings; and
  - effectiveness of the progressive rehabilitation of TSF Cell 1;
- the performance of the Bing Bong Port dredge spoil ponds since the previous audit;
- dust emissions from the Bing Bong Port concentrate storage shed:
- the level of detail and quality of reporting of monitoring results;
- weed management along the river diversion channels and mine site;
- scientific robustness of routine monitoring results collected by MRM;
- relocation or repair of mine perimeter fence lines to keep out cattle that damage rehabilitation efforts and cause erosion;
- procedures and monitoring results relating to the function and management of the overburden emplacement facility (OEF); and
- rehabilitation and habitat creation along the river diversions.

2 BACKGROUND

2.1 Relevant legislation and guidelines

The Department of Resources is the Northern Territory Government agency responsible for mining approvals and compliance. It is the responsibility of the Department of Resources to administer the requirements of the *Mining Management Act* and Regulations.

The MRM operates under a range of relevant Commonwealth and Northern Territory legislation as listed below:

Commonwealth statutory requirements:

Aboriginal Land Rights (NT) Act;

Native Title Act;

Aboriginal and Torres Strait Islander Heritage Act;

Environment Protection and Biodiversity Conservation Act; and

National Environmental Protection Measures.

Northern Territory Statutory requirements:

Environment Assessment Act;

Environment Assessment Act;

Aboriginal Sacred Sites Act;

Weeds Management Act;

Water Act;

Heritage Conservation Act;

Pastoral Land Act;

Waste Management and Pollution Control Act;

NT Lands Act;

Bushfires Act;

Petroleum Act;

Native Title Act;

Public Health Act;

Territory Parks and Wildlife Conservation Act;

Soil Conservation and Land Utilisation Act;

Energy Pipelines Act; and

Traffic Act.

2.2 Previous Independent Monitor Audits

The Independent Monitor has completed three previous audits of MRM's environmental performance: the 2007, 2008, and 2009 operational period and report documents the fourth annual audit undertaken by the Independent Monitor. Before detailing the findings of the 2010 audit, the key findings of the previous Independent Monitor Audit reports are provided below.

2.2.1 2007 operational period audit

This audit was undertaken in 2008 and focussed on the environmental performance of MRM for the 2007 operational period. It included a technical review of environmental management and monitoring practices as well as a compliance audit compared with operating conditions.

Results of the audit indicated a high level of procedural conformance with statutory commitments and conditions, although one non-conformance was observed in that larval mosquito monitoring breeding sites rectification programs had not been undertaken and several incomplete conformances were noted.

In the technical review of MRM's monitoring and reporting for the review period, the Independent Monitor found considerable data gaps as well as a general inadequacy of interpretation of monitoring results both by MRM, and external consultants.

Several monitoring programs were recommended for improvement and/or rectification over the subsequent three to five years. These were:

- improved monitoring, technical review and interpretation of all water monitoring data around the mine, in particular the assessment of seepage from the tailings storage facility into Surprise Creek;
- improved management and subsequent reduction of fugitive dust emissions at the Bing Bong Port load-out facility;
- improvement of dust management practices, particularly at the tailing storage facility;
- improved management and rehabilitation of the Bing Bong Port dredge spoil dump; and
- adjustments to analytical suites for the surface water and groundwater monitoring programs.

The Independent Monitor's audit of the check monitoring systems and procedures used by the Department of Resources revealed that, although the sampling techniques used in the field were satisfactory, the procedural documentation for undertaking this work—that is, sampling manuals, training procedures and checking competency of staff — were not provided in time to be considered in terms of the Independent Monitor's site inspection.

It was indicated that the DoR's check-monitoring could be improved, principally by ensuring that the results of monitoring by the DoR were assessed internally against the results provided by MRM for the commensurate monitoring event.

2.2.2 2008 operational period Audit

In 2009, the Independent Monitor completed an audit of the environmental performance of MRM over the 2008 operational period.

During this audit, some improvements from the 2007 operational period audit were noted, including:

- practices relating to dust emissions from the tailings storage facility TSF Cell;
- water monitoring reporting; and
- efforts to begin a mosquito monitoring program were undertaken.

However, two significant issues that urgently required immediate investigation and reporting were identified. These issues were:

- tailings leachate migration from tailings storage facility Cell 1 into Surprise Creek; and
- saline leachate from the Bing Bong Port dredge spoil affecting vegetation surrounding the spoil ponds.

MRM subsequently took action to bring these issues under more control: A leachate collection sump was installed and further monitoring and investigations were proposed regarding the TSF Cell1 leachate. An outer spoon drain was constructed around the Bing Bong Port dredge spoil pond to redirect saline seepage out to sea. It was noted that these issues would require still further investigation, monitoring and ongoing mitigation measures as per the Independent Monitor's specification.

Other less urgent but still significant issues were:

- fugitive dust emissions at the Bing Bong Port load-out facility; and
- weed management along river diversion channels and around the mine site.

Minor issues that were considered to require medium-term rectification related to:

- the generation of dust from the ROM pad/PACRIM crushing plant towards Barney Creek and its tributary;
- the design and potential recurrence of failure of the drain sump at the base of the ROM pad;
- the poor condition of asphalted and paved surfaces at the Bing Bong Port load-out facility;
- inadequate analysis of the accuracy, reproducibility and precision of routine monitoring results collected by MRM. These inadequacies included checking field measurements against laboratory results and expected objectives and using a data quality sign-off sheet for quality assurance;
- rapid maintenance of fencing damaged by annual floods to improve rehabilitation works; and
- in-place testing of the clay liner of the overburden emplacement facility as part of future OEF expansion.

A copy of this report can be downloaded from the IM website at:
www.mrmindependentmonitor.com.au

2.2.3 2009 operational period audit

The Independent Monitor Audit of MRM environmental performance over the 2009 operational period was undertaken in 2010, with a site inspection being conducted in May 2010.

In 2010 it was found that a number of issues identified in the previous audit report had since been addressed by MRM, these included:

- the outer spoon drain constructed around the Bing Bong Port dredge spoils pond appeared to be operating successfully;
- dust suppression measures at the ROM pad/PACRIM crushing area had been planned and some, such as sprays, were already in place;
- the previously failed sump at the base of the ROM pad had been redesigned and improved for greater storage capacity;
- MRM advised that steps were being taken to gain approvals to relocate the perimeter fence so that the annual flooding destroys less of it, thereby limiting the access of cattle into the mine site; and
- in-place testing of the OEF clay liner had since been undertaken, however, the associated procedures and results to confirm the adequacy of the testing were incomplete.

Also, a number of ongoing issues were found to remain, with additional issues also being identified. Table 1 is an update of the environmental issues that were considered to be significant and required corrective action in order to improve MRM's environmental performance.

A copy of this report can be downloaded from the IM website at:
www.mrmindependentmonitor.com.au

TABLE 1 SIGNIFICANT ISSUES FROM PREVIOUS AUDIT

Significant Issue last audit	2011 Update
Excess water storage in the tailings storage facility which poses the risk of overtopping and embankment failure due to spillways being under-designed for a flood event.	Excess water in the TSF Cell 2 is still an issue. Based on the 2010 Dam Safety Audit, the available capacity is less than the storage capacity required to contain a 1 in 200 year event. As such, the facility does not have sufficient capacity and this will need to be increased by the start of the 2011/2012 wet season. See Plate 1 and Plate 2.
Seepage migration from the tailings storage facility to Surprise Creek and the hazard classification of tailings in Cell 1 and Cell 2.	Seepage migration from the TSF into Surprise Creek remains an issue (See Plate 3). However, an investigation into the geochemical nature of the tailings and water levels in TSF Cell 1 has been undertaken since last audit. This investigation, though compliant with the written instruction, is inadequate at a technical level, moreover it has confirmed that acid drainage will occur.
Fugitive dust emissions from the mine site ROM pad/PACRIM crushing facilities.	This issue has not been significantly improved since the previous audit. During the May 2011 site inspection, dust was still observed emanating from the PACRIM crusher. The IM notes that water sprays are being used more often at the ROM pad than last year, however, few upgrades to dust suppression on the PACRIM plant were observed. It is further noted that contaminated dust monitoring results have not improved in this area between 2009 and 2010.
Fugitive dust emissions from the Bing Bong Port concentrate storage shed.	The primary source of contaminated dust at Bing Bong Port comes from the concentrate storage shed. This year it was observed that the doors to the shed still remain open, which provides an opportunity for lead/zinc/silver dust to escape. As such, this issue continues to be of concern. MRM have indicated that capital expenditures have been approved for updates to the shed which will allow the doors to remain shut while avoiding gas build up.
Detail and quality of reporting of the dust, soil and sediments monitoring program and inclusion of long term trends and base studies.	This issue is still of concern although the Independent Monitor notes that MRM have made some improvements to the quality and content of reporting since the previous audit and that further trends analysis has been conducted for some monitoring areas. However, the level of data analysis and reporting is not considered to be of a high industry standard and in many cases it is inadequate to provide evidence that defensible scientific monitoring methods have been used.
Weed management along the river diversion channels and the mine site.	Weed management is an ongoing commitment and the IM notes that MRM has made some effort to control weeds in the mining lease.
Structural integrity of the Bing Bong dredge spoil ponds.	At the time of the Independent Monitor's site inspection, the Bing Bong dredge spoil was dry and appeared to be stable, however there is still no information available regarding the stability of the pond walls. It is recommended in this report that MRM consider conducting a complete geotechnical review of the walls prior to the 2011/2012 wet season.
Testing of the tailings storage facility Cell 1 clay cap to ensure it meets design specifications.	The clay cap over TSF Cell 1 has now been completed. At this stage, the cap acts as method for tailings dust suppression only. This being the case, we have not been provided with any testing results regarding the cap, such as level surveys, compaction or other geotechnical/ geochemical analyses. Some erosion of the cap was observed during the site inspection in May 2011.

Plate 1 Excess water stored in the TSF Cell 2 in 2010. Note clay cap of TSF Cell1 was approximately 60% complete at the time. Photo: Independent Monitor, May 2010.

Plate 2 Excess water still stored in TSF Cell 2 in 2011. Note the completion of the clay capping of TSF Cell1 since the previous audit. The cap now acts as a measure to suppress talings dust emissions. Photo: Independent Monitor, 1 June 2011.

2009

2010

2011

Plate 3 Photographic comparisons of the same area of seepage from the north eastern toe of TSF Cell1, taken in 2009, 2010, and 2011. Photos show leachate draining from the toe of TSF Cell1 towards Surprise Creek. The flow of leachate does not appear to have decreased over the years, but the level of monitoring and investigations in increasing. Ongoing mitigation and investigatory works will be required for some time.

3 AUDIT METHOD

The audit was conducted in accordance with the Independent Monitoring Assessment Conditions (IMACs) (2006) and the Scope of Services for the Independent Monitor's contract of engagement, as agreed between the Independent Monitor and the Department of Resources.

The full list of documents reviewed this audit period for the Department of Resources and MRM are provided in Appendices C and D.

TABLE 2 INDEPENDENT MONITOR TEAM

Name	Company	Position title	Audit focus	Years of experience
Philip Mulvey	Environmental Earth Sciences	Senior Principal Scientist	Geochemistry , hydrogeology, soils, sediment and dust	31
Peter Scott	Environmental Earth Sciences	Principal Geochemist	Tailings and waste geochemistry	39
Geordie McMillan	Environmental Earth Sciences	Senior Hydrogeologist	Groundwater, geochemistry	10
Don Still	Bewsher Consulting	Principal Hydrologist	River diversion and surface water hydrology	34
Tim Rowles	Knight Piésold	Geotechnical Engineer	Geotechnical issues	14
Dr Bill Low	Low Ecological Services	Principal Ecologist	Flora and fauna	50
Angela Stewart	Low Ecological Services	Ecologist	Flora and fauna	5
Holger Woyt	Low Ecological Services	Marine ecologist	Marine flora and fauna	21
Laura Boland	Environmental Earth Sciences	Environmental Scientist	Environmental management	4
Jorge Alcaino	Environmental Earth Sciences	Environmental Scientist	Environmental science, marine water, sediments, soil and dust	4

3.1 Site inspection

The Independent Monitor undertook a mine site inspection over two days; 30 and 31 May 2011. As part of the inspection, the Independent Monitor inspected the MRM operation of the:

- tailings storage facility;
- Bing Bong Port facility and dredge spoil pond;
- overburden emplacement facility;

- plant nursery;
- ROM pad and PACRIM yard (crushing plant);
- mine site workshop and storage area; and
- Barney Creek and McArthur River diversion channels and rehabilitation efforts.

3.2 Personnel Interviewed

McArthur River Mining personnel were interviewed during the mine site inspection. Gary Taylor, MRM Health Safety and Environment Manager, was the primary point of contact for the Independent Monitor during the audit. Other MRM personnel interviewed during the site inspection included:

- Julie Crawford – Environmental Superintendent;
- Sam Strohmayr – Metallurgical Manager;
- Karissa Grenfell – Mining Manager;
- Robert James – Mining Sustainable Development Manager
- Jason Desmond – Rehabilitation Technician; and
- Mike Williams – Administration Manager.

On 3 June 2011, Geordie McMillan and Laura Boland from the Independent Monitor team met with the following personnel from the Department of Resources to discuss the DoR's processes and procedures used for the assessment of the McArthur River Mine operation:

- Alister Trier – Executive Director Minerals and Energy;
- Russell Ball – Director Mining Performance;
- Peter Zeroni –Director Strategic Policy and Projects;
- Alana MacKay – Environmental Scientist, Mining;
- Gary Martin – Team Leader, Mining Team 1;
- Graham Williams – Team Leader, Technical Support;
- Mitchell Rider – Executive Officer Mining Projects;
- Mike Fawcett – Assistant Director, Mining Remediation;
- Peter Waggitt – Assistant Director, Chief Mining Engineer.

4 RISK ASSESSMENT UPDATE

4.1 Purpose, objectives and scope of risk assessment

Each year the Independent Monitor undertakes an annual risk assessment to fulfil a requirement set out in the Independent Monitor Scope of Services to assess environmental risks associated with the MRM operation. This year the risk assessment was updated based on the technical review of monitoring data from the 2010 operational period and observations made during the May 2011 mine site inspection.

The objectives of the risk assessment are to:

1. identify significant environmental risks associated with MRM operations; and
2. evaluate whether environmental monitoring and assessment practices undertaken by MRM are adequate and appropriate to mitigate the risk of potential environmental impacts.

The scope of the risk assessment is intended to be in line with the scope of the technical audit report in that it focuses on issues that the Independent Monitor considers to be of high-level risk. Lower level risk issues will be examined in subsequent audit reports and will be included in updated annual Independent Monitor risk registers.

Based on the adequacy and effectiveness of MRM's environmental monitoring systems, and their effectiveness in monitoring these issues, risks of potential environmental impacts resulting from the mine site and Bing Bong Port operations, were examined and evaluated, for the following areas:

- tailings storage facility;
- McArthur River and Barney Creek diversions;
- the management of surface water and artificial waters;
- groundwater;
- the overburden emplacement facility;
- Bing Bong Port dredge spoil;
- Bing Bong Port facility fugitive dust emissions;
- the tailings pipeline; and
- flora and fauna monitoring and management.

Scope of information input
Information was generally limited to the 2010 operational period; however observations made during the May 2011 site inspection and more recent information was also considered during the risk assessment, so the scope of the risk assessment comprised all information provided to the Independent Monitor for this audit period.

Temporal and spatial scope of impacts
Both short-term and long term potential environmental impacts were assessed. Similarly, the spatial scope of the risk assessment encompassed potential environmental impacts both within and outside the mining lease area.

4.2 Stakeholders

The following stakeholders were considered to be affected by the potential environmental impacts associated with MRM operations:

- the community of Borroloola;
- Traditional Owners;
- the general public;
- future generations;
- McArthur River Mining Pty Ltd; and
- the Department of Resources.

4.3 Methodology

In general, the risk assessment was undertaken in accordance with the methodology advised within ISO 31000:2009 – Risk Management Principals and Guidelines (Standards Australia, 2009).

Assumptions and exclusions as discussed in section 1.3 apply to the risk assessment methodology.

4.3.1 Risk identification and analysis

Together with their own expert knowledge and experience, the Independent Monitor team used the following information resources to identify potential environmental risks:

- documentation provided by MRM;
- documentation provided by the Department of Resources;
- site inspections undertaken by the Independent Monitor during 2008 and 2009; and
- interviews with MRM personnel during site inspections, and interviews with DoR personnel during a meeting in Darwin on 3 July 2011.

Each team member identified and systematically listed environmental risks relating to their area of expertise (for example, flora and fauna) in Table 15, Appendix A. Other aspects considered and recorded in the risk register include:

- potential duration of impact;
- location of impact;
- causes; and
- existing controls, monitoring or assessment undertaken.

4.3.2 Risk evaluation

Risk evaluation was conducted on the basis of residual risk with known controls in place. Consequently, the risk rating derived is based upon the information sources provided to the Independent Monitor by MRM.

Risk evaluation was undertaken through qualitative analysis, which was supported by data and other information provided by MRM and the Department of Resources. The risk associated

with each potential impact was determined using a matrix of likelihood and potential consequence whereby:

risk = consequence + likelihood

'Consequence' was determined to be the reasonable maximum impact there may be on the natural environment if existing monitoring and assessment controls were inadequate or inappropriate. This consequence was considered with regard to both the location and duration of the impact (see Table 14 and Table 15 in Appendix A).

The reasonable consequence and likelihood of occurrence was considered for each impact in terms of the scales provided in the risk matrix and the results of the risk assessment are recorded in the risk register along with the risk matrix in Appendix A.

4.4 Outcomes of risk assessment

As recoded in the risk register, a total of 71 environmental risk items were assessed by the Independent Monitor to be of significance this audit and these are summarised in the sections below.

This risk assessment will be reviewed and updated by the Independent Monitor again as part of the next audit in 2012.

4.4.1 Extreme risks

In the last audit there were no **extreme** risks identified by the Independent Monitor. In this audit there are two environmental issues which are considered to pose **extreme** risks; these are the potential:

- overtopping of TSF cells leading to an embankment failure; and
- for acid leachate migration from the TSF into Surprise Creek.

The Independent Monitor recommends that MRM consider taking steps to reduce the risk of embankment failure, that may include but may not limited to:

- increasing the freeboard in TSF Cell2 (It is understood that MRM have plans to raise the embankment height and hence increase the freeboard, however, the Independent Monitor has no details on this proposed action);
- increase design storage capacity;
- additional water reduction including Cell 1 runoff diversion from entering Cell1;
- removal of temporary bunding from the spillway; and
- confirming the spill rating of the asset.

In 2009, the IM identified the issue of seepage from TSF Cell 1 draining into Suprise Creek as requiring notification under IMACS Section 6.4. MRM subsequently commissioned an investigation into the geochemical nature of the tailings in Cell1, which was reviewed by the IM this audit. However, the IM believes the reporting of the investigation provided is insufficient to predict the timing and quantity of acidification in the tailings as well as the rate of discharge to Surprise Creek.

The IM notes that environmental monitoring shows that impacts are already occurring in the macroinvertebrate community of Surprise Creek, as a result of the seepage of neutral drainage from the TSF containing elevated sulphate and zinc. This seepage is known to have

been discharging into Surprise Creek since (at least) 2005 for zinc, and since 1997 for sulphate. Elevated lead and cadmium are also contained within the tailings leachate and have been detected migrating away from the TSF, but are yet to be detected in Surprise Creek or in groundwater close to the Creek.

The sulfide minerals in the tailings dam are in excess of the buffering capacity of the tailings carbonate minerals. When the buffering capacity is exceeded, acidity will be generated and heavy metal concentrations in leachate will increase more than 100 times. The acidity together with high concentrations of heavy metals will have a significant adverse impact on Surprise Creek. As an outcome of this report, The IM recommends preparing a contingency plan or consider reprocessing TSF Cell 1 and rebuilding a new TSF on a low permeability base. We consider it likely that the same issue will arise with TSF Cell 2.

4.4.2 High risks

Last audit 26 high risks were identified by the Independent Monitor. This audit 18 **high** risk items were assessed. Almost all of the most urgent of the **high** risk issues (those with a risk matrix result of 4 rather than 5) are associated with the TSF, and include:

- TSF Cell 1 embankment failure causing spillage into Surprise Creek;
- failure of the TSF Cell 2 embankment due to stability failure;
- failure of the TSF Cell 2 embankment due to scouring at the toe of the embankment;
- leachate containing salts and metals from TSF entering Surprise Creek and impacting flora and fauna; and
- contamination of surface soils, vegetation and sediments with salts and heavy metals due to dust emissions from the PACRIM crusher at the mine site.

See the tables in Appendix A for the full list of **high** risk items.

4.4.3 Moderate risks

In the last audit a total of 27 risks were identified as **moderate**, this year, 43 risks were considered to have a **moderate** risk rating. These can be viewed in the tables in Appendix A.

There has been a significant increase in the number of **moderate** risks identified this audit, however, this increase is primarily due to the Independent Monitor broadening the scope of the risk assessment with each audit, as well as including a wider range of potential risks that may not have been deemed significant enough to report last audit. Consequently, this increase in the number of **moderate** risks does not necessarily indicate that the environmental performance of MRM has deteriorated over the last monitoring period.

4.4.4 Low risks

In the last audit 5 low risks were identified and in this audit 8 low risks were identified. These included risk of:

- habitat alteration due to weed infestations on dredge spoil/rehabilitated areas;
- dust blown from the Bing Bong Port facility causing loss of water and sediment quality and loss of flora/fauna in the Sir Edward Pellew Islands;
- production of acidic leachate from the dredged material in the Bing Bong Port dredge spoil ponds;
- inadequate analysis and discussion of environmental monitoring programs causing environmental issues to be overlooked;

- stockpiled topsoil not being available for rehabilitation of tailings dam or waste dumps;
- failure of pumps in the ROM pad sump area during a heavy rainfall event causing sump water to flow towards Barney Creek;
- sudden and significant flood-induced channel bank erosion/collapse leading to an unexpected increase in flood level; and
- intake of heavy metals in cattle grazing on the mine site.

5 GAP ANALYSIS UPDATE

5.1 Gap analysis overview

Assumptions and exclusions detailed in section 1.3 apply to this gap analysis, which is undertaken annually as a requirement of the Independent Monitor Scope of Services. Its purpose is to identify gaps that require improvement in environmental monitoring and assessment undertaken for MRM operations and it is updated by during each audit period.

Included is a comparison of the environmental performance of MRM with:

- best practice industry standards such as the *Leading Practice Sustainable Development Program for the Mining Industry*;
- expert assessment and recommendations; and
- MRM statutory obligations.

Each member of the Independent Monitor team separately identified monitoring and assessment gaps in their field of expertise.

5.2 Gap identification and assessment

A gap is defined as 'a discrepancy between the monitoring program that *is* taking place, and the monitoring program that *should* be taking place if MRM's environmental performance is to be maintained at industry best practice standards'.

Gaps that were identified are listed in the gap register in Appendix B.

5.3 Gap evaluation

To maintain a consistent and systematic methodology between Independent Monitor team members, each identified gap was evaluated in accordance with the *Gap analysis process flow chart*—developed by Environmental Earth Sciences and included in Appendix B—and used to categorise identified gaps as described in Table 3.

All gap categories are considered to have equal weighting; for example, not undertaking appropriate assessment of monitoring data or not undertaking appropriate mitigation measures, a Category 3 gap, may have the same adverse impact as not monitoring at all a Category 1 gap.

TABLE 3 GAP EVALUATION CATEGORIES

Gap Category	Description
Category 1	Monitoring to mitigate potential associated environmental risk is not undertaken.
Category 2	Monitoring is undertaken, but is not sufficient in design—that is, frequency, location, type and so on, are insufficient to identify or quantify potential environmental risks.
Category 3	Monitoring is undertaken and is appropriate in design, however data/output information is not adequately assessed, interpreted or managed to appropriately mitigate potential environmental risks.

5.4 Outcomes of gap analysis

In the last audit the Independent Monitor identified a total of 13 Category 1 gaps and many of these gaps have now been closed. Additionally, a total of 15 Category 2 and five Category 3 gaps were identified.

This year, the Independent Monitor has identified:

- 18 Category 1 gaps;
- 16 Category 2 gaps; and
- 5 Category 3 gaps.

These gaps are detailed in the gap register in Appendix B and are reflected in the comments made in the technical review in section 9.

5.5 Recommended actions

The Independent Monitor recommends that the monitoring or reporting measures suggested in the gap register be actioned by MRM, and/or relevant reporting be provided to the IM during the next audit period to demonstrate how the gaps will be addressed or how they have been closed.

As part of the next audit, the gap register will be reviewed and updated in light of the corrective measures undertaken by MRM.

6 REVIEW OF MRM'S COMMITMENTS

6.1 Review of commitments in the 2009/2010 Mining Management Plan

McArthur River Mining produces a mining management plan (MMP) annually. The 2009/2010 MMP outlines the results of the 2009 operational period, which was reviewed last audit, and also outlines the environmental monitoring commitments by MRM for the 2010 operational period, which is the focus of this audit. In this section we present the results of the IM's review of MRM's environment-related commitments in the 2009/2010 MMP.

The scope of the Independent Monitor's review of the commitments made in the MMP is limited by documentation provided by MRM, the scope of the audit and the time available for the site inspection.

6.2 Update from previous audit

During the last audit, we noted four procedural non-conformances related to MRM's commitments. These were:

- monitoring of a potential sedimentation zone in the McArthur River, downstream towards the Bukalara Range;
- the installation of lysimeters at various stages in the overburden emplacement facility to monitor water infiltration;
- water quality and sediment monitoring at the overburden emplacement facility dams; and
- kinetic leach testing on-site and in laboratory columns.

Due to a lack of documentation provided, two other commitments could not be confirmed. MRM responded to these compliance issues in their 2010/2011 MMP and they have now been resolved.

6.3 Outcome of compliance review for the 2010 operational period

A total of 103 environmental commitments in the 2009/2010 MMP were reviewed this audit. The results of the compliance review can be viewed in Appendix E:

- 71 commitments were found to be compliant;
- due to the limited time for site inspections and lack of provision of documentation, 22 commitments were not able to be verified by the Independent Monitor this audit, however many of these are likely compliances;
- one non-compliance was related to the following commitment:

"Prior to capping the tailings, the post-mining tailings surface topography will be reformed to minimize erosion".

On-site clay cover was observed by the Independent Monitor on May 2011 and, through conversations with staff, it was determined that the cover—placed at 0.5 m thick—had not

undergone reshaping, and was acting as a dust suppression measure only. Additionally, some erosion was observed;

- 9 commitments were found to be incomplete compliances work had been started but not competed. These related to the following commitments, as provided in Appendix E:
    - commitment 9 – cattle will be excluded from the mining and processing areas by the construction of a 17 kilometre fence line;
    - commitment 20 – rehabilitation trials will recommence on the Bing Bong Port dredge spoil and opportunistic planting will occur;
    - commitment 32 – an improvement to the dust monitoring program in 2010 is to occur with the inclusion of Minivol™ dust samplers, which will allow more accurate measurement of air quality to enable comparison with the relevant air quality standard; National Environment Protection (Ambient Air Quality) Measure (NEPM/AS2800);
    - commitment 56 – some vegetation scar mapping has been conducted with the use of aerial photographs based on annual photographs taken by AAH Hatch;
    - commitment 63 – the TSF area has been fenced to exclude stock, and permanent fire breaks will be constructed around the perimeter;
    - commitment 79 – the top of the clay layer encapsulating the PAF cells will be covered by a minimum of 3 m of NAF material;
    - commitment 80 – the PAF dams will consist of two parts: first, a sediment trap dam into which any runoff and/or leachate will flow and second, a main dam with runoff from the OEF spilling into the sediment dam first;
    - commitment 96 – activities completed in the last operational year that were approved in the last MMP included: completion and commissioning of the tailings line upgrade (No. 96); and
    - commitment 101 – operation of water recovery bores from the Surprise Creek corridor back to TSF Cell 2.

MRM have again displayed a high level of compliance with the environmental commitments in the MMP 2009/2010, however it is important to note that a high procedural compliance alone does not equal good environmental performance. There are many technical considerations and other areas of environmental monitoring that are not captured in the review of compliance commitments because the environmental performance is measured through the assessment of compliance with MMP commitments, technical review of data and documentation, discussions with personnel and site inspections, as well as MRM's efforts to improve on performance.

6.4 General review of the 2010/2011 mining management plan report

This audit report reviews the 2010/2011 MMP and reports on the environmental management and monitoring results for the 2010 operational period. It also sets commitments for the 2011 operational period, which will be reviewed during the next audit.

There has been a general improvement in reporting by the MMP over the last few years, with temporal trends in many monitoring programs now being reported and discussed, albeit to a limited extent for some monitoring programs, and the detail and level of reporting for monitoring of flora and fauna are generally good. However, reporting for dust, soils,

sediments, tailings monitoring and tailings seepage prediction, can still be significantly improved in terms of the scientific rigour of reporting, discussions and presentation of results, and providing strategies for improvement in performance.

This issue was discussed with MRM during the site inspection and it was recommended that MRM prepare detailed annual reports for each monitoring program using scientific conventions, quality control documentation, detailed discussions of results and measures for improvement. These could be summarised in the MMP, with the full reports provided as appendices. This was discussed with the Department of Resources in June 2011 and the DoR did not oppose the recommendation, provided the MMP meets its statutory requirements. The IM believes that thorough reporting and discussion of monitoring results is vital to improving environmental performance at the MRM.

MRM's response during the 2009 operational period to the Independent Monitor's findings from the last review of the MRM MMP commitments is acknowledged, however it is disappointing that the 2010/2011 MMP did not mention or discuss many of the other significant environmental issues highlighted in the last audit. This indicates that the Independent Monitor's findings are not being formally incorporated into MRM's environmental planning or environment commitments/goals. Acknowledging and responding to the significant issues identified by the Independent Monitor signifies a transparency in reporting and a commitment to continued improvement, both of which would act to increase the environmental performance of the operation.

Therefore, the Independent Monitor recommends that the next MMP produced by MRM should acknowledge and address the significant issues indentified in this audit to show that MRM does consider the audit findings within their monitoring and management of the MRM operation.

7 REVIEW OF THE DoR'S MONITORING OF MRM

As part of the Independent Monitor Audit, each year a review of the internal processes and procedures the Department of Resources used to monitor MRM's environmental performance is conducted. This appraisal was undertaken through a review of documents submitted to the Independent Monitor (Appendix D), and through a meeting with DoR staff on 3 June, 2011.

7.1 Update of previous assessment of the Department of Resources

The 2010 Independent Monitor Audit reported that, compared with previous audits, the DoR demonstrated an improvement in the amount and detail of information provided with the administrative procedures are considered to be thorough. However, the IM queries the appropriateness of the method by which staff in the DoR are delegated various technical tasks for monitoring and review of the MRM operation. It is recommended that a capability and organisational structure chart be developed that clearly outlines the competencies and areas of expertise of staff in the DoR to improve the staff allocation and capacity of the department to review and assess the MRM operation.

During the June 2011 meeting with the DoR, the issue of staff allocation/methods for assigning certain tasks to staff were once again discussed. In response, the DoR stated that tasks are assigned case by case, based on availability and skill of personnel, nevertheless, even though

it is fairly confident that the DoR takes appropriate care to assign the right technical staff to relevant mining assessment tasks the Independent Monitor still considers that a formalised method or structure chart for assigning tasks to staff should be developed and maintained.

7.2 Review of audits and assessments undertaken by the DoR

This year, the DoR provided the Independent Monitor with audit reports pertaining to the 2010 operational period, including:

- two site inspection reports for the MRM site and the Bing Bong Port, both May 2010; and
- an audit report of MRM's compliance with commitments of the 2009/2010 MMP and Water Management Plan (WMP) (December, 2010).

A review of these assessment reports is provided in the following sections.

7.2.1 Review of field reports

The DoR undertook a mine site visit on 11 and 12 May 2010, and an inspection of the Bing Bong Port loading facility on 13 May, 2010, formalised in the following two reports:

- *Field Visit Report – 11-13 May 2010* – Site inspection of the Mine Site*;*
- *Field Inspection Report – 11-13 May 2010* – Inspection of Bing Bong Port; and

The purpose of the site visits were to:

- inspect the Bing Bong Port loading facility to follow up on comments received about product being spilt at the Bing Bong port facility; and
- provide an opportunity for two DoR staff to become familiar with the mine site and MRM personnel.

Mine site visit overview

The *Field Visit Report* for the mine site inspection outlines the observations from the site visit by DoR mining officers Brett Anderson Steele - Mining Team Leader, and John Ross - Mining Officer. Areas that were inspected included:

- Barney Creek and McArthur River rehabilitation areas;
- tailings storage facility and seepage from TSF Cell 1;
- PACRIM crusher, from which "no dust was observed coming off the conveyor circuit";
- PAF and NAF waste rock stockpiles, which the Independent Monitor assumes refers to the overburden emplacement facility. The DoR noted leachate seeping from the PAF stockpile during the site visit; and
- machinery workshops, where a number of hydrocarbon spill issues were noted.

The DoR provided recommendations in their report, including:

- monitoring of the PAF stockpile seepage;
- cleaning up and preventing hydrocarbon contamination in the workshop areas; and
- weed control along the river diversions.

MRM satisfactorily responded to all DoR recommendations in their 2010/2011 MMP, section 3.4.2.

Bing Bong Port facility inspection overview
The *Field Inspection Report* for the Bing Bong Port facility outlines observations made by the DoR staff during their inspection of the facility on 13 May 2011. The DoR representatives inspected the:

- foreshore area;
- surface runoff pond;
- Aburri Barge;
- concentrate storage shed;
- workshop and fuel storage station; and
- dredge spoil ponds.

Review of field visit reports
With regard to the two reports, the Independent Monitor makes the following comments.

At times, the DoR uses broad, non-specific language and statements in the reporting. For example, the reports make statements such as "the facility was observed to be in good order" (pg.1, *Field Inspection Report – 11-13 May 2010*), without providing details, and "…strict policies and procedures relating to the port operation are in place" (pg.3, *Field Inspection Report – 11-13 May 2010)* without noting what these are and whether or not they are being observed. It is difficult to draw any meaning from these kinds of descriptions.

The reports also refer to conversations held between the DoR and MRM yet does not report on the content or outcomes of these conversations, only that issues were "dealt with" during the conservation. (pg. 3, *Field Visit Report – 11-13 May 2010*). It is essential that the details and outcomes of conversations are at least briefly recorded in site inspection reports so that this information can be reviewed by DoR staff as part of subsequent audits.

Thorough reporting is extremely important, especially considering the potential for staff to move away from the DoR, taking all non-recorded knowledge with them. In this light, we note that at least one of the two DoR staff members undertaking the inspections has since left the DoR.

We understand that part of the purpose of the Bing Bong Port loading facility site inspection was to "follow up on comments received about product being spilt at the Bing Bong port facility…" However, it would be useful if further details were provided regarding what the comments were, who they came from, where the spillages potentially occurred, and how much product might have been spilled.

Given the purpose of the inspection, it seems odd that the DoR did not inspect the actual loading procedure that occurred on 12 May, but inspected the mine site during this time and inspected the Bing Bong Port on 13 May; the day *after* loading occurred. The reasoning for this inspection incongruity is not provided in the reports, and could not be answered by the DoR during the 3 June 2011 meeting because the one DoR person who conducted the inspection and was still employed by the DoR was not present. This further highlights the need for more thorough and timely reporting of information.

Data results regarding sediments or turbidity in the Port does not appear to have been reviewed by the DoR as part of this inspection. Correlating observations with data would have been useful to provide a clearer picture regarding the potential for, or evidence of, concentrate spillage during loading.

The IM is aware of a *Northern Territory News* report in which an anonymous man stated that "quite a bit" of concentrate dust had been washed from the Aburri Barge, and was contaminating the waters of Bing Bong Port (Langford, 4 May 2010). The DoR has advised the IM that this specific media item was not the purpose of the field visit.

7.2.2 Review of compliance audit report 2010

In December 2010, the DoR conducted an audit to assess MRM's compliance with the commitments stated in the 2009/2010 MMP and WMP. This audit was undertaken through a site inspection and desktop assessment of documentation provided by MRM.

The previous MRM MMP compliance audit undertaken by the DoR was conducted in September 2007 – *MMP Compliance Assessment ref: MR2006/026.*

Audit scope
This compliance audit was not intended to be a systematic audit of all MRM commitments, however it is not clear from the audit report as to why the particular 48 commitments were chosen for assessment, and others were not. When queried, the DoR advised that it chose which commitments to assess in the audit based on what they considered relevant.

Further, the DoR's audit of MRM states that the scope of the audit was limited by time, logistics, site accessibility and "areas of professional expertise". The areas of staff expertise are not provided in the report, however, during the June 2011 meeting the DoR advised that the three staff undertaking the audit were specialised in:

- water and tailings (Alana McKay);
- revegetation (Andrew Scott); and
- mine operations and compliance with the *Mining Management Act* (Gary Martin).

The IM considers these limitations to be reasonable, however to ensure good coverage of different areas of compliance through subsequent audits, it may be useful for the DoR to make sure that different commitments are audited, and that different staff with different areas of expertise are used. Other areas of expertise that were not applied to this audit include those associated with geotechnical and geochemical issues, fauna, dust and soil, greenhouse emissions, and waste.

Review of audit findings
The audit findings are presented in a table in the DoR's audit report and it is considered that the audit was carried out appropriately for the 48 criteria that were audited. Relevant documents were requested and reviewed by the DoR, and site observations were applied to the chosen commitments. Comments against each commitment appear to be thorough.

However, the IM cannot fully agree with the DoR's statement that the results of MRM's environmental management systems "… to date are of a high industry standard", because:

- the DoR have not stated which 'industry standards' the MRM environmental management systems are being compared with; and
- the Independent Monitor has consistently found many of MRM's environmental monitoring systems, although improving, to be *below* best industry standards according to the Leading Practice Sustainable Development Program (DRET, 2011), and our own experience.

Review of reporting
The IM considers that the 2010 audit report shows improvement in the level and detail of reporting compared to the 2007 audit conducted by the DoR. The 2007 audit provided to the Independent Monitor only included a MMP Compliance Assessment table, and not the accompanying outline of the audit scope, general observations and overview of the methodology. These sections are essential for contextualising the audit and are required under the DoR's own '*Audits and Site Inspections Procedure'* (CP4-001, October 03-September 04).

Again, as with the site inspection reports discussed above, the detail in reporting should still be improved. For example, it is unclear as to what 'industry standards' MRM are being assessed against, further, the methodology for the audit assessment should be outlined in greater detail to include information regarding how and why certain MMP commitments were chosen for the audit, as well as the technical expertise of the DoR staff undertaking the audit.

It is essential that detailed reporting be undertaken so that information is recorded for ongoing reference within the DoR. As stated above, if information is not properly recorded, this knowledge may be lost if staff members leave the DoR. Furthermore, thorough record keeping is essential for determining environmental performance in the operation of the mine between audits.

In the interests of further improvement, it would also be useful for the DoR to include a more comprehensive update on any of MRM's non-conformances that were picked up during the last audit. It is a requirement of the DoR's own *Audits and Site Inspections Procedure'* that "audit follow-up findings from the previous audit should also be included as a distinct section", however, non-conformances and potential non-conformances from the 2007 audit do not appear to have been followed up in the 2010 audit. Only one issue from a 2006 compliance audit, which the Independent Monitor has not reviewed, is reported in the 2010 audit report Attachment A, section 2.

7.2.3 DoR annual assessment of MMP and WMP

The DoR has suitable procedures in operation for annually assessing MMPs and WMPs and these were provided to the Independent Monitor:

- *Document Review Procedure, AP2-003* – January 2010;
- *Mining Management Plan Assessments, Administrative Procedures for existing Authorisations, CP1-001* – 24/3/11; and
- *Administrative Procedures Checklist Existing Authorisations, Form CP1-002.*

The DoR provided substantial review documentation and correspondence to the Independent Monitor regarding the approval process for the 2009/2010 MMP and WMP, and the comments made by the DoR regarding the MMP and WMP appear to be comprehensive and valid. These comments include requests for further information regarding methods and discussions of results from MRM. The Independent Monitor has also expressed concern over these issues in previous audit reports and they are reiterated in this audit report.

The lack of detail in reporting of monitoring results for many, but not all, sections of the MMP and, to a lesser extent the WMP, are of concern because it raises the question of how, based on the limited information in the MMP, the DoR assesses the technical validity of the environmental monitoring.

During a meeting with the DoR to address this issue, the Independent Monitor proposed that MRM include more detailed reports on each area of environmental monitoring as an appendix to the MMP and WMP each year. The DoR did not have a problem with this idea, provided MRM make available an adequate summary of the findings in the body of the MMP/WMP report to satisfy the requirements of these documents.

7.3 Review of the DoR's check monitoring

As stated in previous audits, the IM considers the check monitoring manuals and methodologies for surface water and groundwater sample collection and analysis to be comprehensive and appropriate.

The IM reviewed the Water Quality Field Report prepared by the environmental monitoring unit (EMU) in April 2010, and offers the following comments:

- the report is generally well presented and it is agreed that bores GW47B and GW47C, TSF seepage bores, may be influenced by the geopolymer installed at the toe of the TSF Cell 1. However, this suggestion should be further assessed before removing these bores from the monitoring network as the chemistry is indicative of a breakthrough of tailings water containing zinc and lead;
- there is no explanation as to why results are inconsistent for many samples, and why incomplete analysis was undertaken—compared with their checklist;
- no nutrients analyses were undertaken in surface waters, and there were incomplete analysis of cations and anions in all samples;
- no alkalinity/acidity/total acidity results were provided—it is understood that these are normally done in the field by the EMU, but they have not been provided in the report; and
- insufficient QA/QC discussion is presented.

After the meeting with the DoR in June 2011, Alana McKay, the mining officer, demonstrated the intranet check-monitoring system used by the DoR for organising and assessing groundwater and surface water monitoring results from mines in the Northern Territory, including MRM. The latest version of the program is called 'SEEP', which was being prepared to supersede the existing 'DEEP' system.

MRM submits their water data on a quarterly basis to the DoR and this data is compared to the data collected by the DoR's own water monitoring conducted at the MRM by the EMU. The SEEP program appears to be a well set-out method for keeping track of MRM's data and trends over time, as well as checking the data for validity against the EMU's data. The IM also welcomes the DoR's suggestion that dust and soil, as well as and other monitoring data may be added to the SEEP program.

7.4 Recommendations for DoR monitoring

The following recommendations are made with the aim of increasing the environmental performance of the MRM operation in terms of the DoR's regulatory involvement. These include:

- increased detail in reporting, including outcomes of discussions, statements of which industry standards the operation is being compared to, the reasons for inspecting certain areas at certain times and so on;
- the monitoring areas examined in audits should be rotated in subsequent audits. It is further recommended that some members of staff be rotated for each audit so that

different areas of staff expertise can be applied to subsequent audits of the MRM operation. The DoR may already do this, however the IM has only reviewed two audits, so it is unclear. Some overlap of staff between audits will also be required to ensure consistency;

- discuss with MRM the possibility of attaching separate detailed reports to the MMP to provide greater detail regarding the status of environmental monitoring at the MRM; and
- as part of future check-monitoring reporting, the EMU personnel should include the items outlined in section 7.3 that were missing from the Water Quality Field Report reviewed.

8 ENVIRONMENTAL INCIDENTS REPORTED DURING THE MONITORING PERIOD

The Independent Monitor requested information from MRM and the DoR regarding environmental incidents that had occurred over the monitoring period. A review of incident handling and reporting is provided in the following sections.

8.1 Incident reports provided by MRM

Information about the incidents provided by MRM included 33 incidents that related to:

- exceedances of trigger criteria for various monitoring results: 24 incidents;
- misplacement or unauthorised dumping of wastes: four incidents;
- three incidents that were not environmental (OHS); and
- two regarding animals being trapped in artificial water bodies.

Most of the incident forms provided to the Independent Monitor this audit relate to exceedances in trigger criteria or guidelines for various monitoring targets, such as surface water, dust and sediments. It is agreed that it is beneficial to report guideline exceedances as incidents; however these incidents should also be collated and reviewed as a whole in the annual reports for each monitoring program. MRM should ensure that all exceedances reported in incident forms are also discussed fully in the relevant sections of the MMP/WMP.

Some exceedances were identified as errors or natural occurrences, however, in some of these cases, MRM failed to refer to any QA/QC results, such as duplicate samples or rinsate samples; for example whether a sample may have become accidentally contaminated through the equipment used. More information needs to be provided before results can be dismissed as an error of sample contamination.

8.2 Incidents reports provided by the DoR

8.2.1 Serious accidents and critical incidents

The Department of Resources provided correspondence and formal notification reports regarding environmental incidents/issues relating to the operation of the MRM. Incidents requiring '*Notification of a Serious Accident or Critical Incident (environmental)*' form under section 29 of the *Mining Management Act*) included the following:

- notification of seepage from the northern side of the North OEF that was not entering the run-off pond (June 2010). The seepage travelled approximately one kilometre down a natural drainage line to the north-east of the North OEF. A sump was subsequently constructed to collect the seepage;
- MRM has not provided the Independent Monitor with any corresponding incident reports or evidence of follow-up monitoring associated with this incident. Further, it is disappointing that MRM did not mention this issue during the site inspection in May 2011 and that the Independent Monitor only became aware of this issue *after* the site inspection during its review of documentation provided this year by the DoR. The IM will request follow-up information from MRM and the DoR regarding how this issue was/is investigated and managed; and
- notification of a short term uncontrolled discharge of water (approx. 100,000 L – 200,000 L) from a pipeline which was carrying water derived from the open pit to the TSF in September, 2009. The water collected in Little Barney Creek, which was dry at the time.

The DoR subsequently requested that MRM provide information regarding the amount of water lost, water quality data, a review of the water management procedures and maps of sampling points and the area of incident. MRM provided the requested information in a timely manner to the department, however the extensive suite of surface water analyses undertaken by MRM within Little Barney Creek appears to be erroneous. Testing for elements such as uranium, holmium, gadolinium, and dysprosium, to name a few, indicates a complete lack of understanding of the actual environmental risks associated with this issue.

Further, the IM has not been provided either by the DoR or MRM with any discussion of the results. An internal email through which a DoR officer requested a senior member of staff to review the results, was provided, however, there has been further correspondence offered. Follow-up and close-out of serious incidents is essential and if not undertaken represent a serious breakdown in environmental performance. The IM will request further information on this issue.

The Independent Monitor is also aware of a fuel spill within the mine site that occurred in June 2011. It is understood that MRM is undertaking investigation and remediation works and that the DoR is being updated fortnightly. The IM will be following up on this throughout 2011 and its findings will be included in the next audit report.

8.2.2 Other complains or incidents

White material at Burketown Crossing
During the last audit, the Independent Monitor reviewed an investigation regarding white material deposited on rocks and sediment at the Burketown Crossing. This issue was initially raised in January 2010 with the DoR by a member of the community of Borroloola.

In the last audit, the Independent Monitor reviewed a report regarding this issue which was commissioned by MRM and conducted by the Australian Institute of Marine Science (AIMS). The investigation concluded that the white material deposited on rocks and sediments had the chemical signature of precipitated salts from seawater evaporation, and was not the result of mining operations.

This year, the Department of Resources provided the IM with some correspondence—February/March 2010—notifying MRM of the DoR's acceptance of the findings and the closing out of the issue. The IM agrees with this outcome.
White material reported at Surprise Creek Bridge

Photos of a white substance on rocks under the Surprise Creek Bridge crossing along the Carpentaria Highway were provided to the DoR by the Environment Centre NT on 1 December 2010 (see Plate 4).

Plate 4 Photo of significant salt build up on rocks along Surprise Creek at the bridge crossing along Carpentaria Highway. Photo: Environment Centre NT

Plate 5 Photo of minor salt on rocks along Surprise Creek at the bridge crossing along Carpentaria Highway as observed by the DoR. Photo: DoR.

The area of impact was inspected by the DoR during their compliance audit inspection on 13 December 2010. However, the DoR officers inspecting the area observed only minor amounts of white material, likely to be salt, build up on rocks along the bank of the creek (Plate

5). On 17 January 2011, the DoR advised MRM by letter that this area should be added to the MRM monitoring program to observe and, if required, collect samples. As part of its next audit in 2012, the Independent monitor will review monitoring associated with this issue.

9 OUTCOMES OF TECHNICAL REVIEW

9.1 Review of surface water and artificial water monitoring

Surface water and artificial water are monitored periodically at the locations provided as shown in Figure 3. The following documents have been reviewed as part of the surface water component of the Independent Monitor's audit for 2009-2010:

- MRM P/L Sustainable Development Mining Management Plan 2010/2011;
- MRM P/L Sustainable Development Water Management Plan 2009;
- URS Australia P/L Development of a Water Management Plan prepared for MRM P/L, report 42213885, dated 23 December 2009;
- Golder Associates Hydrogeochemical Investigation of the Tailings Storage Facility, McArthur River Mine prepared for MRM P/L, report 107633048-003-Rev0, dated 17 June 2011; and
- data sets and field reports (i.e. Excel spreadsheets, copies of completed field monitoring records, etc).

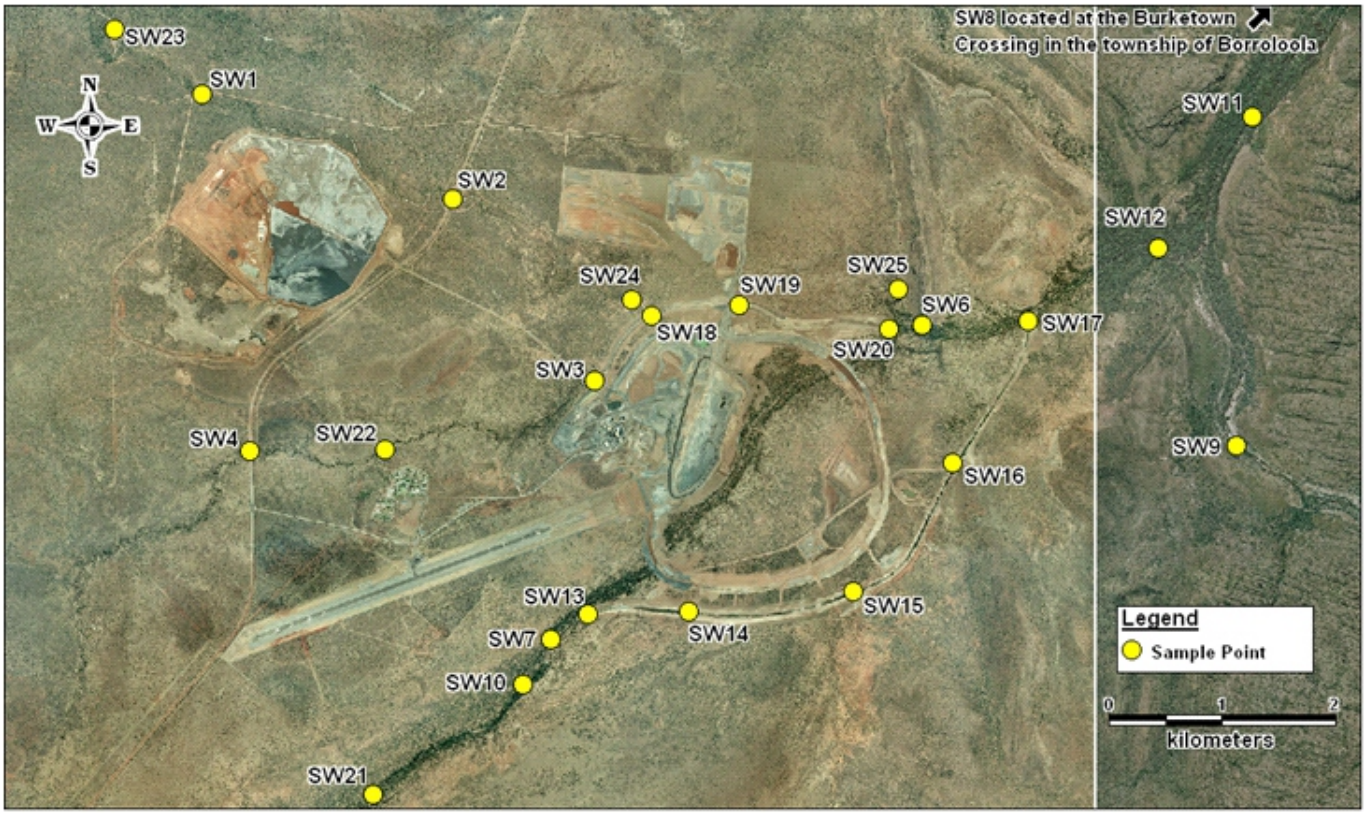
As described in section 4.6 of the WMP, monitoring of the natural surface water in upstream and receiving water environments of Barney Creek, Surprise Creek and McArthur River is undertaken to:

- continually improve the knowledge and characterisation of natural water quality and variation in upstream and receiving water environments;
- assess and monitor potential contaminant impacts of mine operations, including mine water management impacts, and groundwater impacts on surface water quality; and
- supplement the fluvial sediment monitoring program.

In section 4 of the WMP, MRM has identified the following limited list of sources of risk to surface water quality at the mine site:

- potentially acid forming (PAF) waste rock;
- depositional dust: ROM pad/PACRIM, TSF, Bing Bong Port concentrate loading facility; and
- contaminated process water.

The Independent Monitor agrees that these are risks but the list is not complete, it should be noted that due to the nature of the mine expansion—that is new TSF cells, river diversions, civil works and so on, as well as general operational risks—the existence of *all* potential sources of detrimental impact to surface water quality should be identified, regardless of their risk. An example of this is the first point pertaining to impacts from PAF waste rock.



Source: MRM Water Management Plan 2010/2011

Source: MRM Water Management Plan 2010/2011

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Surface water sampling locations (top) and Artificial water monitoring sites (bottom)**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 3**
Drawn By: **PF**	Date: **August 2011**	

Recent incidents reported by MRM to the Department of Resources, in addition to the continued seepage from TSF Cell 1, have demonstrated that the current and near-term impacts on surface water quality are those of “neutral mine drainage (NMD)”, that is increased salinity and the presence of sulfosalts, rather than that of acidic drainage.

During the reporting period, MRM has documented the following measures at the TSF to reduce the risk for increased impacts on the surrounding surface water system(s):

- installed seepage recovery bores along Surprise Creek to the north of Cell 1;
- completed the initial clay capping of Cell 1 as a dust control measure;
- reduced the water retorting to Cell 2 by increasing the tailings density up to 54%;
- commenced tailings deposition in thin laminar layers to increase consolidation and improve water evaporation;
- commenced mechanical evaporation using sprinklers and maximising water surface areas;
- installed a new water drain in the western part of the TSF to intercept water seepage and return water back to Cell 2;
- maintained the eastern drain with water being returned to Cell 2;
- installed sumps and pumps in areas of localised seepage to capture and return the seepage to Cell 2; and
- commenced a feasibility study of the installation of (proposed) evaporation fans.

The presentation and interpretation of surface water monitoring and management by MRM in the reporting period has demonstrated improvement in 2009-2010.

Similar to the monitoring and management of groundwater, the implementation of the WMP has coincided with major improvements in the reporting and presentation of surface water monitoring at MRM.

9.1.1 Surface water monitoring recommendations

Overall, the Independent Monitor concurs with the discussion and presentation of natural surface and artificial water monitoring provided in the WMP. The following are observations and recommendations arising from the review of the 2010/2011 WMP:

- the Independent Monitor understands the purpose of removing data from the longer term trend analysis associated with “cease to flow” monitoring times, as monitoring during these periods is likely to demonstrate “spikes” in concentrations of salinity and dissolved heavy metals—that is through evapoconcentration. However, this data should be provided on the trend charts in the report as these can demonstrate whether the “spikes” are only associated with “cease to flow” occasions, or are part of a longer term trend in changing water quality;
- adjustments to the surface water monitoring program should be implemented by adding sampling points directly under the bridge over Surprise Creek downstream from Cell 1 of the TSF—location of the observed salt crystals by NT Environment Centre, and also additional sampling points on the drainage line where the seepage from the Northern OEF was reported on—incident from MRM to DoR; and
- quality assurance and control reporting should be presented and discussed. As described in previous Independent Monitor reports, a discussion on the quality, precision, accuracy and reproducibility of results is an essential component of water

monitoring. The aspects of the QA/QC reporting should include comparison of field to laboratory results—i.e. TDS/EC, field pH to laboratory pH, relative per cent differences between discrete and intra-laboratory, blind duplicate samples, and findings of the laboratory's quality control reporting.

9.2 Review of groundwater monitoring and management

The following documents have been reviewed as part of the groundwater component of the Independent Monitor's audit for 2009-2010:

- MRM P/L Sustainable Development Mining Management Plan 2010/2011;
- MRM P/L Sustainable Development Water Management Plan 2009;
- URS Australia P/L Bing Bong MLN1126 Hydrogeological Investigation prepared for MRM P/L, report 42213945, dated 21 February 2011;
- URS Australia P/L Development of a Water Management Plan prepared for MRM P/L, report 42213885, dated 23 December 2009;
- Coffey Geotechnics McArthur River Mine – Draft Groundwater Review prepared for MRM P/L, report GEOTLCOV24123AA-AB, dated 29 September 2010;
- Golder Associates Hydrogeochemical Investigation of the Tailings Storage Facility, McArthur River Mine prepared for MRM P/L, report 107633048-003-Rev0, dated 17 June 2011; and
- data sets and field reports—i.e. Excel spreadsheets, copies of completed field monitoring records, etc.

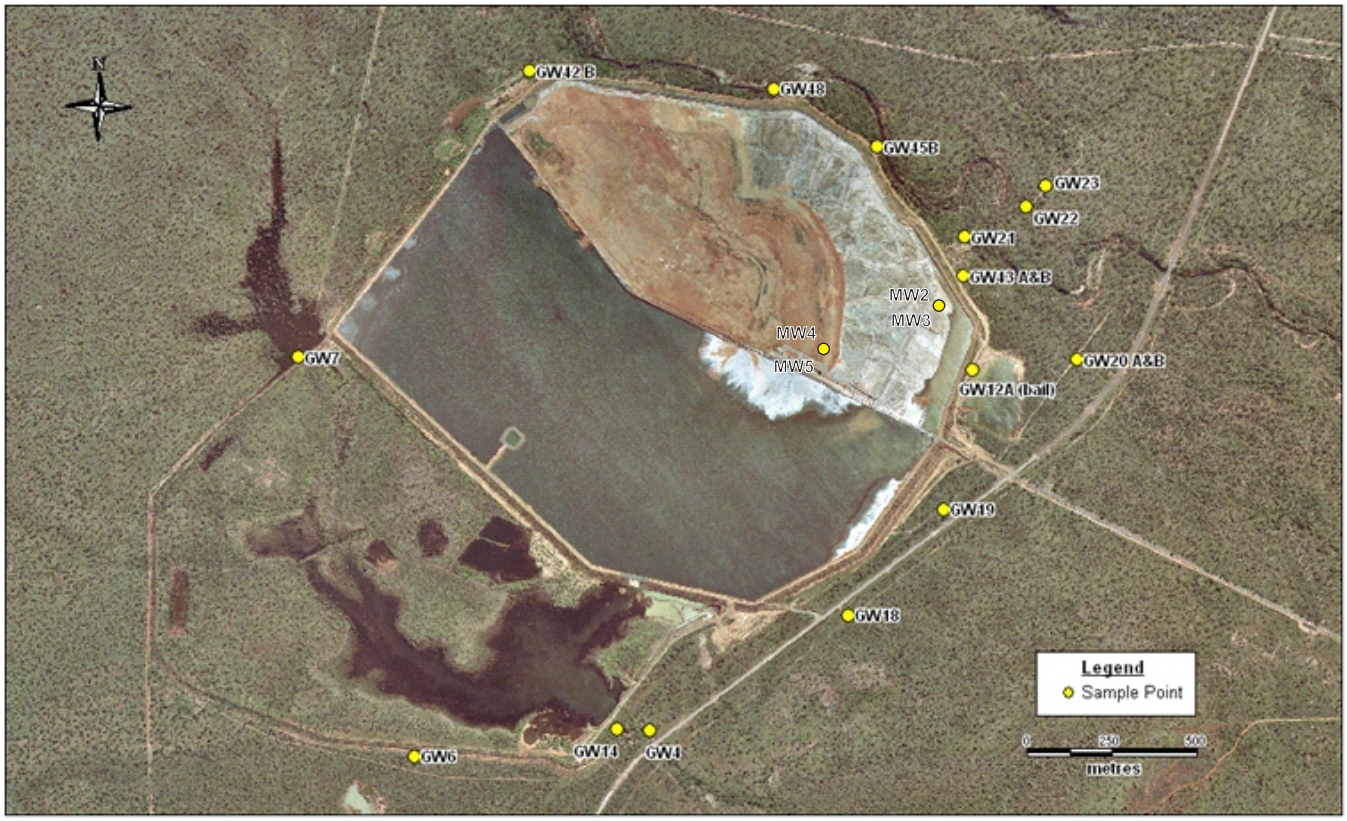
9.2.1 Groundwater monitoring program overview

The objectives of MRM's groundwater management program are to:

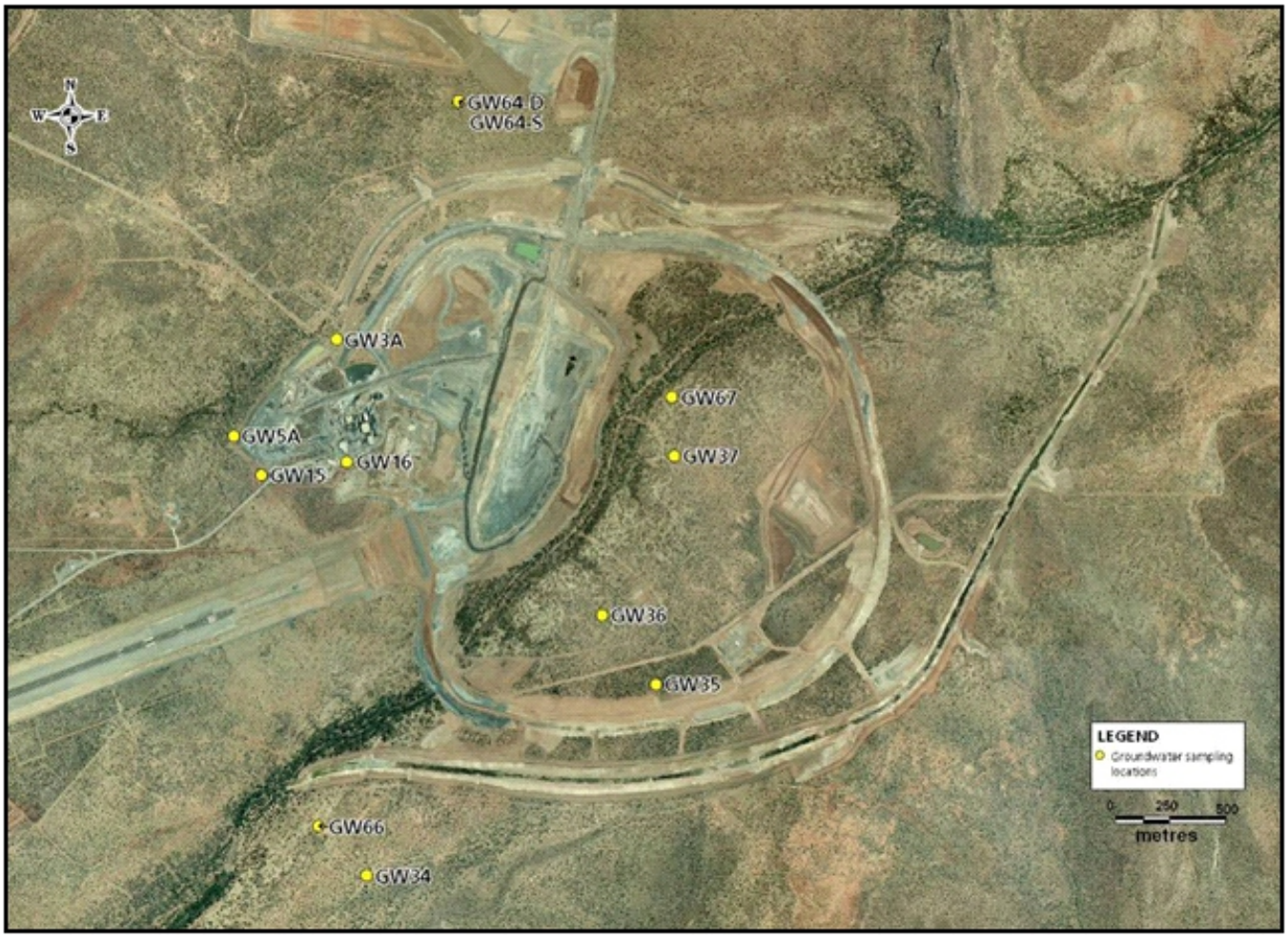
- monitor the impacts of groundwater abstraction;
- determine the impacts of any contaminants in shallow aquifers;
- assess the effectiveness of TSF seepage control systems; and
- assess potential impact of the establishment of the northern OEF.

The objectives of groundwater management are consistent with those stated in the 2005-2008 AER (MRM, 2008) reviewed as part of previous Independent Monitor audits. Overall, the presentation and interpretation of groundwater monitoring and management at MRM has improved compared to the 2008-2009 operational period, which was itself a significant improvement on the reporting for the 2005-2008 operational period. Because the significance of water to both MRM's operational effectiveness and potential environmental impact cannot be overestimated, the introduction of a separate water management report—the *Sustainable Development Water Management Plan*—has been a welcome addition to the reporting of the environmental performance of the MRM operation.

Groundwater monitoring locations, including those recently constructed by Golder Associates at the TSF and URS Australia at the Bing Bong Port dredge spoil dumps, are presented in Figures 4a and 4b.

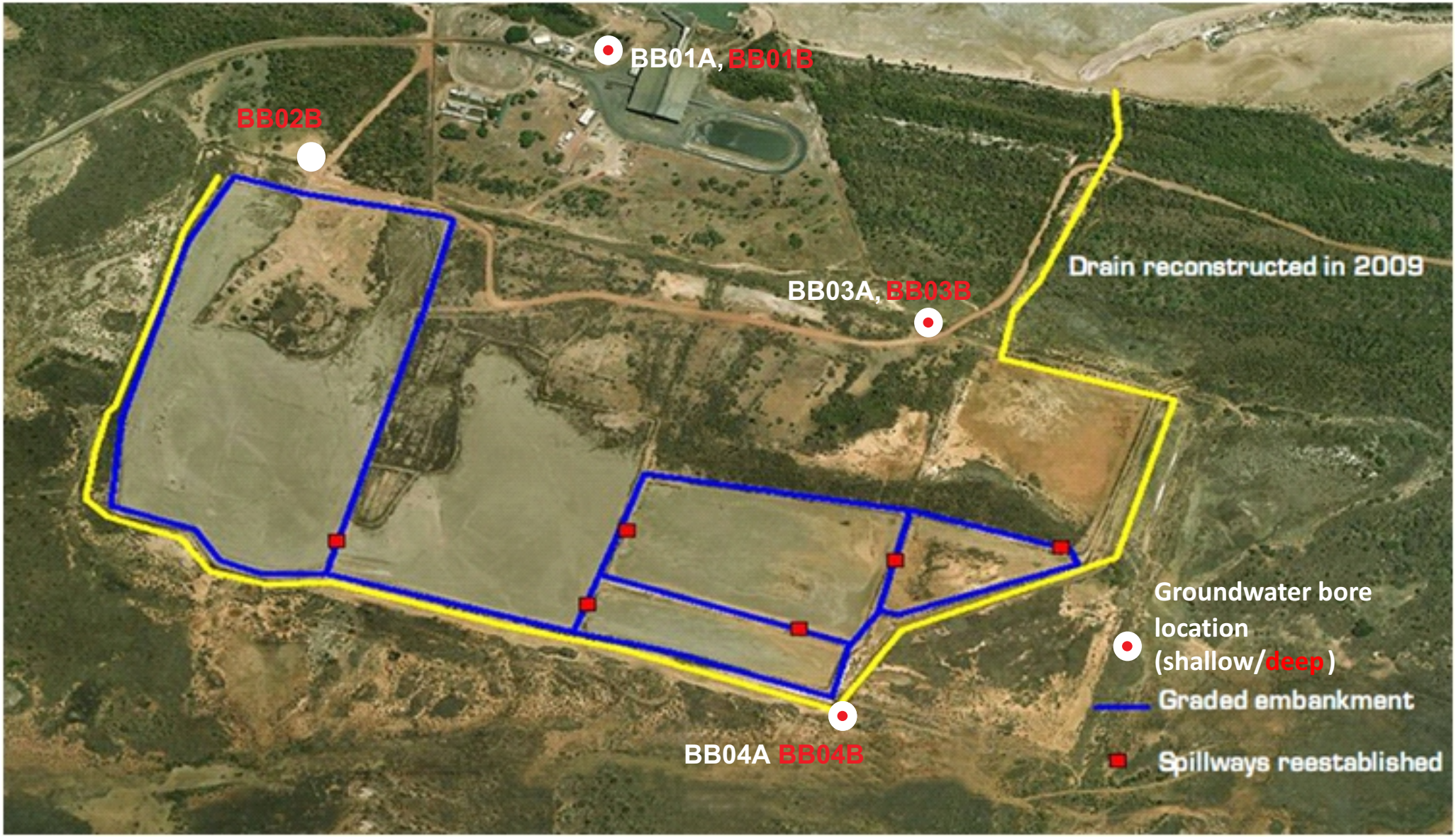


Source: MRM Water Management Plan 2010/2011



Source: MRM Water Management Plan 2010/2011

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Groundwater sampling locations Bing Bong Port and Mine site**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 4a**
Drawn By: **PF**	Date: **August 2011**	



Source: MRM Water Management Plan 2010/2011

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Bing Bong Port Facility**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	Figure **4b**
Drawn By: **PF**	Date: **August 2011**	

9.2.2 Review of URS Mine Water Management Plan

As described in section 5.2 of MRM's *Sustainable Development Water Management Plan*, the objectives for this program were:

- to develop a surface water and groundwater modelling plan;
- to identify groundwater inflow to the existing mining operations, both open cut and underground;
- to develop a monitoring system to manage water for current and future mine requirements; and
- to determine the effects of water management strategies on the Djirrinmini waterhole.

The works undertaken by URS Australia in 2009 included:

- a site visit;
- a review of additional information collected from the site visit including new bores, geotechnical investigations and aquifer intersections within the open pit;
- construction and calibration of a groundwater model of the proposed pit, which extends to the Djirrinmini water and the current bore fields located within the palaeochannel and fractured rock aquifers;
- development of a mine dewatering design and monitoring strategy for the open pit, mine site and bore fields; and
- a report on the results of the groundwater modelling and predicted groundwater impacts to the Djirrinmini water, incorporating a strategy for a modelling plan—surface water and groundwater—for other site requirements which was to provide the basis for a Site Water Management Plan.

Some of the major conclusions and recommendations arising from the URS study included:

- the G Stage development requires cut-back into alluvial sections of the McArthur River and in part, highly transmissive palaeochannel sediments: the H Stage development will require further excavation into palaeochannel sediments and is also likely to intersect basal palaeochannel gravels;
- based on calculated groundwater inflows to the underground workings of 2 500 to 4 000 kL/day, the average estimated groundwater inflows to the current mine range from 5 300 to 6 800 kL/day, and could range between 8 900 and 10 400 kL/day at completion of G Stage;
- groundwater drawdown—assumed to be within the bedrock aquifer(s), as this is not stated—is modelled to be greatest near the end of the G Stage, when mining intersects the palaeochannel sediments but generally confined to the bounds of the mine inner levee. Limited groundwater drawdown (<0.1 m) was predicted at Djirrinmini waterhole in 2013;
- calculated peak open-pit pond volumes of up to 77 ML/day were calculated for February 2009, with a total 2008–2009 wet season pond volume of 724 ML for the open pit;
- predicted combined surface water and groundwater inflows would increase from 2.4–3.0 GL/year (2009) to 4.2–4.8 GL/year at the end of G Stage, and an excess of mine water would need management;

- the OPSIM model needed to be updated to include surface water and groundwater pit inflows and, based on this update, determine the capacity overflow for mine water storages;
- dewatering spears or bores may be required to lower hydrostatic head pressures in the alluvial palaeochannel sediments ahead of mining, which would also assist with wall stability and limit seepage into the pit—section 3.6.16 of WMP states that six dewatering bores were planned for construction in 2010, and further dewatering bore planned details are in section 3.6.17 and 3.6.18 of the WMP;
- groundwater within the horizontal drain holes should be managed to reduce erosion and stability issues within the western pit wall;
- water discharge licenses were recommended to be in place before the 2009-2010 wet season to manage excess mine water discharge;
- irrigation and wetland polishing systems—prior to waterway release—should be investigated to manage excess mine water volumes;
- surface-water catchments within the mine should be managed to reduce the amount of *clean* water becoming impacted from flowing over mineralised areas;
- a mass balance of mine water is required to determine the volume that could be discharged off-site during the wet season; and
- monitoring of open pit flows and quality is required to assist with this mass balance.

Section 5.2 of the WMP describes where MRM is following-up on and addressing the recommendations made by URS, which is commended.

Overall, the Independent Monitor agrees with the conclusions and recommendations made by URS in their Development of a Mine Water Management Plan report and makes the following comments and recommendations:

- there is little information regarding the process of model calibration and uncertainty analysis. It is noted that sections 6.3.5 and 6.3.6 of the report describe model calibration and the model limitations respectively, however there is no description of what parameters were adjusted during the calibration and their effect on the level of certainty in the model;
- it has to be assumed that the model inputs, layers and other data are based on the 2005 hydrogeological investigations undertaken by URS during the environmental approvals process for the mine expansion— that is those in the References section of the report— if this is the case, it should be stated;
- given the above, there is no detail about which bores have been used in the model development and update; and
- the modelled end-of-dry-season groundwater contours in Figures 15, 16 and 17 of the report have significant sharp bends and corners, which indicate anomalous locations used in the model development. This is evident around the TSF—which is partly understandable given the historic seepage and proximity to Surprise Creek—the OEF, and between the airstrip and the TSF. These anomalies have not been explained in the report, and their affect on the contouring should have been assessed during calibration by temporarily removing them from the model, or modifying their parameters to reflect steady-state and/or observed conditions.

9.2.3 Review of the Coffey Geotechnics review of the URS report

In 2010, Coffey Geotechnics undertook a review of groundwater conditions at MRM, which included a site inspection, review of historic reports, review of the (then) recently undertaken mine water management plan and models by URS, and observations and recommendations regarding overall groundwater management—particularly dewatering.

The Independent Monitor concurs with the observations and recommendations made by Coffey Geotechnics, and acknowledges MRM for undertaking this work as the use of an external reviewer at this site, particularly to provide comment on predictive numerical modelling, is considered a prudent and valuable step in the groundwater modelling process.

The recommendations made in this study include:

- preparation of plans indicating the groundwater levels, reduced to mAHD, recorded in alluvial and bedrock bores at the end of the dry and wet seasons, that is biannually;
- preparation of hydrographs showing the variation of groundwater levels with time in bores at the TSF, within alluvium in the flood levee, in bedrock near the pit, and outside but near the flood levee—also the inclusion of the recent bores installed in and beneath TSF Cell 1;
- recording groundwater inflow to the underground workings and to the mine pit plotted over time and annotated to indicate key events in the mine development;
- development and review of the existing groundwater monitoring plan including installation of:
    - continuous water level monitoring devices in selected bores;
    - continuous water level monitoring devices in the underground workings; and
    - monitoring bores behind the west wall of the pit; and
- assessing the capability of the underground workings to provide storage of excess water through reviewing current water quality within the workings and river gauging records to identify likely acceptable durations and rates of discharge of current stored water.

The Independent Monitor concurs with these recommendations, and also with the comments and recommendations made regarding the URS Development of a Water Management Plan (2009) report. As stated in Coffey's comments, "*the results of calibration are not discussed and no comparison of measured and modelled groundwater levels is presented, nor is a comparison of modelled pit inflow with those interpreted from monitoring records.*"

It is recommended that during any future mine groundwater modelling updates, which will be needed during the development of additional stages and also the Third Phase expansion, currently being assessed, that a third party review of groundwater management, such as that done by Coffey Geotechnics, be undertaken again.

9.2.4 Review of URS Australia Bing Bong Port hydrogeological investigation

As described in section 5.2.3 of the WMP, in 2010, URS Australia undertook a hydrogeological investigation of the Bing Bong Port facility, including the dredge spoil ponds and the loading facility. As stated in the URS report, the aims of the study were to:

- use information obtained from drilling and sampling from boreholes located at four sites to characterise the hydrogeology underlying the dredge spoil stockpile area and the runoff pond at Bing Bong Port;

- use information obtained from drilling and sampling from the boreholes to identify potential contaminant migration pathways; and
- apply simple groundwater flow models to delineate potential migration routes and travel times of groundwater from the Dredge Spoil Stockpile Area and Bing Bong Site Runoff Pond to potential receptors.

The quality of information presented and interpretation of field and laboratory results within this report is very poor and the report is severely lacking in the following areas:

- there are no laboratory transcripts;
- there is no discussion regarding quality control and assurance;
- the bore construction details provided are poor and completely inadequate for a hydrogeological investigation;
- the groundwater contours provided are incorrect and do not account for potential hydrostatic mounding within the dredge ponds;
- no field tests were carried out to estimate hydraulic conductivity—these would have been much more appropriate than relying on assumed data;
- the use of the NEPC (1999) groundwater investigation guidelines for livestock use is a poor use of published guideline criteria. The ANZECC 2000 Guidelines for fresh and marine waters are more recent and more suitable for an initial assessment of the groundwater quality;
- there is no discussion on groundwater quality and chemistry apart from salinity and dissolved metals; and
- the desktop discussion on the "existing environment" is limited to surface water and a poor discussion on groundwater. There is no reference to published soil, groundwater or geological maps and reports, which are standard and essential in any hydrogeological investigation.

Consequently, the Independent Monitor recommends that the findings in this report be disregarded until further monitoring is undertaken as part of MRM's routine monitoring, and the results of the surface water and groundwater monitoring are incorporated into the next WMP (2011/2012).

9.2.5 Review of Golder Associates' TSF hydrogeochemical study report

As a result of the Independent Monitor's request under section 6.4 of the IMACs, MRM commissioned Golder Associates to undertake a hydrogeochemical investigation of TSF Cell 1. As stated in section 3.0 of Golder's report, the objectives were:

- to determine background conditions of solid phase and groundwater up-gradient of the TSF;
- to collect solid phase tailings, underlying and down-gradient geology and groundwater samples from within the TSF and in pre-existing bores to determine the:
    - o depth to groundwater and groundwater quality;
    - o quality of tailings pore water and groundwater levels in and below the TSF; and
    - o quality of the solid phase samples and potential for these samples to generate acid mine drainage (AMD) or to attenuate AMD generation;

- to use geochemical methods to determine whether there is natural attenuation of soluble contaminants from the tailings in the geological units below the TSF; and
- using measured field parameters, develop an understanding of the hydrogeology of the TSF and underlying geological strata to model breakthrough curves of contaminants from the TSF to Surprise Creek. The modelling was limited to sulfate (SO_4^{2-}), lead (Pb) and zinc (Zn), as these were considered to be the key elements of concern.

Key findings in the Golder report were:

- attenuation velocities were modelled for the average arrival times of dissolved Pb and Zn from the TSF at Surprise Creek, for 2092 and 2189 respectively, that is 97 and 194 years after initial tailings deposition;
- the tailings can be considered as non-acid forming (NAF), despite the high proportions of sulfide. This is understood to be due to the high proportions of dolomite and the presence of secondary carbonates such as cerrusite, smithsonite, bassinite and gypsum;
- neutral and saline drainage is considered to be the primary form of seepage and impact associated with TSF Cell 1. This is understood to be due to the presence of neutral to alkaline pH in the seepage, elevated concentrations of SO_4, Ca and Mg, and the presence of sulfosalts such as alunite in the tailings and at the seepage expression at Surprise Creek;
- the variability in concentrations of cadmium (Cd), Pb and Zn in monitoring bores is considered to be due to the variability in porosity and preferential pathways, thereby varying the attenuation and adsorption of these metals onto the solid phase; and
- the fractured bedrock underlying the alluvium, within which the current seepage mitigation strategies exist, is reducing the effectiveness of these strategies through the occurrence of high porosity preferential pathways, therefore seepage is still evident between the TSF and Surprise Creek and at Surprise Creek.

The recommendations from this study included:

- MRM to undertake a feasibility assessment of re-processing the tailings in TSF Cell 1, particularly if the concentrations of Pb and Zn are economically viable. This may lead to the removal of Pb and Zn from the resulting residue and removal of pyrite during flotation in reprocessing, which will enable remedial works to be conducted on TSF Cell 1; that is, the placement of a liner;
- construct a diversion of Surprise Creek further to the north-east of the current seepage recovery system to allow the existing creek channel to act as a larger interception trench, and then pump the collected seepage water back onto the TSF;
- construct a cut-off trench around the perimeter of the TSF to intercept seepage so that it can be pumped back to the mill; construct a physical barrier to retain saline seepage within the TSF footprint by filling the trench with bentonite or locally sourced clays, as well as a permeable reactive barrier using a range of materials to attenuate contaminants in the barrier;
- using a limestone or calcium-rich cover on the TSF to provide a source of alkalinity;
- incorporate the Golder installed monitoring bores into the current MRM groundwater monitoring program; and
- use kinetic tests to gain a greater understanding of the sorption and attenuation characteristics of the underlying alluvium and bedrock.

The Independent Monitor makes the following comments on the Golder Associates' hydrogeochemical study report:

- there is little to no discussion about the physical hydrogeological setting of the TSF and its association with the hydrogeochemical modelling. Given the significance of the study, a conceptual model should have been developed and a comparison made with findings from previous studies—that is, the URS 2005 seepage study—as well as a comparison of field observations with published and desktop information. In addition, the aspects of the conceptual model that are presented are incorrect. Aspects of the conceptual model that are considered to be essential include, but may not be limited to:
    - groundwater potentiometric contours, including those piezometers within the TSF Cell 1;
    - description of the physical hydrogeology within, underlying and outside the TSF—that is, is groundwater confined, semi-confined or unconfined?;
    - the aquifer/water-bearing zone thicknesses;
    - provision of the field data, including pH, EC and redox potential recorded during sampling; and
    - comparison of field data with laboratory data;
- there is no discussion on quality assurance and quality control;
- there is no comparison of the findings of this study with, or consideration of historic studies such as URS seepage modelling (URS, 2005) and Soil Con investigation (2007b);
- there is no discussion about calibration and uncertainty analysis of the model used;
- monitoring bore MW1 appears to be incorrectly constructed, with the screen crossing several stratigraphies. If this was due to drilling difficulties, or otherwise, an explanation of the construction method at this location should be provided;
- the screened interval at MW5 is within the dolomitic siltstone, and the screened interval at MW4 is within the tailings. The most significant aquifer for conducting tailings leachate, that is the clayey-gravel to gravel lense lying above the siltstone, is not mentioned;
- the ionic balance—that is the percentage difference between cations and anions—in samples MRMB1–500 and MRMB1–1000 is greater than 10%, which is considered to be outside the acceptable range. Although the laboratory transcripts state this, there is no discussion in a QA/QC section about these anomalous results by Golder Associates; and
- most of the hydrogeochemistry and geochemistry is incorrect or poorly interpreted—see section 9.9.3 for further discussion.

Overall, the Independent Monitor concurs with the recommendations of the Golder Associates hydrogeochemical study of the TSF, however there is the potential that an adverse outcome will occur sooner and be worse than that predicted in this consultant's report—see section 9.9.3 for further discussion.

The current situation with regard to specialist reports on groundwater at the TSF is one where the seepage hydrogeology (flow) and seepage hydrogeochemistry have been assessed separately. Due to the significance of the seepage and the need to continually improve the understanding of the hydrogeology and hydrogeochemistry of the TSF, these studies need to

be brought together by an organisation with competent and experienced hydrogeologists and geochemists. Neither the Golder or the URS studies or reports have achieved this.

The IM recommends that a separate and more robust hydrogeological and hydrogeochemical model and report should be developed and updated annually and that this report be provided as an appendix to MRM's annual WMP with the findings incorporated into the body of the report, including actions to address the recommendations made.

9.2.6 General groundwater management conclusions and recommendations

The general conclusions and recommendations for groundwater monitoring and management include:

- quality control and quality assurance has not been presented or discussed. As described in previous Independent Monitor Audit reports, a discussion on the quality, precision, accuracy and reproducibility of results is an essential component of groundwater and water monitoring reporting in general. This includes, but may not be limited to, a discussion on the comparison of field and laboratory measurements—that is pH in the field and laboratory, TDS/EC ratios—relative percentage differences between discrete and intra-laboratory blind duplicate samples, and findings of the laboratory's quality control reporting and data set evaluations for confirmation of inconsistencies; and
- groundwater contours in each separate formation, but particularly the bedrock and the alluvium, need to be presented at least bi-annually; at the end of wet and end of dry seasons. These can also be used as a check against the predicted drawdowns in the updated URS groundwater model. Separate groundwater contour figures using all available bores should be provided for the TSF, the regional monitoring network and Bing Bong. These will enable greater interpretation of groundwater flow direction(s) and hydraulic gradients and, in turn, provide visual representation of the significant factors in groundwater impacts from the MRM operations. This is a recurring recommendation by the Independent Monitor and is yet to be adequately addressed.

9.3 Review of dust monitoring

9.3.1 Update since the previous audit

With regarding to dust surveillance, the Independent Monitor is pleased to see that MRM have acted upon most of the recommendations made in the last audit report. A summary of the issues indentified in the last report in relation to dust monitoring are presented in Table 4 along with the resultant outcomes or updates.

TABLE 4 UPDATE ON IDENTIFIED ISSUES IN RELATION TO DUST MONITORING

Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
Tailings storage facility needs to be fully capped to prevent fugitive dust generation	Yes	Capping of Cell 1 is complete. The intent of the capping is for dust suppression only, and is expected to result in reduction of contaminated dust – to be reported in the 2011/2011 MMP.

Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
Dust mitigation needs to be increased at PACRIM area	Incomplete.	During inspection in May 2011, dust was observed emanating from the PACRIM crusher. According to MRM staff an additional hood/cover on the crusher has been added recently. No other significant visible improvements were noted since last inspection. Many dust suppression measures still need to be undertaken.
Concentrate bearing dust was observed on banks of Barney Creek diversion rehabilitation area	Incomplete.	Barney Creek was not visibly affected by concentrate during inspection. However, dust was observed to be emanating from PACRIM, which would have the potential to end up in the Barney Creek flood plain/diversion.
Purchase a street sweeper for the Mill, Barney Creek Bridge and PACRIM yard roads to aid dust supression	Incomplete	Gary Taylor (pers. comm.) advised that a street sweeper had been purchased, but it was not very effective. The Independent Monitor believes that its use in these areas should be continued as concentrate dust was visible on hardstand surrounding the PACRIM crusher. The Independent Monitor is unaware of the frequency at which the sweeper operates.
Place a vegetation barrier between ROM pad and main road	No	MRM have indicated that this will be undertaken, however no date has been given.
Roller doors remain open at all times and this increases the chances of rogue dust **MRM should investigate the possibility of an extraction system for concentrate shed**	Incomplete, but plans are being made.	Doors of the shed are still kept open. MRM have advised that capital expenditure on a negative pressure system has been approved, so doors can be kept shut.
Opportunity for improvement of dust fallout monitoring in Bing Bong swing basin	Yes	There is a new dust monitoring location in the swing basin.
No dust monitoring locations in the vicinity of the OEF	Yes	Two new locations near the OEF.
No dust monitoring locations south of the McArthur River channel	Yes	New dust monitoring location south of the McArthur River channel.
Inconsistency in the requested laboratory analyses. These varied between total solids(TS) and total insoluble matter (TIM).	Yes	MRM now consistently requests TIM, lead and zinc analyses.
Sampling gauges need to be left for 30±2 days as per AS/NZS 3580.10.1:2003.	Incomplete	Compliance has increased since last year's audit, however at least one sampling occasion was noted outside the specified timeframe. It is understood that inclement weather/unsafe conditions may sometimes prevent compliance.
No discussion is provided in terms of spatial or temporal trends with regard to Pb, Zn and TIM results.	Yes and no, discussion/charts are only provided for some monitoring locations	Results are not reported in the MMP for PACRIM: D27, D22 and D21and other locations: D04, D17, D06, D03, D20, D08, D25, D05 If this is because these results are deemed to be low or not of concern, it should be stated.

Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
The location for gauges D1 and D5 is not shown .	Yes	Locations are shown in MMP map.
TIM, lead and zinc levels have increased over time, especially in Bing Bong, TSF and PACRIM areas.	Yes and no	Generally TIM, lead and zinc levels have not increased but rather remained similar. A notable decrease in measured dust and metal levels is required, specially at the PACRIM.
Laboratory QA/QC documentation was only partially provided.	No	No laboratory QA/QC documentation was provided this year.

9.3.2 Observations from site inspection

Mine site

Dust remains as an issue in this audit. At the mine site the main source of contaminated dust is from the operation of the PACRIM crusher plant. During its May 2011 site inspection, the IM observed dust emanating from the PACRIM plant (Plate 10), and noted dust settled on surrounding objects (Plate 7). No significant improvements to dust management from the PACRIM were observed this audit. However, we do note that MRM have advised that limiting dust emissions completely from this plant may not be possible.

However, MRM staff did advise that an additional hood had been placed on the plant to try to limit dust, and that sprays were working throughout the plant to suppress dust. The IM also observed that a spray at the top end of the PACRIM conveyor line is now used constantly rather than intermittently (Plate 8).

Water trucks were observed to be operating regularly around the mine site haul roads. Significant wind-borne dust was encountered during the inspection of the store yard area (see Section 10.1), however MRM staff called the water truck to come and dampen down the area.

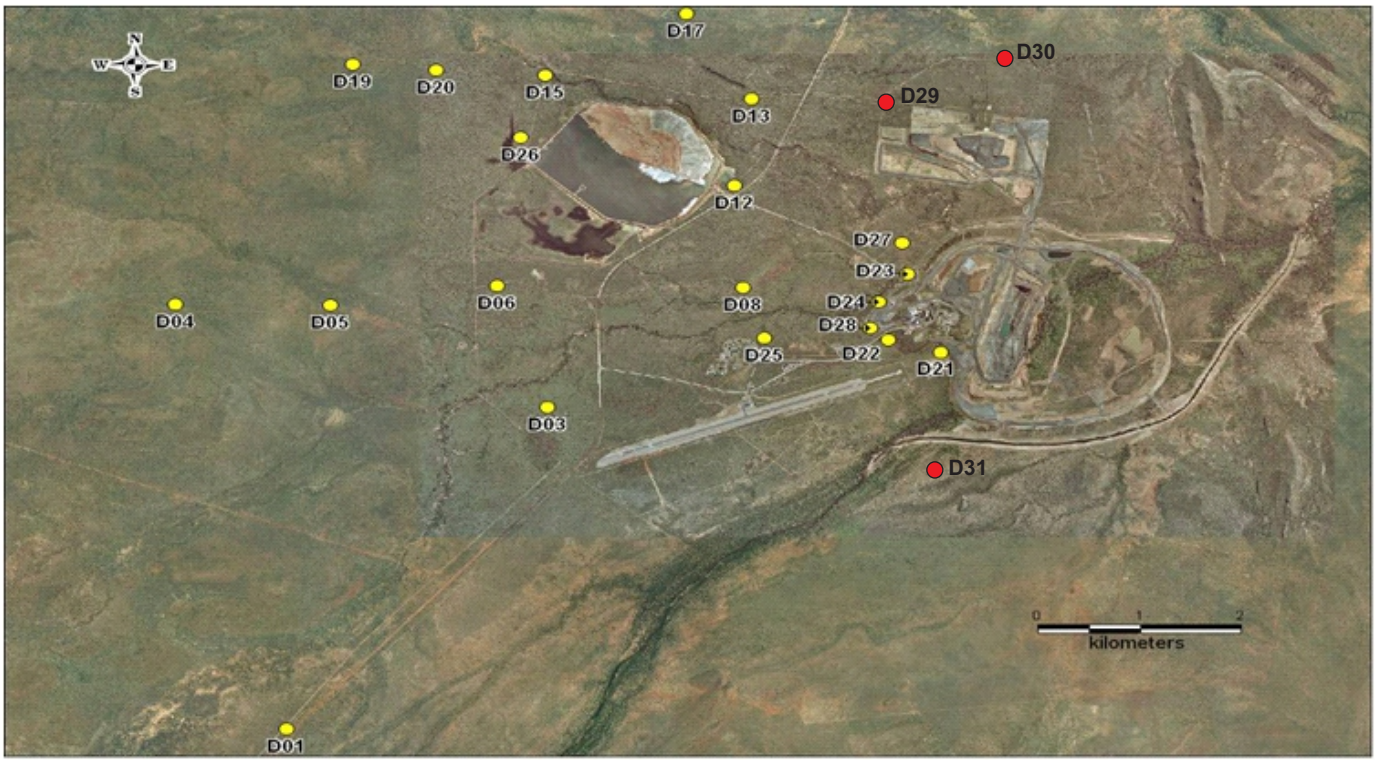
Bing Bong Port Facility

At the Bing Bong Port Facility contaminated dust issues are primarily associated with the concentrate storage shed. Because the shed doors must be kept open to prevent gas build-up, the prevailing winds can pick up dust from within the shed and transport it to the surrounding landscape and marine waters/sediments (Plate 9). Further, the condition of the corrugated iron shed walls was observed to be still poor in many places, with many small holes allowing the potential escape of concentrate dust. These issues have been identified by the Independent Monitor in past years.

During the inspection, MRM advised that capital expenditures to upgrade the shed have now been approved. These upgrades will include a shed ventilation system which will allow the shed doors to be kept shut. The IM looks forward to seeing these improvements next audit.

The additional dust gauge (BB6), which is located on the mud flats (Figure 5), up-wind of the Bing Bong Facility was sighted during the site inspection. It is acknowledged that this gauge was added by MRM in response to a recommendation by the Independent Monitor in the previous audit report.

The Aburri barge was being loaded at the time of the inspection and no dust was seen emanating from the conveyor system or visible anywhere on the surrounding paved surfaces. Please see section 10.3.1 for further details on observations made during the loading procedure.



Source: MRM Water Management Plan 2010/2011

Source: MRM Water Management Plan 2010/2011

- New monitoring locations
- Existing monitoring locations

0 500
Scale in Metres

N

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Dust sampling locations at the Mine site (top) and Bing Bong Port (below)**		
Location: **McArthur River Mine, Northern Territory**		
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 5**
Drawn By: **PF**	Date: **August 2011**	

9.3.3 Dust monitoring program overview

According to the Environmental Monitoring Manual 2010, the dust monitoring program comprises fifteen depositional gauges located at the mine site (for example, see Plate 6) and six located at the Bing Bong Port loading facility. It is acknowledged that MRM has increased the number of locations in response to the Independent Monitor comments from the last audit as follows:

- two additional sites near the northern overburden emplacement facility;
- one new site south of the McArthur River channel. Based on its location, some sampling occurrences maybe missed during the wet season; and
- one additional site to the west of the swing basin on the tidal flat. Based on its location some sampling occurrences may be missed due to tidal movements.

The gauges are to remain in place for a period of 30 ± 2 days, as per AS/NZS 3580.10.1:2003 (Standards Australia, 2003), after which they are analysed for total insoluble matter (TIM), lead and zinc.

Plate 6 Depositional dust monitoring location. Source: Independent Monitor.

As noted by MRM in the MMP, dust levels are generally directly associated with the prevailing wind direction, which is north-west, and dust levels are characteristically higher during the dry season due to the lack of natural soil wetting over this period.

Plate 7 Likely concentrate dust accumulating on objects in the PACRIM yard

Plate 8 Sprays located at the top of the conveyor are now used more often.

9.3.4 Review of dust monitoring program reporting

The results of the dust monitoring program for the 2010 operational period are reported in section 4.2.9.1 of the Sustainable Development Mining Management Plan (MMP) 2010/2011.

Compared with previous years, MRM has shown some improvement in their reporting of dust monitoring results; namely the inclusion of dust analyte concentration charts and discussion of results for selected monitoring locations, however many more improvements are still needed.

With respect to the dust monitoring program, we make the following observations of major concerns:

- the level and detail in reporting on dust monitoring does not meet best practice industry standards, and does not display adequate scientific method. In general, we do not consider the level and detail of reporting in the MMP alone to be of an adequate level to effectively identify:
    - sources of dust generation;
    - effectiveness of dust mitigation measures;
    - temporal trends in dust generation or concentrations of contaminants in dust; or
    - methods for further improvements to the dust management program;
- there are a number of errors in the data analysis provided in the MMP. Further, greater detail in discussions of temporal trends analyses and improvement in validity of data evaluation methods are still required—this is discussed further in section 9.3.5;
- no trigger levels or positive objectives for dust reduction have been applied to the dust monitoring program. The MMP simply states that the objective of the program is to "monitor potential contaminated particulate matter (dust particles) arising from MRM activities" (pg. 74). This objective is considered to be too vague to provide a meaningful basis or direction for a long-term scientific monitoring study.

Other observations include:

- the locations of the following dust monitoring sites are not provided in the Environmental Monitoring Manual Maps or MMP:
    - Bing Bong Port dust monitoring location BBD6—furthermore, no results were provided for this monitoring location and it is unclear whether it exists at all;
    - the new Bing Bong Port dust monitoring location (location later provided when requested);
    - two new gauges at the OEF locations (location later provided when requested);; and
- the standard referred to in the Technical Manual for Environmental Monitoring (MRM, 2010b) needs to be updated from AS3580.1990-91 to Australian Standard AS/NZS 3580.10.1:2003.

9.3.5 Review of data supplied by MRM

The Independent Monitor has reviewed the dust monitoring data supplied by MRM in the MMP and makes the following observations with regard to dust and airborne lead and zinc levels:

- the MMP does not contain discussion of results or concentration charts for several locations including: PACRIM: D27, D22 and D21; and mine site locations: D04, D17, D06, D03, D20, D08, D25 and D05. It is unclear why these results are not reported. If

results are not reported because they are deemed to be low or not likely to pose an environmental hazard, then this should be clarified in the MMP for completeness.

- TIM levels were reported in the MMP in g/m^2; but no timeframe is provided. These results should be reported as g/m^2/month or mg/m^2/day, which is preferred, as per Australian Standard AS/NZS 3580.10.1:2003;
- the use of line charts to present depositional dust and airborne metal results in the MMP, implies spatial interpolation; that is, that the actual depositional dust rate of airborne dust metal concentrations between two monitoring locations can be extrapolated from the graph. This is incorrect. Consequently, due to the fact that data is only true for that specific monitoring point, not other areas in between, we recommend that data be presented in bar charts in future reports;
- laboratory transcripts or internal results spreadsheets were not provided for monitoring locations D01 and D04—although the results for location D01 are mentioned in the MMP. When MRM were queried on this issue, Gary Taylor (pers. comm., June 2011) indicated that these locations are no longer being monitored, and that results discussed in the 2010/2011 MMP for D01 actually correspond to location D27. This information should be clearly recorded in the MMP or other supporting document;
- the number of times that the sampling gauges were not left for the correct number of days (30 ± 2) as required by Australian Standard AS/NZS 3580.10.1:2003 (Standards Australia, 2003), has decreased when compared to the previous year of monitoring. MRM have, therefore, improved their compliance in this respect and it is also understood that inclement weather/unsafe conditions may prevent MRM from achieving full compliance with this condition;
- dust levels and metals concentrations were presented in charts in the 2010/2011 MMP. Compared with previous years, the results do not indicate any noticeable decrease in either dust or metal concentrations in any of the locations reported;
- high lead concentrations and TIM levels were noted in locations close to and downwind of the PACRIM crushing plant—that is, dust monitoring locations D24 and D28. TIM levels at these locations ranged up to 38 g/m^2/month, with lead concentrations as high as 45 000 mg/kg (4.5%). This supports the Independent Monitor's site observation that high levels of lead and zinc dust are emanating from the PACRIM crushing area and impacting the soil in the flood plain of a Barney Creek tributary;
- The Independent Monitor does *not* agree with MRM's statement that "there is little if any correlation between lead and zinc and total insoluble matter (TIM)", which was made in the 2010/2011 MMP. In fact, the Independent Monitor has determined a *strong* correlation through undertaking a linear regression analysis of TIM, lead, and zinc data supplied by MRM, having derived R^2 values of 0.89—for mass of lead versus TIM—and 0.85—for mass of zinc versus TIM, which implies a very high degree of correlation. It is noted that MRM have not provided any evidence of having undertaken such statistical analysis of their data in the MMP, which is concerning; and
- although monitoring location BB1 at Bing Bong Port recorded dust lead concentrations of up to 600 000 mg/kg (or 60%), the TIM at this location has decreased since the last monitoring period; this finding highlights the fact that, although total dust collected at this site may have decreased, the dust that was collected is contaminated with a high proportion of lead, which is likely to have originated from concentrate stored at Bing Bong Port (see Plate 9).

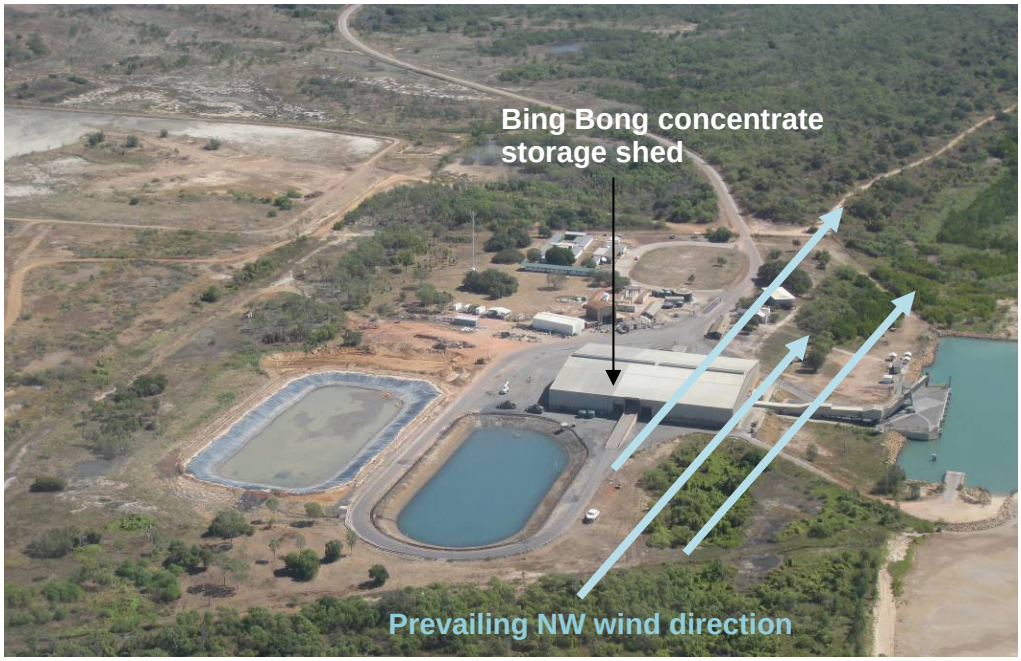


Plate 9 Aerial photograph showing the position of the Bing Bong concentrate storage shed in relation to the prevailing North West wind direction. Photo: Independent Monitor 2011.

The Independent Monitor has also reviewed the raw dust monitoring data supplied by MRM, and provides Charts 1 to 3 showing TIM levels at selected locations—those with the highest TIM levels—in the mine site and Bing Bong Port. As no trigger levels are currently used by MRM to assess the dust results, the IM has applied "nuisance levels" (EDO, 2006) as a trigger guideline. It is also noted that, although not directly applicable to the mining operation, the nuisance level of 4 g/m^2/month gives a general indication of dust levels at each monitoring location. This nuisance level corresponds to a "visible layer of dust deposited each month on outdoor furniture or on a clean car" (EDO, 2006).

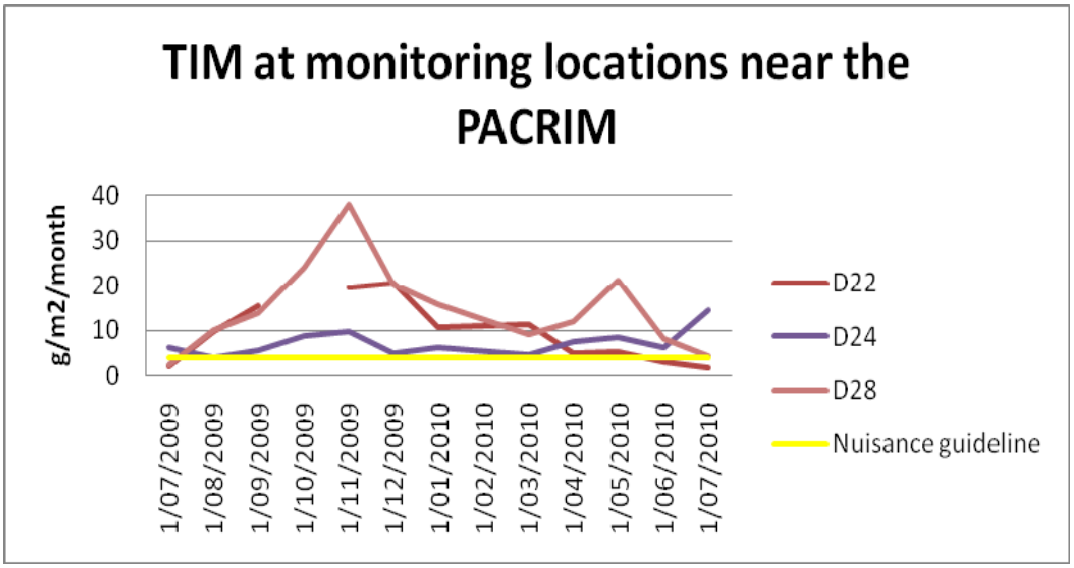


Chart 1 TIM at monitoring locations near the PACRIM.

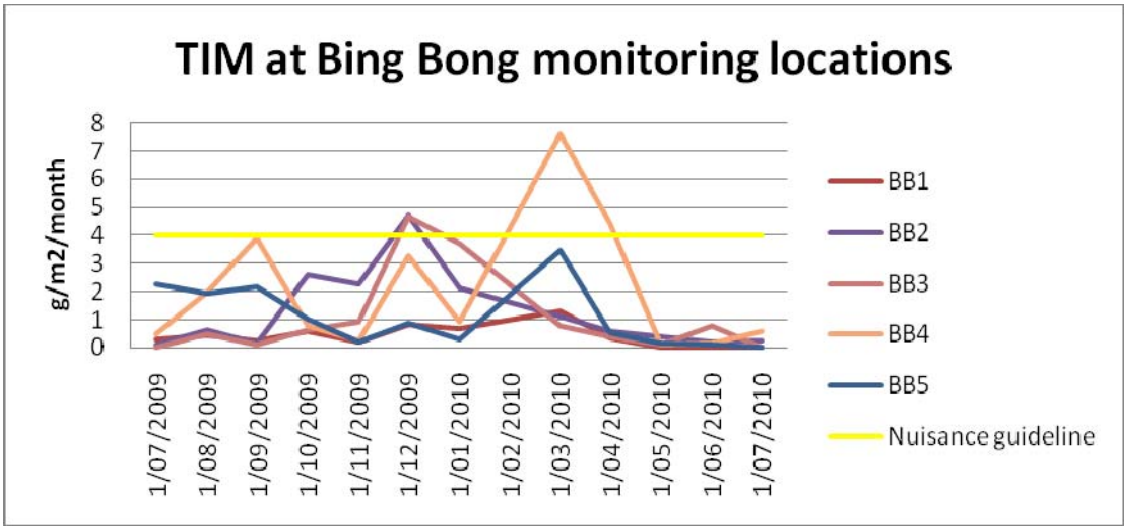


Chart 2 TIM at Bing Bong monitoring locations.

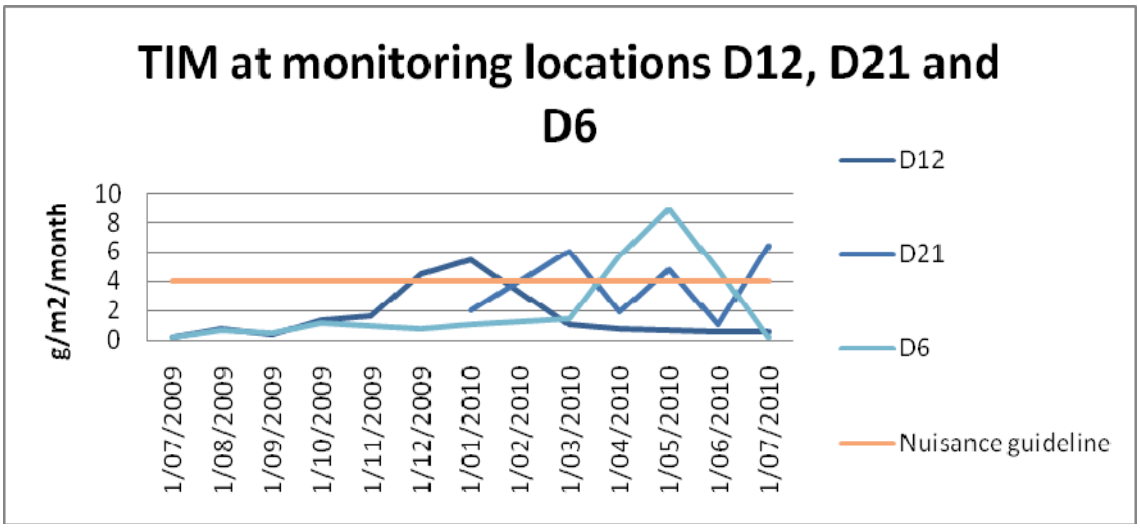


Chart 3 TIM at Bing Bong monitoring locations D12, D21 and D6.

As can be seen in Charts 1 to 3, high dust levels (TIM) have been recorded at monitoring locations near the PACRIM: D22, D24 and D28 (see Figure 5 for locations). Elevated lead concentrations have also been recorded at these locations and it is therefore recommended that further mitigation measures should be implemented. In addition, elevated TIM levels may be an issue at monitoring location Bing Bong Port BB3, being the highest concentration over the nuisance level, and mine site D12, D21 and D6, being the highest concentrations at the mine site.

The Independent Monitor understands that, two monitoring seasons ago, the dust monitoring program changed from monitoring total solids (TS) to monitoring TIM in samples. These two values are not the same and cannot be compared. Therefore, dust monitoring data for only the two previous years of are available for comparison for TIM purposes. However, MRM should still be able to compare long-term temporal trends in heavy metal concentrations and total mass back further than two years ago.

Plate 10 PACRIM area. Note fugitive dust in the centre of the photo. We note that MRM have advised that limiting dust emissions completely from this plant may not be possible.Photo: Independent Monitor 2011.

9.3.6 Bing Bong Dust Audit review, conducted March 2010

The Independent Monitor has reviewed the results of an audit of inhalable levels of metals/metalloids—arsenic, cadmium, lead and zinc—undertaken by MRM at the Bing Bong Port facility, the results of which are contained in the document Bing Bong Dust Audit (MRM, 2010a). Although the dust audit report focuses on dust as an occupational health issue, which is a matter outside the Independent Monitor's audit scope, it nevertheless provides some additional information regarding dust levels and composition.

It is understood that MRM undertook an audit of inhalable dust metals at Bing Bong Port in March 2010. Inhalable metals were captured in institute of occupational medicine (IOM) inhalable dust samplers using eight Airchek 52 vacuum pumps, during concentrate loading. From the documentation supplied by MRM, the Independent Monitor understands that sampling was undertaken for 3.5 hours.

With regard to the Bing Bong Dust Audit report, the Independent Monitor makes the following observations:

- the sampling methodology, using IOM sample heads, and flow rate utilised (2 L/min) complies with Australian Standards AS 3640-2004 *Workplace atmospheres—Method for sampling and gravimetric determination of inhalable dust,* however, the report also mentions that the flow rates of each pump varied between 2016 L/hr and 2172 L/hr during the sampling period. This appears to be incorrect because we understand the IOM samplers used are incapable of such flow rates. It is thought that this may actually be referring to the total volume in litres of air that passed through the sampling equipment. The Australian Standard also requires detailed calibration of both the sample pump and micro balance, of which there are no details provided in the report.

These reporting errors and omissions further indicate a lack of scientific rigour as well as a lack of detail in reporting;

- from the documentation supplied to the Independent Monitor it is inferred that the sampling time was only for a period of approximately 3.5 hrs—that is, from "7:30 am to 11:15", which we infer means 11:15 am—however, since the standard used is for workplace purposes, it is recommended that the sampling time correspond to the standard work shift—that is,12 hrs—as well as being long enough to capture any diurnal changes in wind direction;
- the report quotes a laboratory limit of reporting (LOR) of 0.003 mg/m^3, however all the results for arsenic and cadmium were reportedly <0.005 mg/m^3, except for the West of Gantry E 1871 sample, which is reported as <0.006 mg/m^3. It is unclear whether the LOR was raised to <0.005 mg/m^3 and <0.006 mg/m^3 or if this is an error in the report; and
- as with depositional dust monitoring, it is recommended that results be presented in bar charts so as to not imply spatial interpolation between sampling points.

A comparison of the reported results with the default thresholds indicated in the *Adopted National Exposure Standards For Atmospheric Contaminants In The Occupational Environment* (NOHSC:1003, 1995), shows all metal levels below the default guideline values, if an exposure of eight hours is considered, however, since it is understood from the MMP (MRM, 2010x) that staff works 12 hour shifts, the guideline thresholds need to be modified by a factor of 0.49 as per the Brief and Scala method recommended by Safework Australia (1995). Taking the 12 hour period into consideration, lead levels in samples West of Gantry E 1871 (0.086 mg/m^3), Western ramp of shed E1872 (0.091 mg/m^3), and Eastern ramp of the shed E 1883 are above the modified trigger value of 0.07 mg/m^3.

It is strongly recommended that further mitigation measures be implemented at Bing Bong Port to reduce the levels of concentrate-bearing dust being released into the environment. It may also be useful to regularly undertake a similar dust audit to assess the effectiveness of mitigation measures and also to account for any seasonal variation of airborne metal levels, especially lead, that may not have been captured in this very short initial audit. Although the IM considers that the study does add additional information to the wider dust monitoring program regarding the potential sources of airborne dust and mitigation measures, the program would benefit from more detailed and accurate reporting in line with correct scientific method.

9.3.7 Simtars' assessment review, November 2010

MRM commissioned Simtars to conduct a review of atmospheric and health issues at MRM, the results of this review are reported in the *Program Review of Atmospheric Monitoring & Health Surveillance at McArthur River Mine* report (Simtars, 2010). As with the Bing Bong Dust Audit report (2010), we note that this matter is an occupational health issue, but contains valuable information regarding the causes of fugitive dust at MRM and mitigation measures. The IM agrees with Simtars' recommendations that MRM should:

- explore the use of different water sprays in the concentrate shed to continually keep the concentrate moist;
- where possible consider reducing concentrate stockpiles around the plant;
- use water trucks or water sprays to aid in dust suppression of worked stockpiles; and
- consider implementing an ongoing program to remove spilt concentrate from crushing plant and conveyors.

Plate 11 Dust generated by working drill rig. Photo sourced from Simtars (2010) assessment

Plate 12 Independent Monitor team outside of concentrate storage shed at Bing Bong Port facility.

Further, we agree with the key observations made in the Simtars report (2010), which have been provided below to highlight potential sources of dust generation. These observations include:

- due to lack of training of the operator, the dust suppression system on the working drill rig was not functioning (see Plate 11);
- fine dusts are present below the ejection chute of the mobile crushing plant and within the stockpiles of processed stone;
- concentrates of varying degree of moisture are stored in the shed (Plate 12). As concentrate dries out it increases the risk of fugitive dust emissions from the shed;

- dust generation is reduced by the use of water sprays in the primary crushing plant and conveyors, while a water truck is used to control dust from ore stockpiles. However, it was noted that this water rapidly evaporates due to the high ambient temperatures;
- spilt concentrate was observed in the conveyors and regrind area. This material can dry out and pose a dust generation risk; and
- concentrate stockpiled onsite, when the Bing Bong Port operations are halted, will quickly dry out and increase dust generation potential.

9.3.8 Conclusions and recommendations

Further efforts to control fugitive dust emissions are needed, particularly in the PACRIM area, where high TIM and lead concentrations have been recorded. The latter situation is the issue of most concern with regard to the dust monitoring program undertaken by MRM. This is due to the likely considerable contribution that concentrate-laden dust is having on sediment and soil metal enrichment. The IM also makes the following additional recommendations:

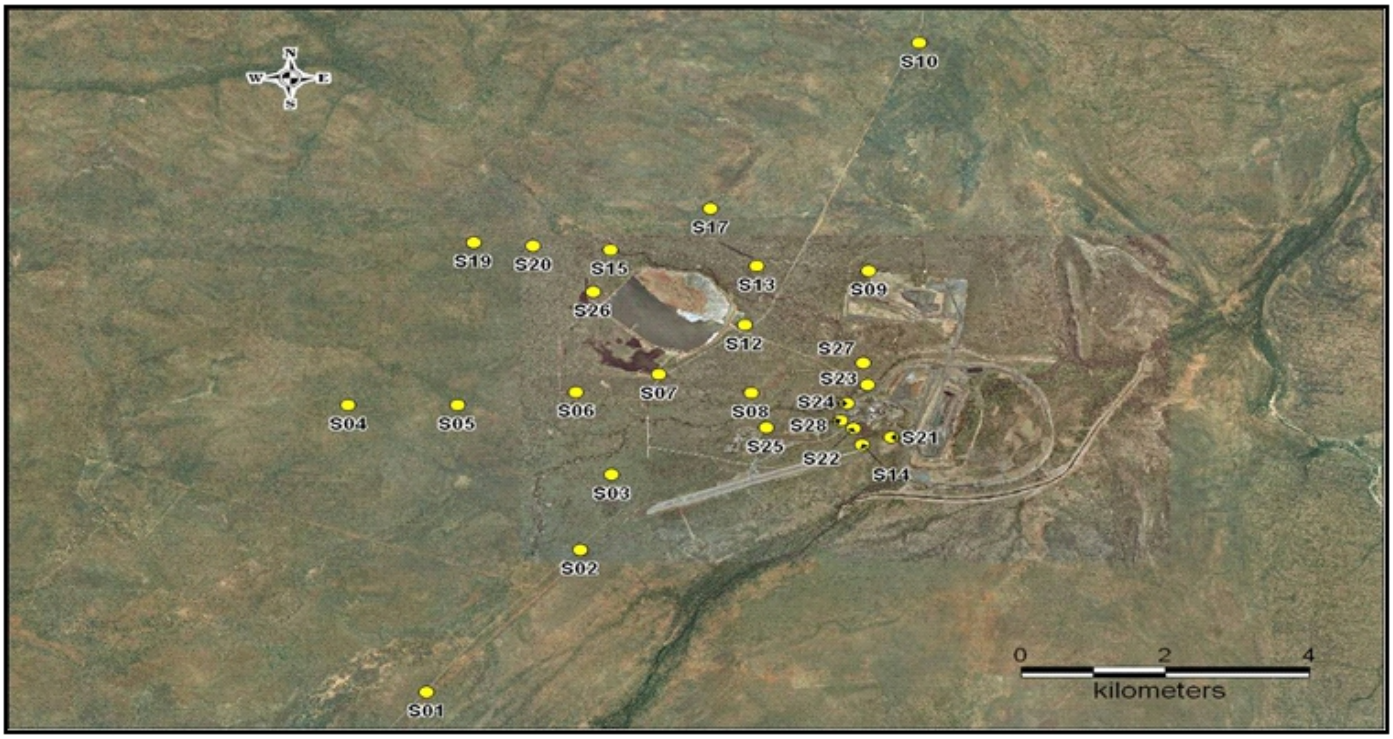
- MRM should work towards eliminating the issues identified in the Simtars' assessment by increasing concentrate moisture, reducing concentrate stockpiles, increasing the use of water sprays and water trucks, implementing a spilt concentrate recovery program and more effectively training MRM staff. It is also recommended that a similar assessment be undertaken annually;
- MRM should improve on reporting issues identified: provide laboratory QA/QC data, update maps and standards referred, improve the analysis of monitoring data, and so on. This should facilitate the identification of problematic areas and trends, and thus aid in the decision making process for implementing mitigation measures. It will also validate and impart greater robustness to the data collected;
- dust mitigation works should be commenced during the next reporting period, including: placing a vegetation barrier between the ROM pad and main road, implementing an extraction system in the concentrate shed and increased use of the street sweeper; and
- investigate the option of applying a commercially available dust stabilisation product to aid in dust mitigation. The Independent Monitor is aware of several products targeting different issues, such as road dust, stockpile dust and work generated dust; that may be useful to MRM. However, the use of these products needs careful assessment and planning to ensure they do not affect the surrounding environment. At the very least, the product to be utilised should comply with Australian and international standards for biodegradability.

9.4 Review of soil monitoring

9.4.1 Soil monitoring program overview

According to the Environmental Monitoring Manual 2010, a soil monitoring program is conducted annually at the mine site and the Bing Bong Port facility. Surface soil samples (0-0.03 mBGL) are collected next to each dust monitoring gauge immediately prior to the wet season and then submitted for analyses for heavy metals/metalloids: arsenic, cadmium, copper, iron, manganese, lead and zinc; cations: calcium, potassium, magnesium and sodium; pH, electrical conductivity (EC) and particle size analyses (PSA).

The soil monitoring sampling locations are presented in Figure 6.



Source: MRM Water Management Plan 2010/2011

Source: MRM Water Management Plan 2010/2011

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Soil sampling locations at the Mine site (top) and Bing Bong Port (below)**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 6**
Drawn By: **PF**	Date: **August 2011**	

Although the soil monitoring program is generally appropriate, the IM believe that there is significant room for improvement. Even though the laboratory analytical program undertaken is comprehensive, given the large area of the mining lease, the number of current soil monitoring locations (23) is insufficient. Once again, this observation was made in the previous Independent Monitor Audit.

Furthermore, the IM notes that the number of soil monitoring locations has decreased since the previous monitoring period—previously 25 locations, now 23—due to two locations not being sampled in 2010 (S09 and S14). These locations were reportedly not sampled due to development works being carried out in these areas which destroyed the monitoring points. These monitoring points should be relocated so that the sampling density of the entire soil program is not decreased further. It is also necessary for MRM to discuss the impact of such a decrease in sampling density within the monitoring report.

Due to the low number of soil sampling locations over the large area of the mining lease, it is difficult to make an accurate assessment of the net impact of the mine on soil in the area. At this stage, the Independent Monitor is not aware of any further plans by MRM to include additional soil monitoring locations.

9.4.2 Review of soil monitoring reporting

The results and reporting for the latest soil monitoring program are found in the 2010/2011 MMP in section 6.5. It is noted that MRM have made some improvements in the latest MMP, namely:

- provision of a discussion on the different soil types within the lease and their characteristics;
- provision of lead concentration charts for the current monitoring period for all locations; and
- undertaking further investigation into elevated concentrations found at some locations.

The IM also notes that MRM have provided complete laboratory transcripts with quality assurance, quality control (QA/QC) documentation and accompanying chain of custodies forms. No breaches to QA/QC in the sampling or analysis process were sighted in these forms.

In regard to the soil monitoring program as reported in the 2010/2011 MMP, the Independent Monitor makes the following observations:

- no field QA/QC section regarding duplicates and split samples, is provided in the MMP so it is assumed that these were not collected;
- it is of concern that the metal concentrations charts provided do not include data for previous years to identify temporal trends;
- MRM currently uses NEPM Human Health Investigation Levels (HIL; NEPC, 1999) as trigger values for contaminants in soil. These trigger values have been derived for the specific protection of human health and are therefore not appropriate as ecological protection thresholds. No site-specific trigger criteria have been derived for the mine site. The derivation of such criteria is proposed in MRM's own current Preliminary Mine Closure Plan (March 2008), yet has not been undertaken. The Independent Monitor has repeatedly recommended that MRM derive site-specific criteria for the protection of local biota or, more appropriately, use background as the trigger level. Again, this is recommended. In the interim, the NEPM Environmental (or Ecological) Investigation Levels (EILs) provide more relevant, and conservative, criteria than the

HILs currently in use, although the IM definitely does not imply that it is allowable to pollute up to this level;

- MRM has not undertaken any study towards the determination of background metal concentrations;
- The Independent Monitor understands that MRM collects soil samples close to dust monitoring locations to compare both results, yet no assessment of soil results with depositional dust metal concentrations appears to have been undertaken. Similarly, no correlation assessment of soil metal results and nearby creek sediment has been undertaken. Both of these assessments would be highly useful in gaining a better understanding of the relationships between dust generation, deposition, transport and fate, particularly as suspended sediments in the McArthur River Delta have displayed lead sourced from the mine—as reported by the Independent Monitor in 2008;
- there is no discussion in the MMP 2009-2010 on the rest of the parameters analysed: soil pH, electrolytic conductivity, particle size distribution, major cations: sodium, calcium, magnesium and potassium;
- in the current MMP, no analysis of the potential for other soil issues, for example erosion, salinity and sodicity) has been made. Because MRM collects extensive data sets including major cations, metals and other physicochemical parameters, investigation into these issues could potentially be undertaken without extending the current suite of laboratory analysis; and
- in the opinion of the Independent Monitor, MRM arbitrarily state that elevated lead concentrations at site S05 are due to “non mine derived” sources. This statement is not supported by any data presented in the MMP and is unclear why the statement has been made. Further investigation or provision of evidence is required on which to base such a conclusion, for example comparison of results with depositional dust metals levels in the area, lead isotope analysis and assessment of physicochemical characteristics.

9.4.3 Review of soil monitoring data

Since 2008, high lead concentrations have been recorded in monitoring locations S05, S15, S22, S24 and S28 as shown in Chart 4 below. In the absence of site specific levels, the Pb EIL threshold of 300 mg/kg has also been included in the Chart 4 as a conservative threshold for comparative purposes.

Elevated lead concentrations at S22, S24 and S28 are in line with the high depositional dust and airborne lead concentrations recorded at corresponding dust monitoring locations, and are most likely due to operation of the PACRIM crushing plant. Elevated lead concentrations at S15 are also potentially due to depositional dust, however sourced from Cell 1 at the TSF. The source for increased lead levels at monitoring location S05 does not appear to be strongly correlated with fugitive dust, and so should be further investigated.

High lead concentrations have also been recorded in Bing Bong Port monitoring location BB2 (although not shown in the graph below).

A decrease in soil lead concentrations can also be observed in Chart 4 since the last monitoring round. Since, to the knowledge of the Independent Monitor, MRM have not undertaken any remediation of these areas, this potentially means that impacted soil has been transported by wind, surface water runoff or floods to local streams or other depositional areas such as flood plans. Consequently, it is likely that contaminated soil caused by MRM operations has been transported offsite, which is not acceptable.

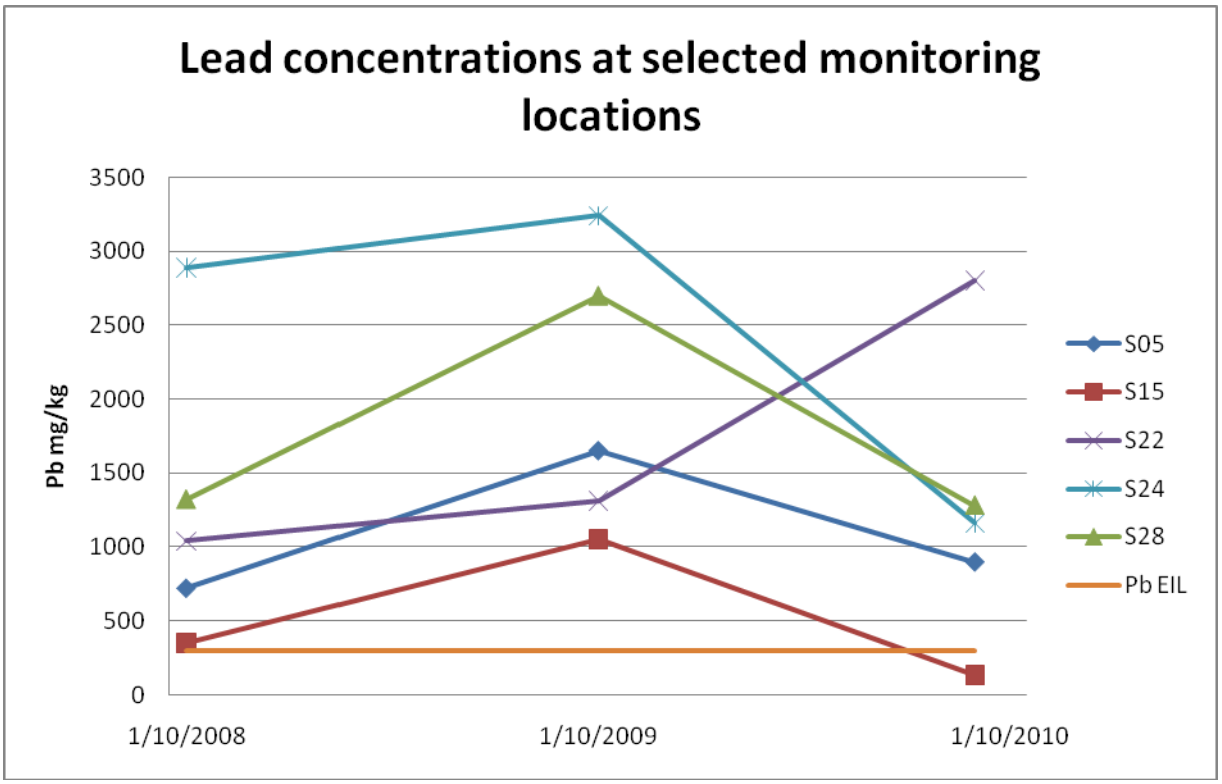


Chart 4 Lead concentrations at selected monitoring locations (those with the highest levels of contaminated soil)

9.4.4 Soil monitoring conclusions and recommendations

Soil contamination via dust deposition and surface water transport appears to be occurring, and, due to the lack of suitable studies, it is unknown whether local biota has been or may be affected by this issue. It is concerning that MRM has not acknowledged this issue in their analysis of soil data within the MMP.

Similar to the dust monitoring program reporting, the level and detail of reporting does not adequately show that valid scientific method or analysis has been applied to the soil assessment and is considered to be of an inadequate standard to be able to identify:

- temporal trends in soil contamination over years of monitoring;
- fate and transport of contaminants;
- contamination mitigation measures; and
- measures for program improvement.

Upon closure of the mine, MRM is required to return the land to its original state, however, information gaps currently exist as to the true extent of the impact of the mining operations on the soils. These gaps are partly due to the lack of studies such as the determination of background concentrations, site specific (ecological) criteria, and the limited spatial density of the soil studies that are being conducted, therefore, it is recommended that MRM address these issues to aid mine closure planning to limit ecological harm.

MRM are also reminded that establishing site-specific criteria is a commitment made in the EIS (URS, 2005). Methodologies for both undertaking an ecological risk assessment and the

derivation of background metal concentrations were described in the previous Independent Monitor Audit (2010).

The Independent Monitor stresses that the NEPM HIL thresholds have been derived for the protection of human health under very specific conditions, and do not by any means constitute a license for MRM to pollute soil until concentrations reach this level. Therefore, MRM should immediately cease applying HIL concentrations as trigger levels up to which contamination is not considered to be an issue.

Temporal monitoring assessments should be undertaken and discussed in detail to evaluate whether contamination is occurring, and where the contamination is coming from.

Other recommendations include:

- field QA/QC needs to be undertaken to confer robustness and reliability to the data collected. This is part of industry standards and has been mentioned by the Independent Monitor in past audits;
- any charts provided need to include data from previous years in order to assess long term trends;
- soil results need to be assessed in line with depositional dust metal concentrations and fluvial sediment concentrations to establish causes and potential transport mechanisms;
- in future, MMP discussions need to take place with regard to all parameters analysed: soil pH, electrolytic conductivity, particle size distribution, major cations: sodium, calcium, magnesium and potassium;
- analysis of potential for other soil issues, such as erosion, salinity and sodicity, should be undertaken;
- in general, whenever elevated or unusual metal concentrations are recorded, MRM should undertake further investigation, such as further sampling in nearby areas or isotope analysis, to determine the causes of the contamination and limit further impacts. In line with this recommendation, further sampling of nearby stream sediment and soil could be undertaken to investigate elevated concentrations in monitoring location S05; and
- consideration should be given to undertaking soil sampling in areas outside the mining lease, ideally in both upwind and downwind locations, to assess whether any mining impacts are occurring outside the mine site due to wind or water transport and deposition.

9.5 Review of fluvial sediment monitoring

9.5.1 Fluvial sediment monitoring program overview

According to the Environmental Monitoring Manual 2010, a fluvial sediment monitoring program is to be conducted biannually at all natural surface water sampling locations as well as within the southern, PAF dam and runoff dam. Sediments are to be analysed for heavy metals/metalloids: arsenic, cadmium, copper, iron, magnesium, manganese, lead and zinc; ions: calcium, potassium, magnesium and sulfate; pH, electrical conductivity (EC) and particle size analysis (PSA).

The fluvial sediment monitoring sampling locations are shown in Figure 7.

The Independent Monitor considers that the fluvial sediment monitoring program is generally appropriate and acknowledges the comprehensiveness of the laboratory analytical program undertaken by MRM. The addition of sampling points in the southern PAF dam and runoff dam is also welcomed as data from these locations should provide additional information regarding any potential effects of mining activities in local streams.

However, the IM is aware that there are no sampling locations in the tributary south east of the Bing Bong Port facility and notes that MRM have indicated that they consider sampling in the area to be sufficient; however, it is considered that a one-off investigation should be undertaken to provide evidence that there is no impact on sediments outside the mine operational area. While the wind in the area is predominantly from a north-west direction, it is nevertheless possible that concentrate-bearing dust is transported to the creek located to the south-east of the Bing Bong Port facility by either surface runoff or occasionally changing wind patterns.

9.5.2 Review of fluvial sediment reporting

The results and reporting for the latest fluvial sediment monitoring program are found in the Sustainable Development Water Management Plan (WMP) 2010/2011 in section 6.5. The Independent Monitor acknowledges the improvements made in the latest WMP, namely:

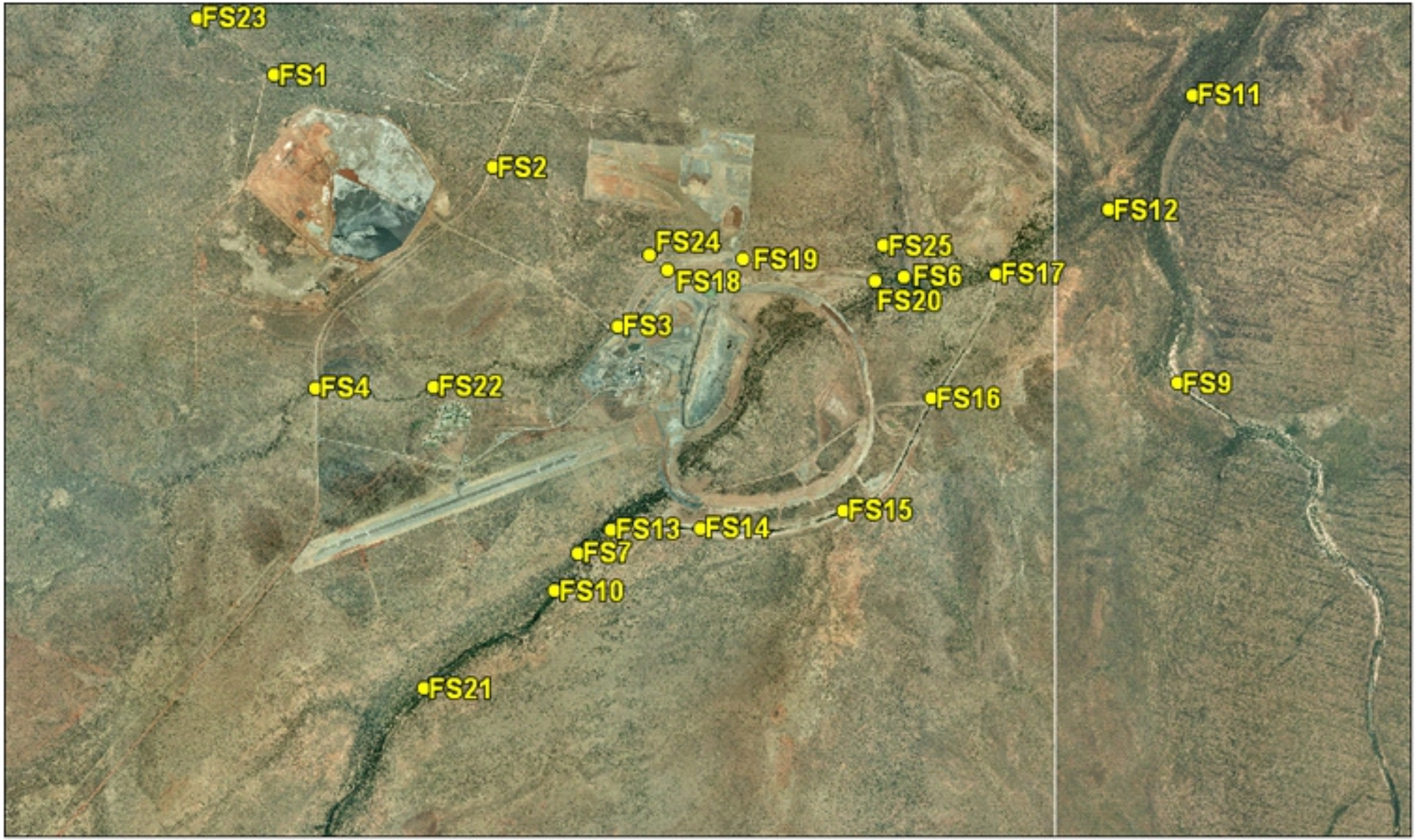
- accounting for missed sampling events, which were reported as less than 3%;
- providing temporal heavy metal concentration charts and a discussion of trends for selected sampling locations;
- undertaking further investigation, albeit limited, into elevated concentrations found at selected locations; and
- for providing an assessment of the potential causes of the elevated metal concentrations.

The Independent Monitor also notes the provision of complete laboratory transcripts with QA/QC documentation and accompanying chain of custody forms for fluvial monitoring. It is also noted that there are no breaches to QA/QC procedures in the sampling or analysis process. However, no field QA/QC section has been provided in the 2010/2011 WMP, therefore, it can only be assumed that complete procedures for QA/QC were not undertaken.

Neither are temporal concentration charts provided for all locations in the 2010/2011 WMP. If this is because other locations are judged not to be impacted by mining operations, this needs to be explained. Even if data only exists for the last three years, it needs to be provided at least as temporal concentration charts.

As in the previous WMP, no interpretation of the analyses of electrolytic conductivity, particle size distribution, major cations: sodium, calcium, magnesium, and potassium; has been provided. However, it is noted that there is a discussion regarding sediment pH for Barney Creek and McArthur River in the most current WMP.

With respect to the fluvial sediment monitoring program findings reported by MRM, the data shows greater heavy metal impacts at downstream locations for all monitored streams (McArthur River, Barney Creek and Surprise Creek).



ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Fluvial sediment Monitoring Locations**

Location: **McArthur River Mine, Northern Territory**

Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 7**
Drawn By: **PF**	Date: **August 2011**	

The IM agrees with the following observations made in the WMP:

- analysis of historical data indicated that elevated heavy metal concentrations in Surprise Creek monitoring locations FS23 and FS24 recorded in 2008 may be due to capping works of the TSF and associated fugitive dust;
- elevated lead and zinc concentrations at Barney Creek location FS03 are attributed to depositional dust generated from the ROM/PACRIM crushing plant and potentially due to traffic nearby Barney Creek; and
- elevated concentrations recorded at FS19 are potentially due to the influence of Barney Creek bridge traffic and surface runoff from the area.

MRM also suggest that elevated heavy metal concentrations in the downstream sections of the constructed McArthur River diversion are due to the natural mineralisation of the stream-bed material. Although the Independent Monitor believes that this may be the case, as it is also possible that the accumulation of heavy metal-impacted sediment from upstream Barney Creek is causing the elevated metal concentrations in the McArthur River channel diversion. Further studies, such as lead isotope analysis, should be undertaken to clarify this issue.

MRM state that, although elevated metal concentrations have been recorded at FS19:

- this can be attributed to influence from the Barney Creek bridge through dust generated by heavy vehicle movements and surface runoff from the area. Despite this influence in this area, no temporal trend is currently evident although limited data is available. This is possibly due to the monitoring site FS19 not capturing the full influence on this area. (p193, WMP 2010-2011).

It is unclear why MRM have made the above statement. Perhaps they are indicating that one location (FS19) is either not enough to capture the effects of dust from traffic, or perhaps the monitoring has not been undertaken for long enough to determine any trends. Furthermore, upon examination of metal concentrations in the >63 µm fraction, the IM believes that there *is* in fact an increasing trend of heavy metal concentrations at this location. (see discussion on assessing of >63 µm fraction heavy metal concentrations in section 9.5.3 below).

The Independent Monitor disagrees with MRM's assumption that Barney Creek location FS04 has "naturally elevated (lead and zinc) concentrations" and MRM must provide further discussion to support such a statement. Nevertheless, it has to be noted that the FS04 monitoring location is close to the Carpentaria Highway which crosses Barney Creek so this area is prone to receiving concentrate-bearing dust dislodged from the road pavement by passing vehicles. This observation was also made in the previous Independent Monitor Audit report (2010).

MRM suggest that elevated concentrations recorded during the current reporting period at FS04 "could be an anomalous result", however it is suggested that these results are potentially correct, as heavy metal concentrations in the 63 µm fraction show similar results between sampling events. The same issue, although with an increasing trend, is noted for location FS18 which recorded an elevated lead and zinc result on 7/10/09: see Table 5 below. Furthermore, MRM state that "…results for this occasion have been removed from the dataset" and, consequently the Independent Monitor cautions MRM against disregarding laboratory results without sufficient evidence. Anomalous results should be presented, but can be removed from statistical evaluation with written justification.

Moreover, if MRM believe these results are anomalous then further explanations need to be provided with regard to what type of error they believe has occurred, for example, cross

contamination, laboratory error and other inaccuracies. Note that good field QA/QC procedures, which MRM has not provided evidence of undertaking, would greatly improve the robustness and reliability of the data collected in addition to highlighting potential errors. Further discussion on the confounding effects of particle size is provided in section 9.5 below.

However, the Independent Monitor does believe that, as MRM state, it may be possible that copper recorded anomalous concentrations in monitoring location FS16 during the 7/10/09 sampling event. Nevertheless, further interpretation considering natural mineralisation, cross contamination and so on, needs to be provided to support MRM's claims.

TABLE 5 TOTAL AND FINE FRACTION LEAD RESULTS FOR MONITORING LOCATIONS FS04 AND F18

Date	FS04 (Total Pb)	FS04 (>63µm Pb)	FS18 (Total Pb)	FS18 (>63 µm Pb)
16/10/2008	121	39	35	Not analysed
10/04/2009	132	52	15	46
7/10/2009	39	35	189	128
9/06/2010	79	31	34	108

9.5.3 Review of fluvial sediment data

Assessing total heavy metal concentrations against the ISQG-Low and ISQG-High thresholds as specified in ANZECC/ARMCANZ (2000), is a good initial approach for determining potential impacts on sediments and local biota. However, in order to determine whether any temporal trends in sediment metal concentrations exist, it is advisable to examine concentrations recorded in fine particles, that is the fraction less than 63 µm). The larger surface area of fine particles translates to a greater metal binding capacity than with coarser particles. Consequently, it is sometimes the case that trends are not readily visible or that metal concentrations appear to be randomly oscillating, when in fact these are being influenced by the proportion of fine particles in the sample analysed.

In line with the above, the Independent Monitor has reviewed the total and >63 µm heavy metal sediment data supplied by MRM and presents its findings in Table 6 below. Note that the "analyte exceeded" column refers to total concentrations, whereas the Independent Monitor comment column, provides an assessment of trends for the >63 µm results as per the explanation in the above paragraph.

Table 6 highlights that consistently elevated heavy metals and/or increasing trend have been observed for locations: Surprise Creek FS02; Barney Creek FS03, FS18, FS19, F20 and FS04; and McArthur River FS17.

The Independent Monitor believes that the primary source of elevated sediment concentrations at Barney Creek is fugitive dust from the PACRIM coupled with runoff from nearby areas and transport of contaminated sediment downstream, however locations FS04, FS19 and F03 appear to also be influenced by dust dislodged from roads by local vehicle traffic in addition to runoff and depositional dust. Surprise Creek location FS02 appears to be affected by dust blown from the TSF, however, since many of the results were collected, the top of TSF Cell 1 has been covered with a clay layer for dust suppression.

Depositional effects of contaminated sediment, or mineralisation effects as MRM suggest, are also observed downstream of McArthur River although concentrations seem to fluctuate, potentially due to variations in the flow regime.

TABLE 6 FLUVIAL SEDIMENT SAMPLE LOCATIONS THAT HAVE EXCEEDED THE ANZECC/ARMCANZ (2000) GUIDELINE ISQGS SINCE 2008

Location	Analyte exceeded	Independent Monitor comment
FS SPD	Pb, Zn	Southern PAF dam. Highest Zn concentration recorded for monitoring program (3 500 mg/kg). Monitoring started in 2010
FS SPRD	Zn	Southern PAF dam. Monitoring started in 2010
FS01	Pb, Zn	Surprise Creek, upstream of TSF. Decreasing Pb/Zn concentration trend due to total dust being reduced
FS02	Pb, Zn	Surprise Creek, directly downstream of TSF. Increasing Pb/Zn trend
FS03	Pb, Zn, Cd, As	Barney Creek, west of Pacrim. Consistently high concentrations of Pb/Zn
FS04	Pb, Zn	Barney Creek, upstream location apparently next to Carpentaria Highway.
FS06	Pb	Barney Creek diversion, downstream mine. Pb/Zn Concentrations slightly increasing
FS12	Pb	McArthur River approximately 4km downstream of mine. Pb Concentrations oscillating and potentially influenced by mobilisation of upstream sediment or natural mineralisation
FS16	Pb, Cu	McArthur River diversion. Pb/Zn concentrations not increasing
FS17	Pb	McArthur River diversion. Elevated Pb concentrations (however last round showed a slight decrease)
FS18	Pb, Zn, Cd, As	Barney Creek diversion (south of OEF). Increasing Pb/Zn/As concentrations
FS19	Pb, Zn, Cd, As	Barney Creek diversion (south of OEF). Increasing Pb/Zn/As concentrations (however last round showed a slight decrease)
FS20	Pb, Zn	Barney Creek diversion (downstream mine site). Increasing concentrations (last round showed however a slight decrease)
FS22	Pb	Barney Creek (upstream of mine site). No trend apparent in Pb/Zn concentrations
FS25	Pb	Pb concentrations slightly elevated

Notes:
1. shaded analytes exceeded ISQG-High. Unshaded exceeded ISQG-Low
2. Increasing trend is determined by comparing heavy metal concentrations in the 63 µm fraction

9.5.4 Fluvial sediment conclusions and recommendations

The Independent Monitor believes that the most significant finding is that consistently elevated heavy metals and/or increasing trend have been determined for the following locations: Surprise Creek FS02; Barney Creek FS03, FS04, FS18, FS19 and FS20; and McArthur River FS17. It is therefore recommended that dust mitigation be increased in the areas nearby and measures taken to prevent runoff of contaminated material into these areas. Consideration should be given then to conducting a specific investigation of metal concentrations in sediment at these areas with an increased spatial density, to determine the extent of contamination and subsequently assess the need to remediate sections of contaminated streams. Urgent attention is required to prevent the ongoing ingress of dust/runoff sediments entering creeks and rivers close to the mine. In addition, the following recommendations are made:

- conduct a study to determine background heavy metal concentrations. It is understood that no such study has yet been undertaken and it is vital for determining suitable targets for mine closure planning and for the protection of local stream biota;
- evaluate trends in sediment concentrations, both increasing and decreasing, and correlate with mine site activities; for example, assess whether the covering of TSF Cell 1 has reduced dust emissions and metal levels in sediments;
- the assessment of sediment concentrations in the total fraction against ANZECC/ARMCANZ (2000) ISQGs is useful, MRM also needs to assess for for particle size, pH and metal concentrations in fine fractions;
- No toxicity testing has been undertaken for sediments exceeding the ISQGs thresholds. ANZECC/ARMCANZ (2000) recommends the analysis of pore water, the use of 1M HCl and/or the analysis of acid volatile sulfides (AVS) for a measure of potential ecotoxicity of sediments exceeding the ISQG thresholds. The IM notes that MRM has not undertaken either of these analyses for sediment samples that exceed guidelines, with the exception to the marine sediment monitoring undertaken by AIMS (2010), and recommends that both analyses be used in future monitoring; and
- MRM should implement field QA/QC in future monitoring rounds to add rigour and reliability to the data.

TABLE 7 LOCATIONS THAT HAVE EXCEEDED THE ANZECC/ARMCANZ (2000) GUIDELINE ISQGS SINCE 2008

Sample Location	Date	Pb (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	As (mg/kg)
FS SPD	10/06/2010	**74**	432	—	—
FS SPD	18/11/2010	—	3500	2	—
FS SPRD	18/11/2010	—	1270	—	—
FS01	16/10/2008	187	511	—	—
FS02	16/10/2008	152	646	—	—
FS02	4/11/2010	92	—	—	—
FS03	16/10/2008	433	742	—	—
FS03	10/04/2009	336	462	—	—
FS03	7/10/2009	873	1080	2	26
FS03	9/06/2010	1030	677	—	25
FS03	2/11/2010	82	—	—	—
FS04	16/10/2008	121	—	—	—
FS04	10/04/2009	132	—	—	—
FS04	9/06/2010	79	312	—	—
FS06	7/10/2009	87	—	—	—
FS06	9/06/2010	57	—	—	—
FS12	9/06/2010	60	—	—	—
FS16	3/11/2010	59	—	—	—
FS17	10/04/2009	56	—	—	—
FS17	8/10/2009	52	—	—	—
FS17	10/06/2010	96	—	—	—
FS18	7/10/2009	189	1060	3	28
FS18	2/11/2010	134	276	—	—
FS19	16/10/2008	111	348	—	—
FS19	10/04/2009	55	206	—	—
FS19	7/10/2009	106	454	—	—
FS19	9/06/2010	114	280	—	21
FS19	2/11/2010	439	1320	3	42
FS20	7/10/2009	59	—	—	—
FS20	9/06/2010	78	226	—	—
FS20	4/11/2010	68	—	—	—
FS22	10/04/2009	94	—	—	—
FS22	9/06/2010	140	—	—	—
FS25	7/10/2009	58	—	—	—

Note(s):

1. shaded analytes exceeded ISQG-High. Unshaded exceeded ISQG-Low

9.6 Review of marine monitoring–seawater and sediment

9.6.1 Overview of seawater and sediment monitoring

The marine monitoring program aims to assess whether activities at the Bing Bong Port facility are having a significant impact on sediments and seawater in the area. Contamination of sediments and seawater has the potential to impact on marine biota within the estuary and/or Sir Edward Pellew Islands.

Monitoring is undertaken by both MRM and the Australian Institute of Marine Science (AIMS) and the results of these investigations are found in the latest version of the WMP (MRM, 2010x) and the *McArthur River Mine: Annual Marine Monitoring Program* (AIMS, 2011).

The marine monitoring program undertaken by MRM, as detailed in the Technical Manual for Environmental Monitoring (2010), includes:

- monthly sampling of eight seawater sample sites including two in the swing basin, three in the dredge channel and three at the control site;
- four seawater sampling locations using the diffusive gradients in thin-film (DGT) technique, which are deployed for a period of four to six days every month; and
- bi-annual marine sediment monitoring at seven locations including sites in the swing basin and dredge channel, and a reference site located at a distance away from the Bing Bong Port facility.

MRM seawater and marine sediment sampling locations are shown in Figure 8.

The 2010 marine monitoring program undertaken by AIMS includes:

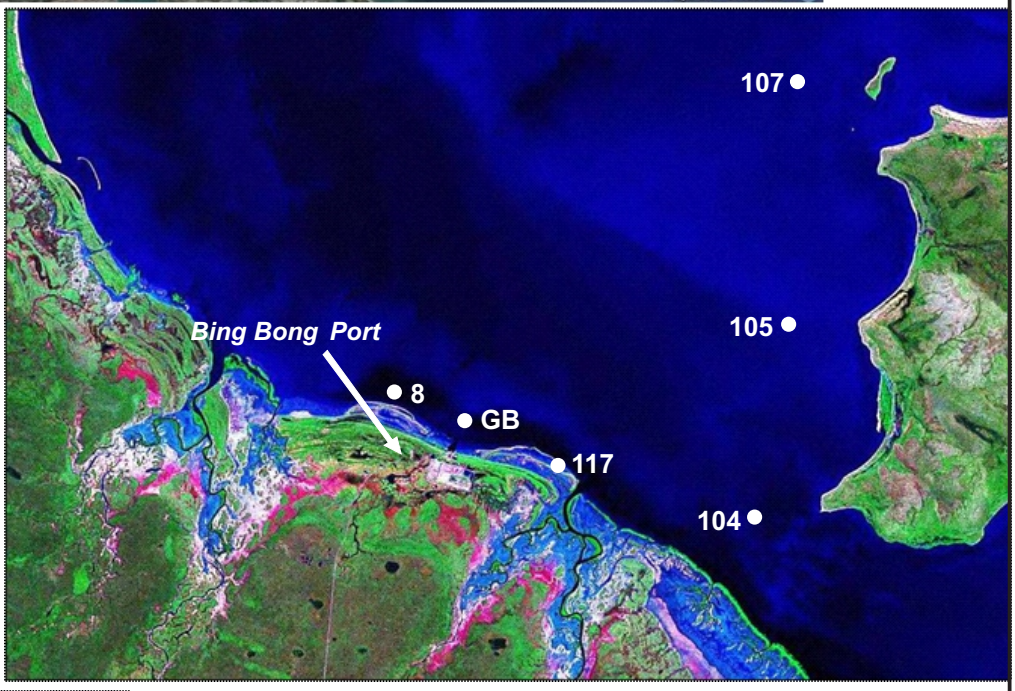
- sediment sampling at ten locations in the Bing Bong Port area;
- seawater, filtered and unfiltered, sampling at seven locations in the Bing Bong Port area;
- sediment and seawater sampling at seven locations in the Sir Edward Pellew Islands; and
- seagrass, gastropods and oysters sampling at Bing Bong and Sir Edward Pellew Islands.

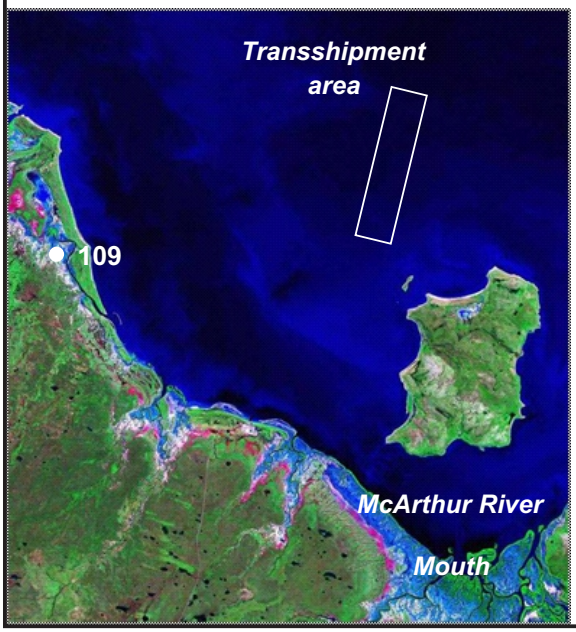
Note that seagrass, gastropods and oyster analysis is discussed in section 9.7.7 Review of marine biota monitoring.

AIMS seawater and marine sediment sampling locations are shown in Figure 9

In addition, the AIMS undertook an investigation of seafloor sediments in the trans-shipment area. The results of this investigation are found in the report *Metal concentrations and Pb isotope ratios in seafloor sediments from the XstrataZinc MRM Trans-shipment area* (AIMS, 2010) and were reviewed by the Independent Monitor as outlined below.

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW		Title: **Monthly Marine Sampling locations for seawater and sediment at Bing Bong Port**	
		Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**			Job No: **211011**
Project Man: **GM**	Scale: **As shown**		Figure **8**
Drawn By: **PF**	Date: **August 2011**		





All three images sourced from AIMS Annual Marine Monitoring Report 2009

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Monthly Marine Sampling locations for seawater and sediment at Bing Bong Port**	
	Location: **McArthur River Mine, Northern Territory**	
Project: **Independent Monitor 2010 Operational Period**		Job No: **211011**
Project Man: **GM**	Scale: **As shown**	**Figure 9**
Drawn By: **PF**	Date: **August 2011**	

9.6.2 Review of seawater and sediment monitoring reporting

The Independent Monitor considers the frequency, locations and analytes included in these programs to be appropriate, however we make the following observations:

- MRM's approach regarding the seawater monitoring program, namely for establishing background concentrations (control sites) and statistically assessing differences in metal concentrations between sites within the swing basin and control sites, is agreed, but it is noted that an equivalent approach is lacking for dust, soils and fluvial sediment monitoring;
- it is unclear whether seawater samples collected as part of the monthly seawater monitoring program undertaken by MRM correspond to unfiltered or filtered samples. It must be noted that unfiltered samples do not provide information regarding the metal concentrations in the dissolved phase, and thus are not recommended for the assessment of water quality. These samples are, however, useful for isotopic lead studies. Suspended sediments in the McArthur River delta region are representative of river water discharge as well as disturbed sea water sediments;
- MRM's approach for investigating metal bioavailability fractions in seawater using the DGT methodology is valuable, however no results or discussion of this monitoring is presented in either the WMP or the reports produced by the AIMS;
- MRM have selected the ANZECC/ARMCANZ (2000) threshold values for the protection of 95% of the species as a target for marine water quality, however, there is no explanation as to why this level of protection was chosen instead of the more conservative 99% protection level;
- no QA/QC results were provided to the Independent Monitor for any of the programs undertaken by MRM, consequently, none of these results are scientifically defensible;
- partial QA/QC analyses results were provided in the reports undertaken by the AIMS, regarding reference materials and blanks, however no inter/intra laboratory sample results, such as duplicates and splits, were sighted; and
- no long term trends analysis of seawater and sediment results are presented in the WMP. It is noted that a table detailing basic statistics is presented in the WMP, however, full results including past monitoring rounds should be appended for completeness.

9.6.3 Review of seawater and sediment monitoring results

In general, lead and zinc results for both seawater and sediments recorded higher concentrations in the swing basin site as opposed to the control sites, indicating an impact from mining operations. Lead isotope analysis undertaken on sediment at a beach site west of the Bing Bong facility also revealed an MRM ore impact—an isotopic lead signature—in lead concentrations.

Most seawater results were below the ANZECC/ARMCANZ (2000) threshold for the protection of 95% of the species; however one exceedance was recorded at monitoring location MSW08 for lead and zinc. This monitoring location is the closest to the Bing Bong Port and also exceeded the threshold in last year's Independent Monitor Audit. Lead and zinc concentrations in seawater do not show a noticeable decrease from last year's results.

Sediments with lead concentrations exceeding the ANZECC/ARMCANZ (2000) ISQG-Low were also recorded in transect composites MS06 and MS07. In the previous audit report, he Independent Monitor recommended that sediments be collected at either side of the

transects, outside the swing basin, to assess the lateral extent of the heavy metal impact. It was also recommended that the transect samples be collected as point samples, which are analysed individually, rather than composite samples. Once again these recommendations are emphasised in this audit report.

It is noted that AIMS did collect a sample of beach sediment west of the Bing Bong Port facility and this sample recorded elevated lead concentrations with MRM's ore isotopic signature. In addition to lead, this sample also recorded high concentrations of zinc, arsenic and cadmium. Although all results are below the ANZECC/ARMCANZ (2000) ISQG-Low threshold, zinc, lead and cadmium have shown a trend of increasing concentrations since 2008, thereby providing a cogent reason to urgently address fugitive dust emissions.

9.6.4 AIMS Trans-shipment area investigation

The AIMS undertook an investigation of seafloor sediments in the trans-shipment area, collecting samples in the trans-shipment anchorage area and a control site.

The results of this investigation indicated that sediment in the trans-shipment area had elevated lead and zinc concentrations, most likely due to enrichment from fugitive MRM ore concentrate. This could be due to improvements made by MRM regarding dust mitigation practices on the Aburri barge, or possibly due to natural dispersion of seafloor sediments.

The Independent Monitor agrees with the AIMS conclusion that lead and zinc sediment concentrations would not be expected to have an impact on sediment quality in the area as they are below the ANZECC/ARMCANZ (2000) ISQG-Low threshold values. It is however noted that nickel concentrations are also slightly elevated—above sediment quality ISQG-Low values, and thus further information needs to be provided in future studies with relation to elevated nickel concentrations. It is noted that elevated nickel is not associated with the MRM ore-body.

9.6.5 Seawater and marine sediment recommendations

The Independent Monitor makes the following recommendations based on the review of MRM's marine monitoring program:

- MRM should ensure that seawater samples collected as part of the monthly seawater monitoring are filtered so as to assess the dissolved metal phase concentrations, which will give a more indicative picture of water quality, except when assessing the impact of suspended samples;
- include the results of analyses undertaken using the DGT methodology in future WMP. This should include the presentation of all results, trend analysis and conclusions;
- ensure that laboratory transcripts, chain of custody forms and QA/QC interpretation of results are provided in future Water Management Plans or associated marine monitoring reports;
- ensure that the chosen ANZECC/ARMCANZ (2000) 95% of protection level values for seawater are protective of key ecosystem species, and provide an explanation into why this level was chosen—note that we do not consider this marine system as being partially degraded (as choosing a 95% protection level implies);
- provide a long-term trend analysis. MRM has not provided such an analysis in the 2010 Water Management Plan and this is an essential tool to assess the effectiveness of contamination mitigation measures adopted at Bing Bong Port. The Independent Monitor has repeatedly indicated to MRM the need to assess long term data, however only slight improvements have been made over the last four monitoring periods;

- samples at either side of the transects, outside the swing basin, should be collected and analysed to assess the lateral extent of heavy metal impacts. In addition, transect samples already being collected as part of the marine monitoring program should be analysed individually and not composited;
- given that nickel levels were found slightly elevated in sediment samples collected in the trans-shipment area, it is recommended that this analyte be added to all future monitoring programs, alternatively, an explanation for the elevated nickel concentrations should be provided;
- determination of lead isotope ratios of suspended sediments in the McArthur River delta and at Bing Bong Port should be continued; and
- monitoring of the McArthur River delta sediments east of Bing Bong Port should be undertaken as the potential for impact exists at this location.

9.7 Review of flora and fauna monitoring

9.7.1 Overview

Following this year's site inspection, it appears that flora and fauna monitoring and management at MRM is generally moving in a positive direction. Most of the concerns raised by the Independent Monitor last operational period have since been addressed, as summarised in section 9.7.2 below. However a few issues from the last operational period still need to be addressed or completed. The IM notes that the significant issue regarding seepage from the TSF and the subsequent impact of heavy metal accumulation in macro invertebrates and fish still requires close, ongoing monitoring.

McArthur River Mine received higher rainfall over the 2009/2010 wet season and the 2010/2011 wet season prior to the site inspection, than in the previous two operational periods. This has had both positive and negative impacts on various flora and fauna monitoring and management. Two examples of positive outcomes for aquatic fauna are that any concentrations of heavy metal contamination in local streams may have been diluted, and that fish passage in the river diversions and flood-out areas is likely to have been enhanced (Indo-Pacific Environmental, 2010). Conversely, a negative impact of increased rainfall has been the lack of access for seed collection and fence completion/repair by MRM staff.

It is again recognised that MRM revegetation works are challenged by seasonal conditions as well as the large extent of the area being rehabilitated. MRM have provided evidence that they have begun to develop systems to deal with these issues and have directed considerable resources into rehabilitating the diversion channels over the 2010 operational period. A similar effort is planned for the next operational period.

Observations and recommendations for each area of flora and fauna monitoring are provided in the following sections, with a summary of recommendations provided at the end of this section.

9.7.2 Improvements since the previous operational period

The Independent Monitor acknowledges the following improvements:

- 40 000 tubestock were planted along diversions and there is a particularly successful establishment of tubestock planted along the MR diversion. More target species were

planted along the McArthuir River channel including *Casuarina cunninghamiana, Lophostemon grandiflorus, Melaleuca sp., Pandanus sp.*;

- a sled watering system is in use and proving effective for dry season planting;
- the addition of large, woody debris into the MR diversion at approximately 30 locations to improve fish habitat shows early signs of species composition improvement around the debris;
- riparian bird monitoring has been carried out satisfactorily, but the results show that the MR diversion is not yet functioning as a bird habitat (see below);
- purple-crowned, fairy-wrens living at the edge of Barney Creek rehabilitated area may begin to use Barney Creek habitat in the coming year;
- macroinvertebrate monitoring sampling is thorough;
- freshwater sawfish (*P. microdon)* are increasingly using the diversion for passage to upstream permanent waterholes;
- opportunistic sowing of native grass seeds on dredge ponds with available seed and staff;
- halting of *Parkinsonia* field trials and killing of *Parkinsonia* with chemicals around the dredge ponds has been carried out promptly;
- further weed control has been carried out around Bing Bong Port to remove bellyache bush;
- Bing Bong Port dredge spoil ponds spoon drain was reinstated before the previous Independent Monitor inspection in May 2010 to direct saline, possibly acid, seepage from the dredge ponds into the marine environment and not to the surrounding vegetation;
- surrounding vegetation at the dredge spoil ponds appeared slightly improved from last year, although this may have been due to favourable seasonal conditions;
- the wallaby study carried out found that MRM operations are not affecting agile wallaby numbers at Bing Bong Port; and
- heavy metals samples from barramundi were taken and submitted to a lab for analysis in March 2011, but the results were not available at the time of writing.

9.7.3 Mine site flora monitoring–terrestrial

McArthur River diversion vegetation monitoring

On 1 July, 2011, the areas of ongoing revegetation along the upstream section of the McArthur River diversion were inspected. This area exhibited significantly more vegetation growth than observed during the site inspection in May 2010. While it is recognised that the McArthur River diversion is yet to provide functioning habitat for riparian birds, MRM is nevertheless moving in the right direction with substantial efforts being made towards rehabilitation in 2010, with a similar amount of works planned for 2011. The Independent Monitor was also informed that seed collection and further rehabilitation was being undertaken at the time of the site inspection (Crawford, J, pers. comm. 2011). MRM have advised that approximately 40,000 trees were planted in 2010, and the same amount is aimed to be planted in 2011, before and during the wet season. We note that high flood velocities and accessibility issues make revegetation of the Mcarthur River a challenge.

It is noted that revegetation works have only been undertaken on the mine-side bank of the diversion at this stage, and that the opposite bank still remains un-vegetated. Furthermore,

most of the revegetation efforts have been undertaken on the upstream section of the McArthur River diversion. Due to access restraints caused by the recent wet season, the downstream section of the diversion was not inspected by the Independent Monitor.

The following observations were made during the Independent Monitor's 2011 site inspection and following a technical review of relevant documents supplied by MRM:

- sections of the mine side of the McArthur River diversion channel show significant improvement since the last site inspection (See Plate 14 and Plate 15 for a comparison).
- the success of revegetation is mainly attributed to the high numbers of suitable tubestock planted, around 40 000, in the dry season of 2010 and the effectiveness of the watering sled that was trialled in 2010. This irrigation sled system allows plants to establish before annual wet season flooding and the sled system can be removed easily to avoid flood damage (MRM 2010c).
- Some native species identified as important riparian bird habitat species or species found on the original McArthur River were planted from tubestock. These included *Pandanus sp, Casuarina cunninghamiana, Melaleuca sp, Nauclea orientalis, Chrysopogon* and *Lophostemon grandiflorus* with *Eucalyptus camaldulensis* proving to be a very rapid and robust revegetation species along the diversions (MRM 2010a section 4).
- two key species: *Barringtonia acutangula* (freshwater mangrove) and *Chionachne cyathopoda* (native cane grass) were almost absent from the planted stock due to difficulty in seed collection in the wet season, poor seed viability or difficulty in cultivating from seed (Taylor, G, Crawford, J, pers. comm. 2011). These species have been identified as being particularly important to the riparian bird indicator species and will be more of a focus in 2011/2012.
- only minor tubestock planting has taken place on the opposite side of the McArthur River diversion, however, MRM have advised that a second watering sled for the opposite side of the diversion has been ordered and is expected to be ready for the wide-scale tubestock planting in the 2011 dry season. Access across the diversion may be possible during July/August (Crawford, J pers. comm. 2011, MRM 2010c). Some sections on the opposite bank may be difficult to revegetate due to lack of substrate availability (Taylor, G, Crawford, J, pers. comm. 2011). The Independent Monitor agrees that extra attention may be required in these areas.
- weed control in the operational areas has been satisfactorily documented in the annual Weed Management Plan and Weed Registers (MRM 2010d).
- MRM should focus on achieving species diversity along the diversions that more closely resembles the original river channels as per commitments in the 2009-2010 MMP (MRM 2009b, pg 38). It is understood that establishing species diversity will be a focus of attention for MRM in 2011 and 2012 (Crawford, J pers. comm. 2011 and Rehab plan, plant density excel sheet).
- annual vegetation monitoring of Barney Creek has been carried out since tubestock were planted in 2008. Annual vegetation monitoring was carried out for the first time on the McArthur River diversion by CDU in July 2010, although this occurred immediately after planting and provides limited data for comparison at this stage. Annual vegetation monitoring of the Barney Creek and McArthur River diversions is scheduled to be carried out again in 2011.

2008

2009

2010

2011

Plate 13 Photographic comparisons of an area along the upper section of the McArthur River diversion that is currently undergoing revegetation. The photographs show the progressive establishment of vegetation on the mine side of the river diversion from 2008-2011. This is a positive outcome for the diversion rehabilitation; however, more revegetation works downstream and on the opposite bank are required in coming years. (All photos by the Independent Monitor).

Plate 14 Revegetated bank of the upstream McArthur River diversion (mine-side), inspected by the Independent Monitor team, May 2011. Photo: Independent Monitor.

Plate 15 McArthur River diversion Channel as inspected by the Independent Monitor team, May 2010. Photo: Independent Monitor.

Barney Creek vegetation monitoring

Barney Creek vegetation growth has continued to improve since the Independent Monitor's last inspection (See Plate 17). We note that flood velocities are not as high along this part of Barney Creek, which have allowed for successful revegetation in this area. Also, this area was planted one season prior to revegetation at the McArthur River. Two key species were noted: *Eucalyptus camaldulensis* (river red gums over 8 m tall) and *Chionachne cyathopoda* (cane grass). Cane grass was observed to be providing habitat for the Purple Crowned Fairy Wren during the IM site inspection, which suggests that revegetation of cane grass is proving successful in these early stages.

Revegetation focus on Barney Creek is shifting to species composition rather than mortality in an attempt to achieve a channel community that more closely resembles the original Barney Creek riparian section. The Independent Monitor understands that MRM aims to plant targeted tubestock along Barney Creek in 2011, and that irrigation is being removed from areas in Barney Creek where it is no longer required (Crawford, J pers. comm. 2011).

Currently there is only one vegetation analogue/reference site for Barney Creek and it is located along Surprise Creek, which runs past the northern edge of the TSF and into Barney Creek. It is quite different from the original Barney Creek in flow pattern and vegetation. The site on Surprise Creek is located downstream of the TSF seepage issues so is probably not a good reference site for the Barney Creek diversion.

MRM have indicated that they agree with the recommendation in the previous Independent Monitor Audit report that an analogue site upstream along Barney Creek should be included in the 2011 vegetation monitoring program, and it is planned to be incorporated in the 2011 vegetation monitoring for Barney Creek (MRM 2011a).

Plate 16 Cane grass stands adjacent to Barney Creek diversion. The original Barney Creek corridor is in the background. Photo: Independent Monitor.

2009

2010

2011

Plate 17 Photographic comparisons of the same revegetated area of the Barney Creek diversion taken in 2009, 2010 and 2011 by the Independent Monitor.

2008

2009

2010

2011

Plate 18 Photographic comparisons of the Surprise Creek confluence with Barney Creek taken by the Independent Monitor from 2008-2011. Photographs show the improvement in revegetation over the four year period. Photos: Independent Monitor.

Weed Management
Large infestations of noxious weeds around the mine were identified as a significant issue as part of the previous Independent Monitor Audit; particularly concerning noogoora burr along the river and creek diversions.

In the period since the 2010 site inspection, weed control around the mine has been concentrated around eradicating *parkinsonia*, a weed of national significance and Class B and C in the NT; bellyache bush, Class A and C weed to be eradicated—incorrectly named as Class B and C weed in the 2010-11 Weed Management Plan: devil's claw, Class A and C; and chinee apple (*Ziziphus mauritiana*), Class A and C. This weed control has been documented in the Weed Management Registers, Weed Management Plans and by photographs (MRM 2010a, 2010b, 2011b). Noogoora burr, Class B and C, was sprayed along the Barney Creek diversion and in sections along the McArthur River diversion just prior to the 2011 Independent Monitor's site inspection.

Following advice from Weeds NT, spraying by helicopter, quad bike, basal spraying and backpack, manual removal and burning, as appropriate, have been methods used. Progress has been made towards controlling parkinsonia, devil's claw and bellyache bush in operational areas.

Noogoora burr is continually entering the river diversions from large infestations upstream in non-lease areas. Cattle roaming in the mining lease are also a potential source of weed spread along the diversions. In May 2011, the Independent Monitor noticed individual weed plants or seedlings emerging along the McArthur River diversion. The spraying of noogoora burr just prior to the site inspection appeared to have been effective as, during the inspection in may 2011, we noted dead adult plants and a lack of large visible infestations in the sections of the channel.

It is recognised that weed management is an ongoing commitment and MRM has directed appropriate effort into controlling weeds in the lease since the previous Independent Monitor site inspection (MRM 2010b).

Weed control in the operational areas has been satisfactorily documented in the annual Weed Management Plan and Weed Management Registers (MRM 2010b). The success of weed control in the lease can be determined to some degree by before and after photographs provided by MRM, the annual vegetation monitoring program by CDU (CDU 2010), the Weed Management Plan and, to a lesser degree (MRM 2010b), as well as by the Independent Monitor's site inspections.

Stock exclusion fencing
Cattle were once again observed along the diversion channels and around the mine site during the Independent Monitor's May 2011 site inspection (See Plate 19). The redesigned 12 km long cattle exclusion fence, as per commitments in the 2009/2010 MMP (pg 111), commenced in 2010 but has not yet been completed.

The IM understands that its construction began in late 2010 after cultural approval was obtained, however, work was halted due to the arrival of the wet season (MRM 2010c pg 98). MRM indicated that the fence is to be finished in the dry season of 2011 and that mustering of cattle will need to be carried out. As recommended in the riparian bird monitoring program exclusion of cattle from areas being rehabilitated would greatly enhance their habitat value.

Plate 19 Cattle at the upstream start of the McArthur River diversion at the location where the original McArthur River is met by the diversion channel. Photo: Independent Monitor.

Tailings storage facility seepage, vegetation dieback and rehabilitation of Cell 1
Observations made during the 2011 site inspection indicated that vegetation dieback from seepage on the northern side of the TSF has not increased when compared to the previous year. This may either be due to the long duration of the wet season, which may have diluted the seepage; or effective mitigation measures, including the recovery bore, sump and capping on TSF Cell 1, or a combination of these two factors. The Independent Monitor understands that the TSF is likely to continue to seep for some time and that negative consequences have been observed in fauna downstream in Surprise and Barney Creeks (these are discussed in section 9.7.4).

MRM should continue to regularly visually monitor this area, as well as the entire perimeter of the TSF, to notice any new areas of seepage. Water monitoring at the TSF seepage site, documented as being carried out weekly by MRM (2010c), will be the first method by which increased salt and heavy metals will be detected, but macroinvertebrate monitoring that is carried out annually (as discussed in 9.7.3) may show how seepage is affecting biota more representatively.

Some grasses and acacia species have been established on the clay cover of Cell 1 with limited success, possibly due to poor seed viability. MRM have not undertaken any other revegetation of this clay cap, which is being used as a temporary dust suppression method only, before subsequent layers are added as part of the staged rehabilitation of TSF Cell 1. Given the acid migration upwards an alkaline capillary break will be required underneath the final growing medium.

The Independent Monitor understands that the purpose of the current clay capping on TSF Cell1 is for tailings dust suppression, however wind erosion can still affect the cap during the dry season due to its lack of vegetation cover. MRM have indicated that trials with specific plants and techniques will be undertaken in order to prepare for the rehabilitation of Cell 1, which is scheduled for 2014/2015, after the third and final clay capping is completed (MRM 2010c pg 209, Crawford, J pers. comm. 2011).

Plate 20 Salts from tailings leachate seeping into Surprise Creek. Photograph: Independent Monitor.

Plate 21 Clay capping of TSF Cell1. Photograph: Independent Monitor.

Rehabilitation and monitoring of other areas of the mine site
As stated in commitments in the relevant MMP (MRM 2009b), rehabilitation/revegetation of other areas around the mine, apart from the diversion channels, will be carried out progressively as the areas become available.

The 2010-2011 MMP (section 6.6 and section 8.3.1) provides an estimate of rehabilitation status of the river diversions, bunding at the base of the ROM, portions of the mine levee wall, and the TSF.

Portions of the mine levee wall where topsoil had been placed (documented in the 2010-11 MMP (MRM 2010a), were observed by the Independent Monitor, although no seeding has been carried out to date because rehabilitation of the wall is ongoing (Gary Taylor pers. comm. 2011). The Independent Monitor also viewed the rehabilitated bunding at the base of the ROM pad; this is constructed mainly of rock and is designed to reduce the risk of leakage into the surrounding vegetation. Natural colonisation by grasses and acacias would be sufficient revegetation in this area.

The TSF was inspected in May 2011 and progress is consistent with the rehabilitation estimate; further work of opportunistic grass sowing has been carried out since the MMP was produced.

Details of other areas to rehabilitate, other than the diversions and the TSF, are not very specific in the documents; generally, no timelines are given, presumably due to the fact that MRM are looking to expand their operations in the future and are using most of the areas.

It is understood that the main OEF, which was inspected by two people from the Independent Monitor team in May 2011, is operational and is expected to be so for some time (Taylor G, pers. comm. 2011), but it is not included in the status updates. If it is the case that this OEF will be operational for some time, the Independent Monitor considers that it would be useful to include a dot-point in the rehabilitation estimate in the MMP to indicate this fact. Some smaller OEFs inside the mine bund walls were not inspected by the Independent Monitor except from a small aircraft in May 2011 (Rowles, T, pers. comm. 2011), and they may be due for revegetation, although this is not clear. A sentence indicating what is planned for these smaller OEFs should also be included in the rehabilitation estimate in the MMP.

Topsoil management
A topsoil management section was included in the previous MMP (2009/2010) (Section 7.2.2). More information was provided in the most recent MMP, however there is limited information regarding current topsoil stockpile locations or approximate time of stockpiling for weed management and seed viability purposes (MRM 2010b, section 2.1). The Independent Monitor did not inspect topsoil stockpiles in the 2011 site inspection. Gary Taylor from MRM (2011) described most of the topsoil to be in one location near the OEF and the stockpile is covered with vegetation.

Recommendations for mine site revegetation and monitoring

- MRM should persist with the successful planting of cane grass and freshwater mangroves on the McArthur River diversion as these species have been identified as key habitat plants for riparian birds. At this stage, it is not clear how MRM will achieve a greater number of these species on the diversions—that is, the amount of cane grass that will actually be available for transplanting from future mine pit clearing;
- MRM should focus on achieving a species mixture along the diversions that more closely resembles the original river channels as per commitments in the 2009-2010 MMP (MRM 2009b, pg 38). MRM agree with this recommendation and have indicated that increasing of species diversity will be a focus of attention during 2011 and 2012 (MRM 2010c section 6.8, Crawford, J, pers. comm. 2011, Rehab plan-plant density excel sheet);
- the vegetation monitoring program undertaken by CDU on the McArthur River diversion should be expanded. Currently, samples are collected from a length of only approximately 1.2 km from a total of 11 km on both sides of the diversion, consequently, data from this sampling strategy may not necessarily be representative of conditions along the entire length of the channel;

- comparison of actual data versus baseline and data from analogue sites for Barney Creek should be expanded in the annual revegetation monitoring reports;
- it is stated in the 2009-2010 and 2010-2011 MMPs (MRM 2009b pg 113, MRM 2010c pg 148) that native and exotic grasses will be sown on the TSF for rehabilitation, however, the Independent Monitor recommends against the use of exotic species for rehabilitation;
- MRM should include a status update in the MMP on the major areas to be rehabilitated, such as the OEFs, indicating whether they are still operational; when rehabilitation is likely to commence and which areas have been completed; and
- MRM should provide information, with a map, in the topsoil section of the MMP, describing current stockpile locations, future areas requiring topsoil and from where the soil will be sourced.

9.7.4 Mine site fauna monitoring

Riparian bird monitoring

The riparian bird monitoring and banding program was carried out by EMS (2010d, 2010f) during the 2010 operational period. This program was implemented as a means of measuring the success of rehabilitation on the river diversions as a functioning riparian corridor (EMS 2010f). MRM uses the recommendations provided in the monitoring program as a tool to direct revegetation strategies.

Approximately 56 survey plots at 26 sites are monitored seasonally (EMS 2010f) to assesses the changes in distribution and abundance of riparian bird communities along the diversions and at reference sites. It includes banding of birds to assess the seasonal movement of birds in the mine area, in particular the two indicator species, the purple-crowned fairy wren and the buff-sided robin (also known as the white-browed robin).

This program incorporates rapid vegetation assessments using TRARC (tropical rapid vegetation assessment) at all bird monitoring plots. According to the results of the monitoring, the McArthur River diversion remains distinctly different from the original river and reference sites and provides limited habitat for riparian birds, however, as vegetation matures, this situation is expected to improve.

Purple-crowned fairy-wrens (PCFW) are an indicator species used to assess the effectiveness of rehabilitation of the diversions, however, to date, no PCFW have been found using the diversions as habitat, although Barney Creek diversion has good stands of cane grass and some sections are now similar to the surrounding woodland community (EMS 2010f), so it may be expected that PCFW will begin to use Barney Creek diversion in 2011 (Barden, P, pers. comm. 2011). A family of purple-crowned fairy-wrens was sighted by the Independent Monitor in cane grass in the area between the mine levee and the Barney Creek diversion in the May 2011 site inspection.

Mature stands of riparian vegetation and leaf litter are also important for other indicator bird species. During the Independent Monitor site inspection (2011), in communications with the Paul Barden from EMS, the white-browed robin was identified in riparian bird monitoring reports and the Independent Monitor believes that this bird may be a good indicator of final rehabilitation success on the diversions.

The riparian bird indicator species are suitable species as they are somewhat territorial and they inhabit riparian corridors almost exclusively as they require a specific riparian vegetation structure. Many of the other species of birds banded in previous years have not been re-

captured or sighted again, suggesting that they are more mobile species and may not be as affected by fragmentation.

Fish monitoring
Fish (freshwater sawfish) monitoring was carried out as part of commitments made for Commonwealth Government approval. Fish recaptures in the tagging program have begun to provide information on fish movements (Indo-pacific Environmental 2010a).

Freshwater sawfish (*Pristis microdon*), which are listed as vulnerable under both federal and Northern Territory legislation, were again captured in waterholes upstream and downstream of the McArthur River diversion, with the first recapture of *P. microdon* being recorded in September 2010.

The main recommendation of the fish reports and last year's Independent Monitor report was for the addition of large woody debris into the MR diversion to provide fish habitat. This has been carried out and recorded by MRM (2010c).

In the September 2010 Interim Fish report (Indo-pacific Environmental 2010b) and personal communications with Dean Thorburn from Indo-pacific Environmental, during the May 2011 site inspection, it was indicated that the woody debris is already starting to improve fish habitat. Indeed, the Independent Monitor observed 10 fish species around one of these log jams in the May 2011 site inspection (Plate 23).

Heavy metal analysis in fish and molluscs, as per commitments in the 2009 Water Management Plan (MRM 2009a, pg 97), was reported on for the first time after a number of years of data collection (2005-2009) without reporting. The Independent Monitor is pleased that techniques for future monitoring of heavy metals in fish have been standardised for comparison and interpretation of results in future years.

Although the previous work was not standardised, results indicate that fish near the Surprise Creek TSF seepage area have increased levels of heavy metals. If this emerging trend is confirmed and there are increasing levels of heavy metals in fish, and macroinvertebrates (as discussed below), the seepage will require further remedial action.

During the Independent Monitor's November 2010 visit to the community of Borroloola, it was observed that an MRM freshwater sawfish monitoring sign near the Borroloola boat ramp was in need of maintenance (Plate 22). It is recommended that the conditions of public signs be checked regularly by MRM to ensure their upkeep.

Plate 22 MRM Sawfish monitoring sign requiring maintenance at the Borroloola boat ramp.

Plate 23 Large woody debris along the McArthur River diversion. Photo: Independent Monitor.

Macroinvertebrate monitoring

Macroinvertebrates were monitored by EMS (2010c) in low recessional flows using the AUSRIVAS Northern Territory protocol, a method which compares macroinvertebrate fauna sampled with macroinvertebrate fauna found in similar rivers in the NT that are pristine, or closer to pristine (AUSRIVAS website accessed July 2011). The monitoring program was developed in consultation with what is now the Northern Territory Department of Resources (DoR), EMS and MRM.

There were 23 sites sampled in 2008 and 2009, comprising sites that were potentially exposed to TSF seepage and mine activities; diversion sites and upstream and downstream reference sites. Among the sites sampled were riffle and stream edge habitats, and the sampling program included surface water and fluvial sediment chemistry sampling.

Generally, the surface water and fluvial sediment sampling showed a decreasing gradient of heavy metals and sulfates from sites adjacent to and immediately downstream of the TSF and processing areas, to downstream MR sites (EMS 2010c). This was also generally the case in macroinvertebrate fauna. The 2010c report by EMS states that there is evidence of a gradient of elevated metals, sulfate and other constituents associated with the Surprise Creek, Barney Creek system. Impacts on macroinvertebrate communities are illustrated by significant negative correlations between macroinvertebrate taxa numbers in response to increasing levels of key variables, for example Cu, Pb and SO_4 (EMS 2010c pg 52).

Due to the lack of riparian vegetation, the McArthur River diversion had higher temperatures and turbidity compared to reference sites, but showed a general trend of recovery in downstream reference sites.

The macroinvertebrate monitoring is an important tool for detecting effects on biota from mine operations and should be continued. Macroinvertebrate results are influenced by seasonal conditions, for example large wet season flows decrease evapoconcentration, so multiple years of sampling will be required to produce meaningful trend data.

Recommendations for mine site fauna monitoring

- plant more cane grass on the McArthur River diversion for purple-crowned fairy-wrens;
- exclude cattle to allow rehabilitation;
- continue macroinvertebrate monitoring to gauge effects of mine operations and river and creek diversions on biota;
- continue to monitor and add large woody debris into the diversions as required; and
- improve dust suppression techniques and intercept/stop seepage from the TSF into Surprise Creek to reduce heavy metal and sulfate impacts on biota.

9.7.5 Bing Bong Port flora

Vegetation monitoring on the dredge spoil ponds
Dredging of the shipping channel and disposal of the sediment on the dredge spoil, was carried out in 2009 and again in early 2010 (MRM 2010a).

Opportunistic planting on an area of the dredge ponds was carried out by MRM staff and seven EMU personnel with moderate success. Grasses appear to have naturally colonised the raised spoil areas, however little colonisation was observed on the lower-lying areas of the spoil.

Following recommendations in the Independent Monitor's previous audit, the *parkinsonia* noxious weed biological control trials that were proving ineffective and posing a high risk to weed spread, were immediately halted, however, *parkinsonia* around the dredge ponds was exterminated effectively. Further weed control has been carried out around Bing Bong, in particular targeting bellyache bush *(Jatropha gossypiifolia)* and the Independent Monitor commends MRM as it is possible that the bellyache bush population in the area has now potentially been eradicated (MRM 2010d).

Only highly salt tolerant species such as *Samphires* and *Trianthema sp*. were growing in the area between the dredge pond wall and the spoon drain, where seepage is occurring. This suggests that acid sulfate conditions are possibly occurring, although this has not been confirmed. Surrounding areas that are naturally swampy have a range of species growing such as *Melaleucas*.

Dredge spoil ponds and surrounding vegetation dieback
Vegetation dieback surrounding the dredge spoil, which is caused by saline seepage from the ponds, has been an issue of concern raised by the Independent monitor in previous audits. In 2009, it was flagged as an urgent issue requiring immediate attention under Independent Monitoring Assessment Conditions (IMACs) Section 6.4. In response, MRM constructed a spoon drain outside the dredge spoil walls to redirect saline seepage back out to sea and halt the effects on the surrounding vegetation.

An orthophoto of the dredge pond area, the surrounding dieback area and mangroves was submitted to the Independent Monitor, however no interpretation has been made by MRM (See Plate 24). Furthermore, no formal ground truthing has been carried out to determine the composition of species on the spoil, particularly weeds, or to monitor vegetation dieback of surrounding vegetation.

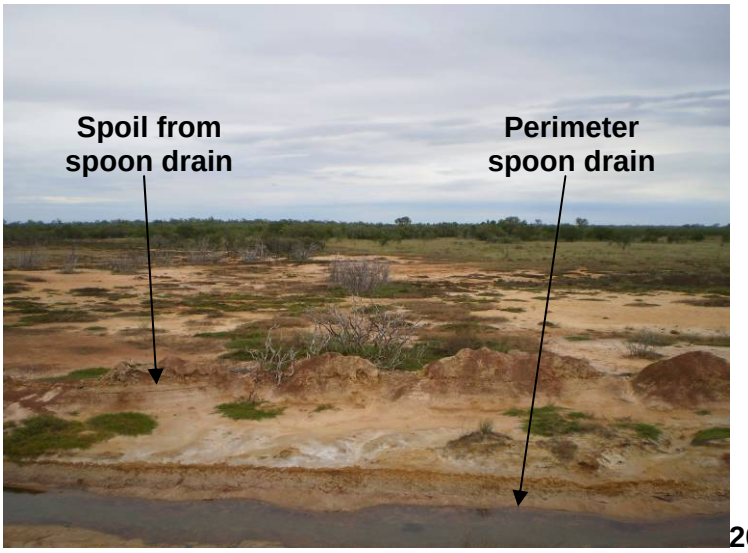
The impact by salt discharge is being monitored by salinity analysis of the soil around the dredge ponds and this should be continued.

Plate 24 Orthophoto of Bing Bong Port facility, sourced from Environmental Monitoring Manual I005 Rev 0, MRM 2010.

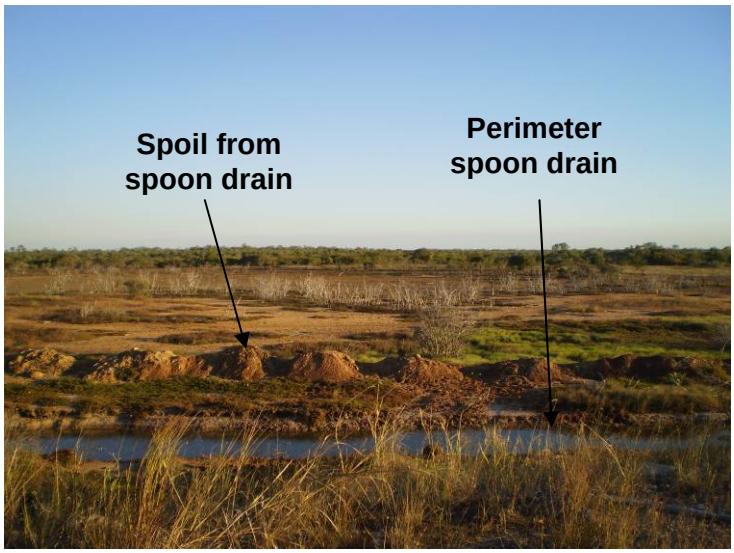
Vegetation has been monitored by visual comparison of aerial photos for the areas of vegetation cover. Differential comparison of critical areas on the photos between years could be used to provide quantitative changes in vegetation cover. Alternatively differential analysis of SPOT or Landsat imagery could be made to show the changes in vegetation cover within the salt impacted areas. Following the acknowledged initial impact, the critical information is that there is no visible change in the vegetation coverage of the area and that data shows a decrease in salinity is occurring.

Ground surveys of vegetation composition on the dredge spoils and surrounding areas need to be carried out as part of the annual vegetation monitoring.

2009

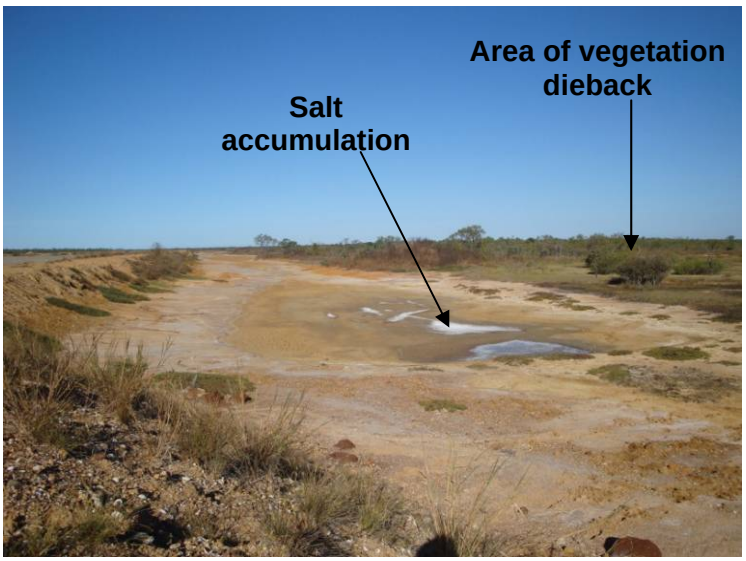


2010

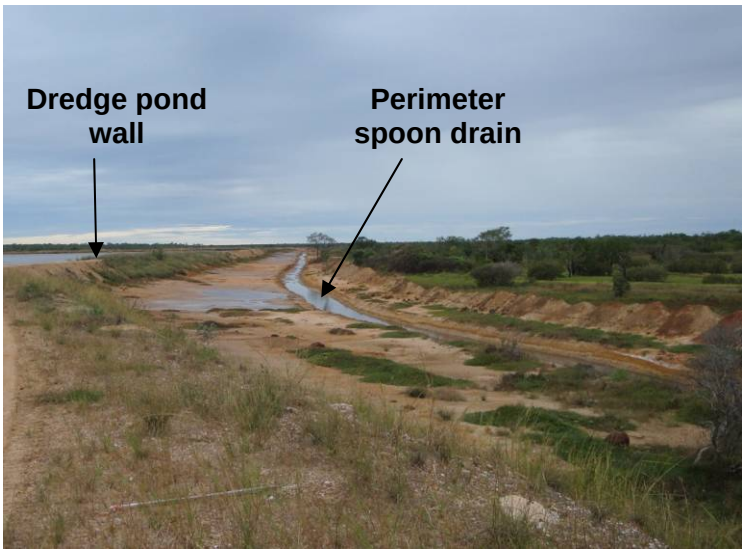


2011

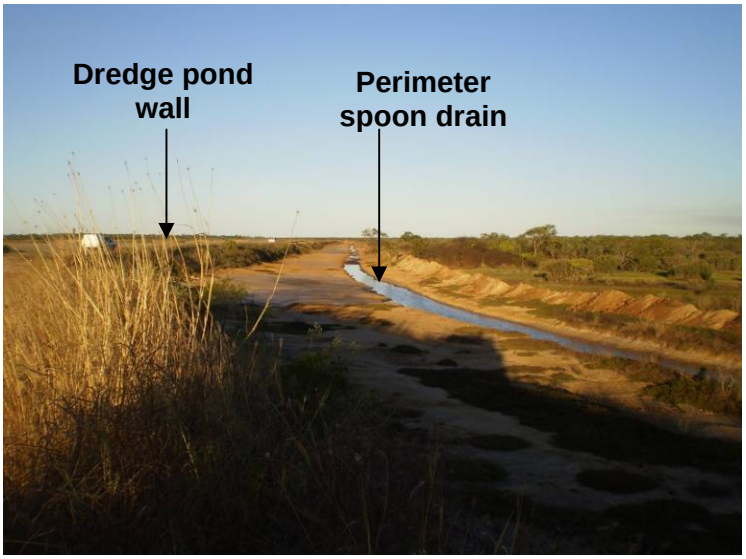
Plate 25 Area of vegetation dieback outside the dredge spoil ponds as photographed in 2009, 2010 and 2011. With the addition of the spoon drain to redirect saline seepage out to sea, vegetation growth has slightly improved since 2009. Photos: Independent Monitor.



2009



2010



2011

Plate 26 Series of photographs taken in 2009 (top) 2010 (middle) and 2011 (bottom), showing the outer toe of the spoil ponds, with the spoon drain subsequently installed to redirect saline seepage. Photos: Independent Monitor.

Dredge spoil rehabilitation trial

A PhD student from Charles Darwin University (CDU) was scheduled to undertake a plot trial study on the site to investigate the potential for future vegetation rehabilitation of the dredge spoils at Bing Bong Port facility. In preparation for this study, MRM had constructed a number of plot trial areas within an area of the dredge spoil, each consisting of shaped areas of swales and higher ridges (See Plate 27). These were inspected by the Independent Monitor during this year's site inspection.

Plate 27 Plot trial area of the Bing Bong dredge spoil, constructed by MRM. Photo: Independent Monitor.

Unfortunately, MRM staff confirmed that the CDU PhD revegetation study did not commence as planned due to the student pulling out. The lack of this vegetation trail created a gap in MRM's monitoring commitments and no firm strategy is in place to rectify this issue, although MRM are aware of the situation and are looking for alternatives such as contracting the work (Taylor, G, pers. comm. 2011).

Bing Bong flora recommendations

- maintain the spoon drain to reduce the risk of saline concentrated seepage causing dieback in vegetation surrounding the spoil;
- create a dredge management plan well in advance of scheduled dredging operations. MRM have been delaying the creation of dredge management plans until just prior to commencement of works. This is of concern to the Independent Monitor as a lead-up time is required to determine and implement best practice management, such as collection and propagation of local seed and engineering works; and
- commission a suitable contractor to commence revegetation studies as well as to interpret and truthify orthophoto vegetation mapping. This should include ground surveys of species composition, dieback areas and reference sites in vegetation studies.

9.7.6 Bing Bong Port fauna monitoring

Mosquito monitoring (MRM and Bing Bong Port)
A mosquito monitoring program has been undertaken as per the mosquito monitoring plan with sampling undertaken once a month in the dry season–May to October–and twice a month in the wet season–November to April. Mosquitoes collected were analysed and reported on by the Medical Entomology Department (MED) in Darwin.

Extremely high numbers of the disease vector mosquito *Aedes vigilax* were collected from traps at the Bing Bong dredge spoil in January 2010 (Plate 28). The annual report by the MED states that "the northern salt marsh mosquito *Aedes vigilax* was collected in numbers likely to cause an extremely high pest problem at Bing Bong during December and January, the catch of 27,040 adult females at Trap Site 2 on 14 January 2010 is an extraordinarily high number for a CO_2 baited trap on a single night".

High numbers of disease vector mosquitoes were again recorded at Bing Bong and around the mine in the wet season of 2010/11 (Department of Health, 2011).

Following advice from the Department of Medical Entomology, insecticides were used in the water runoff pond at Bing Bong Port facility. Also, safety awareness posters were placed around prominent mine buildings

Personal communications with MRM indicate that MRM does not believe that stagnant water in the dredge ponds during the wet season is contributing to the high mosquito numbers (Taylor, G, pers. comm. 2011) and the Independent Monitor acknowledges that MRM cannot control tides or areas outside of the operational areas that may provide vast mosquito breeding zones from time to time.

Following a visit by an expert from the Medical Entomology Department in Darwin to the MRM in March 2011 and the Bing Bong Port facility in July 2011, the subsequent report (Department of Health, 2011), made a number of recommendations with regards to mosquito monitoring and control.

The Independent Monitor agrees that mosquito larval counts carried out at Bing Bong dredge ponds in the wet season would help to determine whether the dredge ponds are acting as breeding areas for high numbers of disease carrying mosquitoes.

The Department of Health, 2011, report also highlighted a number of other areas that may cause ponding of water around Bing Bong such as the point where the spoon drain passes under a culvert north of the dredge ponds and is pooling. Also, the wall of soil on the outside of the spoon drain surrounding the spoil acting as a damn wall for the outer swampy areas. If the dredge ponds do prove to be a source for large numbers of mosquitoes, engineering works are recommended as per the mosquito monitoring report. These works should include making the ponds free draining, and/or removing vegetation from ponds where water will pool. Old tyres should also have drainage holes inserted to prevent them becoming mosquito breeding sites at the waste dump at the mine.

On collection of the six traps, the Independent Monitor noted that at various sites on eight occasions a trap light was not working during the operational period. An email from Alan Warchot (Department of Health) in July 2011, explained in more detail why traps fail and that the percentage of trap failure at MRM is in the normal range.

Plate 28 Mosquito monitoring sites at Bing Bong Port facility. Aerial image from the MRM 2010/11 Mine Management Plan.

Bing Bong macropod study

In response to community concerns raised in previous operational periods, MRM commissioned EMS (2010g) to conduct an investigation into whether MRM operations were affecting agile wallaby numbers in the Bing Bong area.

The Independent Monitor is satisfied that the study carried out addresses this concern and is satisfied with the conclusion that MRM operations are not likely to be affecting agile wallaby numbers in the Bing Bong.

Migratory bird surveys

Following the 2010 operational period, migratory birds surveys were recommenced in line with Commonwealth approval requirements. Surveys were carried out by EMS in February and April 2010 (2010a, 2010b). These surveys, particularly the April 2010 survey, highlighted the importance of the Port McArthur area, east of Bing Bong, as a nationally and globally significant migratory bird staging area and indicated that the Bing Bong Port area is not used by a large number of birds.

In the previous reporting year, the Independent Monitor stated that migratory bird surveys were not useful for the mine operation, however the Independent Monitor does recognise the importance of these surveys for their contribution to the global understanding of migratory birds.

Bing Bong fauna recommendations

- MRM should selectively carry out larval counts of mosquitoes from the dredge ponds in the wet season nine days after a number of heavy rainfall events;
- MRM are to fill in artificial dips where water forms ponds around the mine in the dry season, as described in the Mosquito Monitoring Report (Department of Health 2011); and
- the Independent Monitor recommends against spraying the dredge ponds with insecticide as this may have further negative impacts on other invertebrates and the surrounding environment.

9.7.7 Review of marine biota monitoring

Seagrass monitoring
Results of the 2010 survey of seagrass communities adjacent to the Bing Bong Port facility indicate that the overall seagrass distribution, density and species richness, has increased since the 2009 survey, but has not returned to the levels recorded in 2007.

Laboratory analyses on the seagrass species *Halodule pinifolia*, sampled from three sites along the Bing Bong coast, revealed metal and arsenic concentrations, as well as lead isotope ratios, in leaves and roots, within the ranges reported since 2002 for this and two other species: *S. isoetifolium and H. ovalis*, and do not indicate any impacts from mining.

Heavy metal monitoring in biota
Heavy metals in barramundi and crabs: four barramundi tissue samples were submitted to the lab in March 2011, however, results were not available at the time of writing. No documentation of crab sampling was submitted.

Heavy metals in gastropod molluscs: elevated levels of Pb and Zn attributed to the MRM ore concentrate were recorded in the gastropods *Telescopium telescopium* and *Terebralia semistriata* as well as in surface sediments from the beach immediately west of the load-out facility, however, sediment concentrations were below the ANZECC (2000) Interim Sediment Quality Guideline-Low values and Pb concentrations in *T. telescopium* and *T. semistriata* were below ANZ Food Standard guidelines.

Heavy metals in bivalve molluscs: the Cd, Pb and inorganic As concentrations in two species of oysters; *Saccostrea cucullata* and *Saccostrea mordax*, from the Bing Bong and Sir Edward Pellew Islands sites, were within the range of concentrations measured in the previous annual monitoring programs, which were below the ANZ Food Standards (2009) maximum levels for molluscs.

Marine monitoring recommendations

- future seagrass monitoring should continue to be undertaken at the end of the dry season to avoid confounding associated with seasonal variations—that is fluctuations in extent related to seasonal changes rather than long-term trends;
- inclusion of seagrass control sites beyond any potential influences of the Bing Bong Port operations would provide a more thorough assessment of changes of seagrass distribution and cover within the current study area;
- should a large disturbance to seagrass communities be identified, a post disturbance survey should be conducted in order to assess whether these changes relate to natural disturbances or Bing Bong operations; and
- to avoid confusion, the organisms examined for heavy metal contamination should be referred to as gastropods or bivalves rather than molluscs. Although both groups are molluscs, they are described separately in the Annual Marine Monitoring Report (Parry, 2011a).

9.8 Review of geotechnical monitoring

Geotechnical monitoring associated with major structural works that have the potential to impact the environment performance of the operation was reviewed by the Independent Monitor. This works include the:

- tailings storage facility (TSF);
- overburden emplacement facility (OEF);
- river diversions; and
- the Bing Bong dredge spoils.

9.8.1 Geotechnical review of TSF and water management dam

Table 8 provides an update on the recommendations made in the Independent Monitor's previous audit conducted in 2010.

TABLE 8 UPDATE ON TSF RECOMMENDATIONS FROM PREVIOUS AUDIT

Recommendation/Observation	Update
The TSF Cell 2 should not be used to store excess water.	Excess water is still being stored on the facility, which has the potential to reduce the stability of the embankments and lead to increased seepage and lower tailings densities within the facility. Although a trial to use evaporative fans to reduce the water level is proposed by MRM, additional measures should be investigated to reduce the water load on the facility, such as pumping water to the WMD.
Analysis of the emergency spillway required.	The spillway was raised and reconstructed during the monitoring period. The 2010 Dam Safety Audit indicates that a review of the spillway capacity is being conducted; however, the report detailing this work has not been sighted by the Independent Monitor. It is, therefore, not possible to assess if the spillway has sufficient capacity to discharge the probable maximum flood.
The completion of the clay capping of TSF Cell 1 is recommended to reduce rainfall infiltration.	This capping has been completed with water now being collected within drainage channels and sumps at the surface of TSF Cell 1, and removed to TSF Cell 2. However, MRM have advised that the primary purpose of the capping is to reduce tailings dust generation from the top of TSF Cell 1.
Routine monitoring of phreatic surface within the embankments is required.	A limited number of bores and piezometers have now been installed, although standing water level monitoring is yet to commence. However, we consider the number of piezometers to be insufficient for geographic spread to allow quantification of the phreatic surface throughout the facility.
Freeboard in TSF Cell 2 is inadequate, excess water to be removed or the cell wall to be raised.	Based on the 2010 Dam Safety Audit, the available capacity in TSF Cell 2 is 1 721 ML with a required storage capacity to store a 1 in 200 year event of 2 630 ML. As such, the facility does not currently have sufficient capacity, so the capacity of TSF Cell 2 will need to be increased by the start of the upcoming wet season.

TABLE 8 UPDATE ON TSF RECOMMENDATIONS FROM PREVIOUS AUDIT (CONTINUED)

Recommendation/Observation	Update
Improve the monitoring regime within the facility, in terms of details and scope; including a review of water levels, piezometric data and survey monuments; so that the level of surveillance is in line with the ANCOLD guidelines for high hazard category dams. MRM should commit to transitioning the monitoring program from a qualitative based assessment to a quantitative one.	Some improvements have been made such as the installation of survey monuments and limited piezometers, however these may be insufficient to allow quantitative assessment. The current level of monitoring is well below the standard that is required to allow for a comprehensive assessment of the performance of a high hazard dam. Therefore, there is a risk that the facility is being operated in a manner that is unsafe or may lead to undesirable impacts or failure of the facility.
Determine the safe operating limits for the piezometric levels within the embankment and settlement in the embankment crest.	There is no evidence that this has been conducted and, as only limited monitoring has been installed, it would not be possible to verify that the piezometric levels are below the safe operating limits.

Documentation reviewed
The following documents were reviewed by The Independent Monitor prior to the inspection of the site:

- Tailings Storage Facility Monthly Operating Reports (MRM, 2010-2011)
- Tailings Storage Facility Infrastructure Inspection Reports (MRM 2010-2011)
- Sustainable Development Mining Management Plan (MRM October 2010)
- McArthur River Mine – Tailings Storage Facility (URS, March 2010)
- McArthur River Mine – Stage 1 Design Report for Proposed Raising of Cell 1 of the Tailings Dam (Maunsell McIntyre, 2000)
- McArthur River Mine – Tailings Storage Embankment Inspection Report (Australian Mining Engineering Consultants, January 2003)
- Geotechnical Report on Tailings Dam Raises - McArthur River Mine (Australian Mining Engineering Consultants, June 2003)
- McArthur River Mine – Tailings Storage Facility Dam Safety Review Report (Allan Watson associates, 2010).
- McArthur River Mine – Hydrochemical Investigation of the Tailings Storage Facility (Golder Associates, June 2011)
- McArthur River Mine, OPSIM Water Management Update and Review (Water Solutions Pty Ltd February 2011)

Following a review of these documents the IM noted that no construction reports or as constructed drawings were available for Cell 1 of the TSF facility. This prevents a complete assessment of the facility from being conducted as there is no documentation regarding the material used in construction or the as constructed configuration of the facility.

Only limited data could be found on the construction of TSF Cell 2 to its current configuration, although a construction report for the 2010 spillway raising was reviewed. The IM considers the construction methods and quality assurance testing appropriate for the structure.

The current embankment configuration and embankment crest levels do not match the design embankment levels and embankment configuration shown in the Geotechnical Report on Tailings Dam Raises – McArthur River Mine (Australian Mining Engineering Consultants, June 2003); it is therefore unclear if the current facility complies with the assumption made within the design report.

The Tailings Storage Facility Dam Safety Review Report (Allan Watson Associates, 2010) does not include an analysis of the embankment stability and therefore fails to address the safety of the current facility adequately.

This is a high priority issue that needs to be addressed as soon as possible; however a full and meaningful stability review of the embankment cannot be completed until piezometers are installed to determine the phreatic surface within the embankments. It is therefore recommended that the designer of the facility is contacted; a plan for installation of piezometers is produced, and the installation expedited to allow a comprehensive stability review to be conducted.

Based on the lack of documentation available and inconsistencies between the documents and the actual facility, an assessment of whether the facility is being constructed and operated to the design intent is not possible. The designer of the facility should be contacted and a summary of all design assumptions produced and compared to the actual operating conditions. Should any of the operating conditions, such as the level of water within the facility, be outside of the design assumptions, the design should be reviewed to ensure that the facility can accommodate modified conditions.

The water management model for the site appears to show poor correlation between the modelled water inventory and measured inventory, although this is not identified within the 2011 Water Management Update and Review report. During 2009 and 2010, the model at times underestimated water stored in the facility by between 300 ML to 650 ML or 17% to 24% of total stored water volume. Further work should be conducted to refine the model and improve predictions. The prediction within the model are used to define when the facility's capacity will be exceeded and the large inaccuracy could lead to the facility's capacity being exceeded prior to the predictions made in the model, leading to the uncontrolled release of water from the facility.

Overall, the level of reporting and record keeping for the TSF is poor and well below the standard which would be expected for a high hazard dam. It would be expected that for each stage of construction of the facility, comprehensive design reports and as-constructed reports would be available along with detailed and comprehensive annual safety audit reports. At the McArthur River Mine there appears to be a large amount of data that would be expected but that is not available. It is supposed that the design and construction was supervised by consultants and requests should be made by MRM to these consultants to supply all old design and as-constructed reports to allow future audits to be presented with a complete set of documents and enable them to be fully informed.

Geotechnical site inspection findings
At the time of inspection, Cell 1 of the tailings storage facility had been decommissioned, and rehabilitation of the top surface had commenced. Active deposition of tailings was occurring into TSF Cell 2, with water from the top surface of Cell 1 being stored in the water management dam. An aerial view of the TSF is presented in Plate 29.

Tailings storage facility embankments
The external batters and crest of the embankments of the tailings storage facility were inspected during the audit visit.

The embankments were found to be generally in a good condition with no major erosion requiring remedial works and no obvious signs of major deformation (See Plate 30).

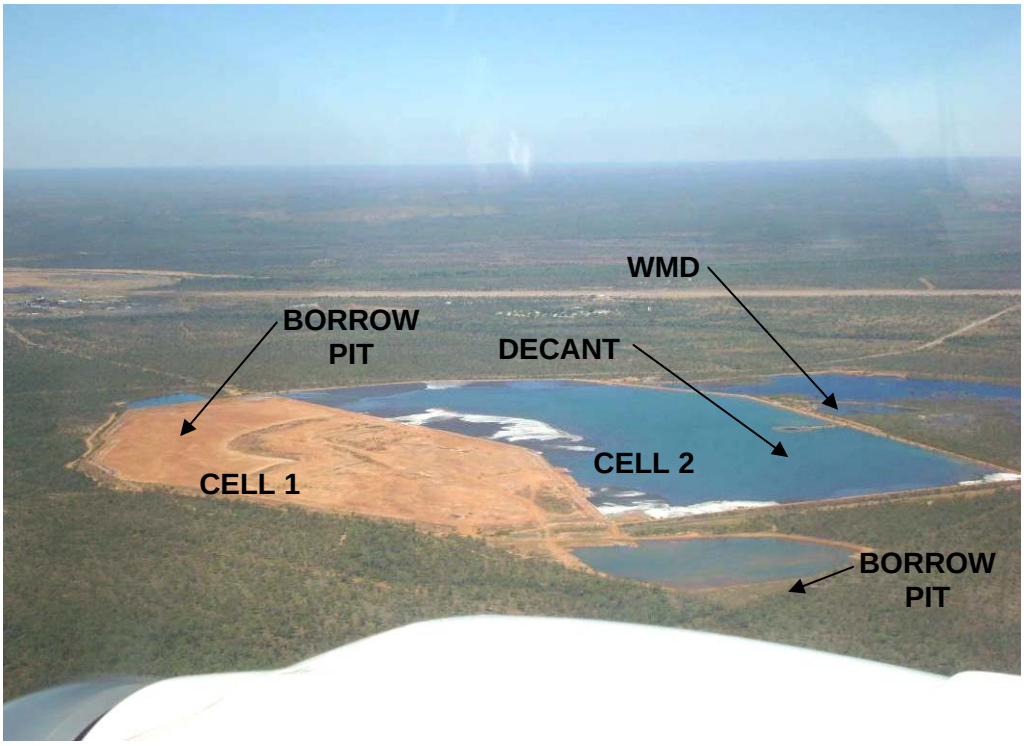


Plate 29 Aerial view of tailings storage facility (TSF) and water management dam (WMD). Photo: Independent Monitor.

Plate 30 General view of embankment crest of TSF Cell 1 showing the embankment crest generally in good condition. Photo: Independent Monitor.

The crest of the embankment was generally in good condition with positive drainage into the facility. Localised erosion and damage caused by traffic over the wet season had been repaired.

For the first time, seepage was observed by the Independent Monitor on the downstream batter along the north eastern margin of Cell 1 adjacent to Surprise Creek. This indicates that water levels in the dam were high against the dam wall this wet season. Seepage was evident from salt precipitation and vegetation die back as well as damp patches along a 25 m stretch of the embankment (see Plate 31). Further evidence of seepage was again clearly visible downstream of the embankment between the facility and Surprise Creek.

Plate 31 Salt precipitation and seepage on TSF Cell 1 Embankment toe adjacent to Surprise Creek. Photo: Independent Monitor.

A geo-polymer cut-off wall and recovery bores have been installed in the area of seepage adjacent to Surprise Creek, but they appear to have had limited effectiveness at reducing seepage. The audit team was also informed that pumping of the recovery bores only occurs during the dry season as infrastructure in the area floods during the wet season (see Plate 32).

In the 2010 Independent Monitor Audit, it was recommended that a quantitative assessment of the effectiveness of the geo-polymer cut-off and dewatering bores was to be conducted. However, although a study on the groundwater chemistry and hydrology was conducted by Golder Associates it failed to address the effectiveness of the geo-polymer cut-off and dewatering bores.

Seepage was observed from the embankment outfall drains adjacent to Surprise creek and inspection of these drains indicated that they were partially blocked by precipitates and salts. Failure to allow free flow of drainage from the embankment drains will lead to an increase in the phreatic surface, which in turn is likely to lead to a reduction in the embankment stability.

A single line of piezometers and monitoring bores has been installed across the north eastern margin of TSF Cell 1 adjacent to where seepage is expressing. Although monitoring of the phreatic surface is yet to begin, these piezometers should be used to monitor the effectiveness of the dewatering bores when they are operating.

Settlement monitoring prisms have been installed on the embankment crest of both TSF Cell 1 and Cell 2, which are scheduled to be monitored on a bi-annual basis.

Seepage was evident downstream of the water management dam (WMD) embankment at the intersection between the WMD and Cell 2. The seepage was evidenced by a large area of wet ground and salt precipitates on the surface. During the inspection, it was not possible to ascertain whether the seepage was from the WMD or Cell 2.

Plate 32 Extensive salt precipitation and active seepage zone downstream of TSF Cell 1 embankment toe adjacent to Surprise Creek. Photo: Independent Monitor.

Embankment geotechnical monitoring recommendations

Additional piezometers and monitoring bores should be installed and monitored around the perimeter of both TSF Cell 1 and Cell 2 to ascertain the level of the phreatic surface within the embankments; this will be required before the comprehensive safety audit can be conducted. A limited number of piezometers have been installed during the monitoring period, however they are limited to a single line across the embankment of Cell 1 and do not provide sufficient monitoring points for a full understanding of the hydrogeological conditions present within the embankment. Phreatic surface or standing water levels were not recorded. It is recommended that at least six lines of piezometers be installed in each of TSF Cell 1 and TSF Cell 2, with vibrating wire piezometers installed within the foundation material and tailings in three boreholes in each line.

A full and comprehensive safety audit of the facility is required which includes a full review of the geotechnical stability of the embankments. This inspection and review would need to assess the location of the phreatic surface within the embankment by the installation of piezometers (see previous comment). Material parameters for the analysis should be defined from the as-constructed records (if available) or from geotechnical investigation of the embankment via core drilling and/or piezoprobe drilling. The stability assessment should include static and pseudo-static analysis and should model the embankment and pond in its current configuration as well as under high water conditions likely to prevail in the upcoming wet season. The results of the analysis should be compared to ANCOLD guidelines for Tailings Dam Design, Construction and Operation to ensure that acceptable factors of safety are achieved—that is, factors of safety under static condition with a high pond should exceed

1.5 and the factors of safety under earthquake loads with a high pond should exceed 1.1. If these factors of safety are not achieved, more detailed dynamic deformation analysis of the embankment will be required to ensure that the facility is geotechnically stable.

Monitoring of the prism should occur quarterly and ad hoc, with the monitoring frequency being increased after significant rainfall events and prior to and immediately after any construction activities. MRM monitoring procedures for the prism should be updated to reflect the requirement to conduct more frequent monitoring.

All seepage outfall drains should be inspected and any that are partially or totally blocked should be cleaned immediately to ensure that free flow of seepage will occur.

Additional seepage control measures adjacent to the Surprise Creek seepage are recommended to lower the phreatic surface and to reduce seepage escaping into the environment. Furthermore, the system should be designed to allow seepage recovery to occur year-round and consideration should be given to a subsurface seepage recovery system with submersible pumps. As evidenced by the seepage occurring at the embankment toe, the phreatic surface in the area adjacent to Surprise Creek is currently higher than previously observed. This phreatic surface is likely to rise during the wet season when pumping is not being conducted. By pumping year-round, it should be possible to permanently lower the phreatic surface within the embankment toe, thereby increasing the overall geotechnical stability of the embankment and reducing the risk of piping failures through the embankment.

A seepage recovery system downstream of the water management dam (WMD) embankment at the intersection between the WMD and TSF Cell 2 is recommended to recover seepage in this area. Based on the topography, it is clear that the area becomes inundated during the wet season and therefore the seepage system should be design to allow subsurface collection of seepage all year round.

TSF Cell 1 inspection geotechnical observations
During the Independent Monitor Audit visit, the top surface of TSF Cell 1 of the tailings storage facility was inspected and found to have been completely covered with a layer of compacted soil. Based on a visual inspection of the soil material, it appears to be a lateritic clayey sand with gravel (see Plate 33). This capping was being conducted during the previous operating period audit and, having now been completed, should act to reduce infiltration of rainfall into the tailings surface and, although it will eliminate fugitive dust emissions from tailings surface, it will not eliminate dust all together.

The surface of TSF Cell 1 was sloped down to the perimeter embankment where a channel was formed to allow water to be directed to a sump at the south-east and north-west limits of the facility adjacent to the divide wall with TSF Cell 2. Silt fences were installed in places across the facility and sumps had been made from which to pump water to the water management dam during the wet season, but no pumping was taking place at the time of inspection. The sumps were also equipped with a spillway to allow excess water to discharge to TSF Cell 2 if/when pumping capacity was exceeded.

Minor scouring of the surface of the soil layer was evident, but no tailings were visible. Localised salt precipitation was visible on the surface, potentially as a result of the capillary rise of salt through the cover system and/or due to evaporation of surface waters off the cover (Plate 33).

A line of monitoring bores has been installed across the TSF Cell 1 surface from adjacent to Cell 2 in the centre of the facility, extending in a line to the bores installed within the

embankment adjacent to the Surprise Creek seepage zone, however, standing water level data was not available.

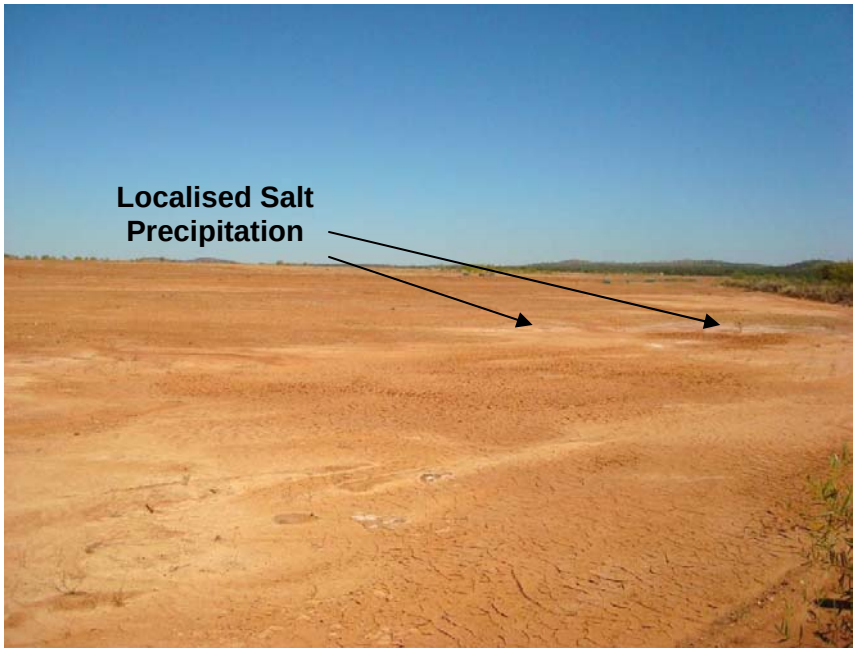


Plate 33 Top Surface of Cell 1 showing soil cover in place, note localised salt precipitation of surface. Photo: Independent Monitor.

Based on the inspection visit, no major concerns or issues from a geotechnical perspective were raised regarding the top surface of TSF Cell 1, however more robust erosion control and sediment collection systems, such as rock, check dams could be considered if continuing scouring of the top surface occurs.

TSF Cell 2 inspection geotechnical observations
During the inspection, TSF Cell 2 was being used for active tailings deposition, with deposition concentrating on the west and east wall of the cell. Deposition is via spigot deposition with the spigot rotating to deposit thin layers of tailings, which is in line with the design intent.

As evidenced by deep desiccation cracking on the tailings beach, good drying and desiccation of the tailings beach is being achieved (See Plate 34).

A very large supernatant pond has developed in TSF Cell 2 with the pond directly against the southern embankment for the full length of the southern embankment (see Plate 29). This large pond reduces the area available for sub-aerial deposition of tailings with a larger proportion of the tailings sedimentation occurring in a subaqueous environment. Subaqueous deposition normally results in lower density tailings and steeper beach slopes, which may impact on the available capacity within the facility. This large pond will increase the phreatic surface within both the tailings beach deposits and potentially within the embankment and foundation materials, which could lead to a reduction in the stability of the cell wall. Furthermore, the large pond and high phreatic surface will apply a greater driving head which may result in increased seepage from the facility, either through the base of the cell or through the embankments.

Plate 34 Desiccation of deposited tailings on beaches in TSF Cell 2. Photo: Independent Monitor.

At the time of inspection, the water level in the facility was sitting at approximately 47 m RL, while the maximum water level reached during the 2010-2011 wet season was approximately 47.7 m RL. It was noted that the crest of the spillway is at 48 m RL.

In previous audits the spillway apron had active seepage, so this was inspected and the construction report of the repairs to the spillway reviewed. Repairs to the spillway appear to have eliminated this seepage and no issues with the concrete spillway were noted (Plate 35).

To raise the spillway invert to a level of 48.5 m RL to provide additional freeboard capacity during the 2010-2011 wet season, a temporary bund has been constructed in the concrete spillway from soil surrounded by geo-fabric (see Plate 36).

Open seepage collection drains have been constructed along the east and west downstream toe of TSF Cell 2, these drains both contained significant water at the time of inspection (see Plate 37 and Plate 38).

A large pond of water was present to the north-west corner of TSF Cell 2 at the start of the Little Barney Creek diversion (see Plate 39).

There was no bunding on the ramp between TSF Cell 1 and 2 of the tailings delivery pipeline and return water pipeline.

Plate 35 Concrete spillway apron where seepage was noted during previous audit. No seepage was visible during the inspection. Photo: Independent Monitor.

Plate 36 Temporary bund in spillway constructed of soil covered in geofabric. Photo: Independent Monitor.

Plate 37 Western seepage collection drain at toe of TSF Cell 2. Photo: Independent Monitor.

Plate 38 Eastern seepage collection drain at toe of TSF Cell 2. Photo: Independent Monitor.

Plate 39 Pond at inlet to Little Barney Creek diversion to north-east of TSF Cell 2 and upstream of the water management dam. Photo: Independent Monitor

TSF Cell 2 geotechnical recommendations

The construction of the temporary bund which has been placed in the spillway reduces the capacity of the spillway to discharge water under extreme rainfall events and increases the risk of an embankment overtopping event which could lead to a catastrophic failure of the facility. Therefore, this temporary bund should be removed immediately and should not be replaced under any circumstances.

Excess water should be removed from the facility. MRM have committed to the commissioning of evaporative fans as a trial to increase evaporation from the facility to accelerate removal of water (Verbal communication: Sam Strohmayr, metallurgy manager MRM). According to the design documents reviewed, the volume of water currently stored in the facility is higher than the design assumptions. Storage of excess water on a tailings storage facility not specifically designed as a water retaining facility is considered to be a high risk operation which can lead to embankment instability. Available storage capacity is currently available in the water management dam (WMD) and consideration should be given to rapidly pumping the water out of TSF Cell 2 into the WMD where evaporation trials can be conducted without the risk of storing excess water in TSF Cell 2 for extended periods.

A review of the design documentation indicates that the stability of the embankment may be compromised by having the pond directly against the external southern wall. All the stability assessments which could be found in the design reports show a tailings beach at the embankment, with the pond level adjacent to the embankment lower than was observed in the site inspection. It is questionable if the embankments constructed upstream, which do not have filters or seepage control features, are designed as water retaining embankments and would be capable of storing water directly against them without their stability and integrity of being compromised. To rectify these issues, the following should be undertaken as a high priority:

- installation of piezometers along the southern embankment to fully define the location of the piezometric surface within the embankments;
- a full design and stability review of the southern embankment; and
- consideration should be given to relocating the decant pond to the common embankment between TSF Cells 1 and 2, where the increased phreatic surface will less likely effect the stability of the embankment as it is supported by the tailings stored in TSF Cell 1. Furthermore this would allow any embankment raises along this common wall to be easily designed as water retaining embankments with appropriate design features such as filter drains and drainage blankets incorporated.

Prior to the imminent wet season, a full review of the water balance model and storage capacity of the facility is required to ensure that sufficient capacity is available within the facility to store all tailings and waters during the wet season. To perform this work a clear understanding of the geometry of the tailings surface below the pond will be required, which may require a bathymetric survey of the facility. Although an annual review of the water balance using the software OPSIM has been conducted, it shows that the model at times underestimates the volume of water within the facility, therefore a better calibration of the model is required before it can be used to assess available storage in the facility.

Both the open seepage collection drains and the ponding at the inlet to Little Barney Creek will act to raise the phreatic surface at the toe of the facility as surface runoff and rainfall cannot flow away from the facility but it ponds and then percolates into the ground at the toe of the facility, possibly leading to reductions in the stability of the embankment. Consideration should be made to the replacement of the open drains with a subsurface drainage and collection system. Furthermore, the viability of eliminating the pond at the Little Barney Creek diversion inlet should be assessed.

The pipelines on the ramp onto the TSF should be in a bunded corridor or be placed inside a double containment pipe to ensure that any tailings or fluid release due to main pipeline failure can be directed to a suitably sized sump to prevent release into the environment.

Water management dam (WMD) geotechnical inspection observations
At the time of the inspection the embankments of the WMD were observed to be in generally good condition with no visible sign of deformation or any erosional features which would require remediation.

In the WMD, the pond was at approximately 40.5 m RL at the time of inspection and the water level in the facility was dropping at a rate commensurate with evaporation. MRM plans to construct bunding within the facility this dry season to increase the surface area and increase evaporation rates to reduce the stored water volumes (Verbal comm. Sam Strohmayr, metallurgy manager MRM).

Two spillways were inspected, one of which was a concrete lined spillway and the second was excavated to bedrock. Both spillways had an invert level of 42 m RL and were in good condition. There was a pumped decant and a siphon discharge system installed in the water management dam but, at the time of inspection, they were not being operated (see Plate 40 and Plate 41).

There are two waste disposal sites located in the WMD; one for disposal of putrescible and general waste, where the waste is burnt prior to being dozed into an excavated cell; the second is for disposal of potentially contaminated waste such as rags, old plant components and reagent containers. The general waste dump area was in good condition, however the potentially contaminated waste area was partially submerged and had limited access. This

was in a similar condition during the 2010 inspection. It should be noted that water running over waste material promotes/accelerates leaching and leachate migration.

Plate 40 Siphon discharge system at WMD. Photo: Independent Monitor

Plate 41 Pumped decant system at WMD. Photo: Independent Monitor.

9.8.2 Review of overburden emplacement facility (OEF) geotechnical monitoring

The overburden emplacement facility (OEF) is a constructed facility where waste rock or overburden from the mining operation is placed once it is extracted from the pit. These rocks are classified as potentially acid forming (PAF) because natural sulfides in the rock have the potential to cause acid leachate when combined with water and oxygen. Therefore, it is important to limit exposure of PAF to these elements and control/manage any acidic leachate that may be produced. This is primarily managed through the design, monitoring and appropriate classification of the materials that make up the OEF into clay liner, non acid forming (NAF), and PAF.

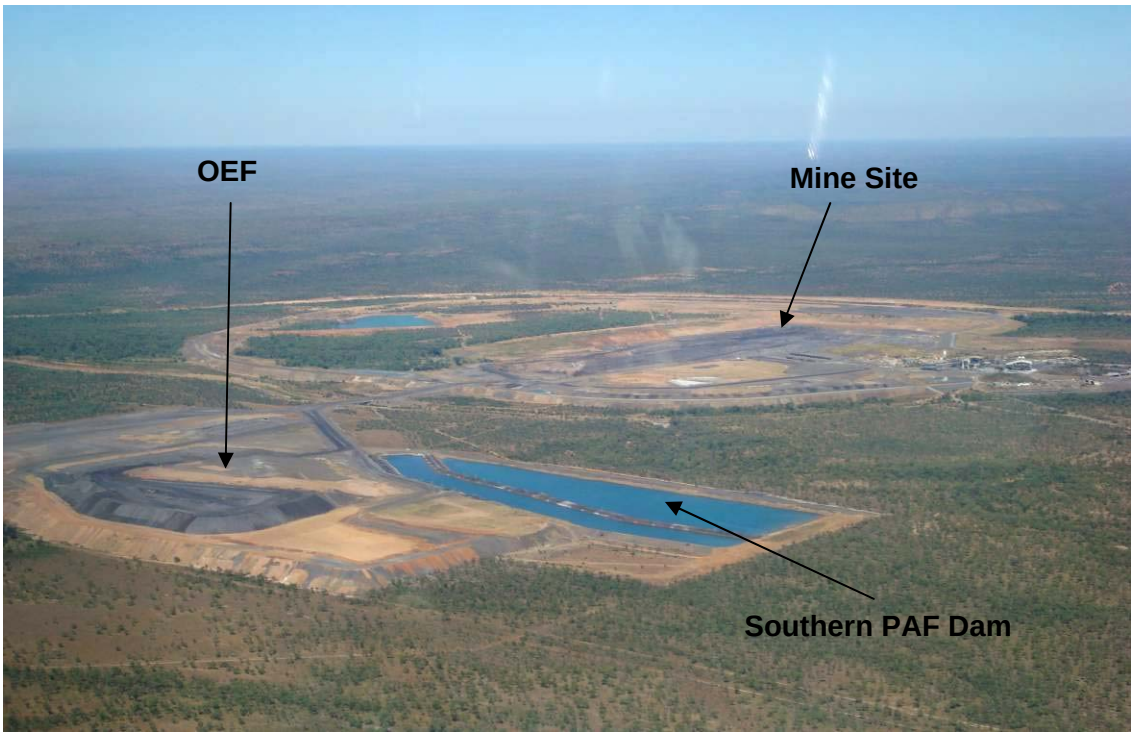


Plate 42 Aerial photograph of the OEF, southern PAF dam, and mine site. Photo: Independent Monitor

Table 9 provides an update on the recommendations made in the Independent Monitor's 2010 audit, regarding geotechnical recommendations concerning the OEF.

TABLE 9 UPDATE ON OEF RECOMMENDATIONS FROM PREVIOUS AUDIT

Recommendation	Update
Implement with a matter of urgency a QA/QC program as per the URS design report, to ensure the Overburden Emplacement Facility clay liner is being constructed in accordance with the design to avoid future potential complications.	The QA/QC monitoring program for clay placement remains very poor and below a standard that would considered a suitable level for a facility designed to store material with a high contamination potential. Although some data is available, it shows poor quality construction control and the data is insufficient to fully assess if the facility is being constructed to the design intent. This recommendation is reiterated in this 2011 audit and improvement in the clay placement and quality control should be made as soon as practical.
For all future cell construction, ensure that the clay liner is placed under Level 1 Supervision, or develop a method specification in conjunction with URS that allows for minimal supervision and testing of the liner construction. Method specifications are developed through the use of trial programs and quantitative testing. Through these trial programs a standardised placement method is developed, that meets the design specifications.	Based on the number of test results and the poor construction quality, the level of supervision could not be considered Level 1 Supervision. During the site inspection and discussions with MRM staff, there was no indication given that a method specification has been adopted. This recommendation is reiterated in this 2011 audit and improvement in the clay placement and quality control should be made as soon as practical.

Documentation reviewed
The following documents were reviewed by the Independent Monitor prior to the inspection of the site:

- McArthur River Mine – Overburden Emplacement Facility (OEF) Design (URS, July 2008);
- Monthly Monitoring Reports (MRM 2010-2011);
- Weekly Monitoring Reports (MRM 2010-2011); and
- Clay Sampling Testing Results (Various Laboratory Report 2010-2011).

No construction reports or as-constructed drawings for the facility were available to the IM this audit. This prevents a complete assessment of the facility being conducted as there is no documentation regarding the material used in construction or the as-constructed configuration of the facility. MRM have since advised that as built data for the OEF is available, but it requires *Vulcan* software for viewing (not currently available to the IM). The IM will aim to attain this data next audit for review. It is recommended that in future, a standalone monthly QA/QC report for all construction work at the OEF is compiled to include results of all testing conducted, location of tests and details of how non-conforming areas have been treated/reworked with secondary testing results clearly defined to show that the non-conforming areas were brought within specification prior to placement of PAF material over these areas. Furthermore, at the completion of each construction season an annual construction report should be produced which contains all data collected during the construction season, including soil testing results, survey data, design modification and field engineering changes.

As there is no detailed technical specification for the construction of the facility, it is not possible to ascertain how many of the construction control tests are actually meeting the

required specification, or if testing is being conducted at the frequency intended by the designer. A detailed construction technical specification is required for the facility. This should be produced by the designer of the facility and should be reviewed annually by the designer to ensure that the specification can be met and the meeting the specification results in the facility operating as per the design intent.

Clay sampling reports are limited to laboratory test reports and information as to where the samples were collected is not provided. Furthermore, the compaction test results do not indicate if the material meets specification or if any of the areas tested, which were deemed to have failed to meet the specification, were reworked to meet the specification. The test location should be recorded either by a hand held GPS or surveyed and the laboratory reports should contain details of the required specification, with all data to be summarised in a monthly report.

Only 15 *in-situ* compaction and moisture content test results could be found in the documentation supplied, of these eight test results, that is over 50% of all tests, indicated that compaction was at or below 95% of the standard maximum dry density, which indicates that low densities were being achieved within the clay liner. In addition, the moisture content of seven of these tests was less than two percent below optimum moisture content, potentially indicating that the material had been compacted dryer than optimum moisture content, which will have resulted in a higher permeability of the material than if it had been compacted around or above optimum moisture content. The results of the tests which were available to the auditors indicate that very poor quality control is being applied to the construction of the OEF clay liner, and the liner may not perform as per the design intent. Any areas of clay which are still exposed and have recorded low densities or low moisture contents should be reworked prior to placement of PAF waste.

Monthly geotechnical reports were not reviewed or requested for the months after January 2011, as this is outside the review period for this IM audit.

OEF site inspection geotechnical observations
The inspection of the OEF included viewing the asset from a distance and an inspection of the top surface and tip head.

At the time of inspection, no clay liner or NAF base was being placed or compacted at the OEF but active end dumping of PAF material was being conducted from the crest of the OEF. No paddock dumping in advance of the end dumping of the PAF waste was observed.

A large area of NAF base and clay base liner had been constructed so that it extended several hundred meters from the front of the active tip face. At the time of inspection, the clay was exposed to the elements and, therefore, likely to be desiccating (see Plate 43). A large area of clay cover on the western batter of the OEF was exposed to the elements. This clay cover showed signs of erosion and gully formation where rainfall runoff had been flowing over the clay cover.

The clay cover on the batter is being constructed at a slope of 1V:4H and approximately 40% of the southern batter of the OEF had a layer of NAF waste placed over the clay cover.

Some clay covering had been placed on the top surface of the OEF (Plate 44) time of the site inspection; however, much of the surface PAF material was still exposed.

Plate 43 Prepared basal NAF layer and clay liner layer at OEF, as viewed from the top surface of the OEF. Photo: Independent Monitor

Plate 44 Top surface of OEF (PAF waste in foreground and an area clay covering in the background). Photo: Independent Monitor

Recommendations for OEF geotechnical monitoring
Consideration of a redesign of the overall construction philosophy for the OEF should be made to facilitate construction from the base up. The base-up construction method, which is considered best practice for management of PAF waste rock, disposes of the waste by paddock dumping, thereby reducing segregation of the PAF waste and eliminating the coarse rubble zone at the base of the tip head. The coarse rubble zone formed by end tipping allows the free flow of oxygen into the centre of the waste dump, which increases the rate of sulphide oxidation deep within the dump. Further, by using base-up construction, the cover on the external batters can be constructed in horizontal layers, which makes the construction and management of quality control for the cover simpler and more effective.

Exposure of the completed basal clay liner to the elements should not be allowed, this has the potential to desiccate the clay, leading to cracking which increases in permeability of the clay. To prevent desiccation of the basal clay liner, a layer of NAF base should be immediately paddock-dumped over the completed basal clay liner, as specified in the design report.

Similarly, exposure to the elements of the completed clay cover on the batters should not be allowed as this has the potential to desiccate the clay, leading to cracking, which increases in permeability of the clay. In addition, the exposed clay on the batter is susceptible to erosion during rainfall events. A layer of NAF waste should be immediately dumped over the completed clay cover on the batter to protect the cover.

When the OEF reaches the design height, and prior to each wet season, if best practice management is to be implemented, MRM would need to construct a cover on the top surface to minimise infiltration of rainfall and runoff into the PAF waste. A cover design should be evaluated and tested well before the cover needs to be constructed.

9.8.3 Geotechnical review of river diversion channels and structures

A construction report–*Levee & diversions, McArthur River Mine Expansion Project, Xstrata* Zinc (Connell Hatch 2009), was reviewed for this audit assessment.

A review of the document indicates that the construction report is a high quality report containing sufficient details of the construction activities conducted for the channels to allow the channel to be fully inspected and assessed.

The Barney Creek diversion and the McArthur River diversion were inspected as part of the Independent Monitor visit.

From a geotechnical perspective, the Barney Creek diversion was generally in good condition (see Plate 45), however, minor batter erosion was evident in the Barney Creek diversion upstream of the bridge to the OEF (see Plate 46). The erosional feature in the Barney Creek diversion, which was reported in the previous audits, had been repaired satisfactorily with large rock placed to limit the likelihood of ongoing erosion.

From a geotechnical perspective, the McArthur River diversion was also in generally good condition, (see Plate 47 and Plate 48).

Plate 45 Barney Creek diversion channel. Photo: Independent Monitor

Plate 46 Barney Creek diversion channel upstream of bridge to OEF; note minor erosion of the batters. Photo: Independent Monitor

Plate 47 Plate 18: McArthur River diversion 100 m downstream of inlet. Photo: Independent Monitor

Plate 48 McArthur River diversion 500 m downstream of inlet. Photo: Independent Monitor

Minor erosion that had occurred near the inlet to the McArthur River diversion channel was observed where surface water flows from the old river channel alignment into the diversion channel. Remediation of this erosion and reshaping of the area had been completed.

Minor erosion of top-soil from the pit bund was visible where surface water flows from the old river channel alignment into the diversion channel (see Plate 49). Minor localised erosion was also evident at various locations along the channel where loose un-cemented soils were exposed in the diversion channel batter slopes (see Plate 50 and Plate 51).

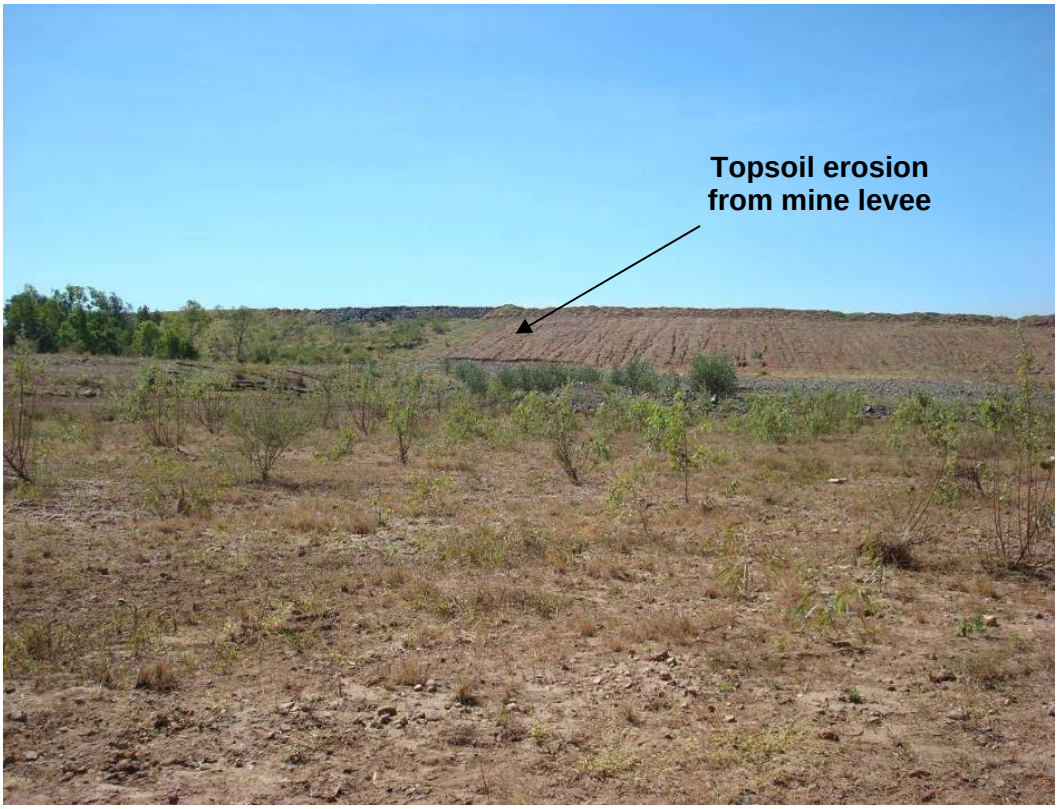


Plate 49 View of mine levee showing erosion of topsoil along base. Photo: Independent Monitor

Plate 50 Minor erosion of McArthur diversion batter. Photo: Independent Monitor

Plate 51 Minor erosion of McArthur diversion batter. Photo: Independent Monitor

Based on the site inspection of the diversion channels, no major geotechnical issues were noted. The extent of the erosion which was observed did not merit rehabilitation as the system should be dynamic with minor erosion and sediment deposition within the channels considered to be acceptable. Replacement of topsoil along the bund walls is probably not warranted as it is likely to be remobilised in subsequent flooding and a more resilient outer facing such as rock fill would be more appropriate. This has been recommended in previous Independent Monitor Audits.

Ongoing monitoring of the diversion channels is being undertaken, with MRM conducting regular visual inspections as part of rehabilitation works and photographic surveys conducted for both sides of the channel.

Further review of the hydraulic performance of the river diversion is provided in section 9.10.

9.8.4 Bing Bong Port dredge spoil geotechnical review

The following documents were reviewed by the audit team prior to the inspection of the site:

- Bing Bong Dredge Monthly Inspection Reports – (MRM 2011); and
- File Note 8 April 2011 – MRM.

A review of the document indicates that inspection may be spasmodic as reports were not included for all months of the operating period. However it was encouraging to observe that additional inspections were conducted after major rainfall events (File Note 8 April 2011). No design document for the dredge spoil facility was included in the data package supplied to the independent monitor and therefore it is unclear if any geotechnical design or construction specification was produced for the facility. Requests from previous independent monitor audits have not yielded design or construction documentation for the dredge spoil ponds. It is apparent that the construction was undertaken by experienced operators without any design drawings. Further, the construction method appears to have consisted of scraping soil from the existing local material to create bunds.

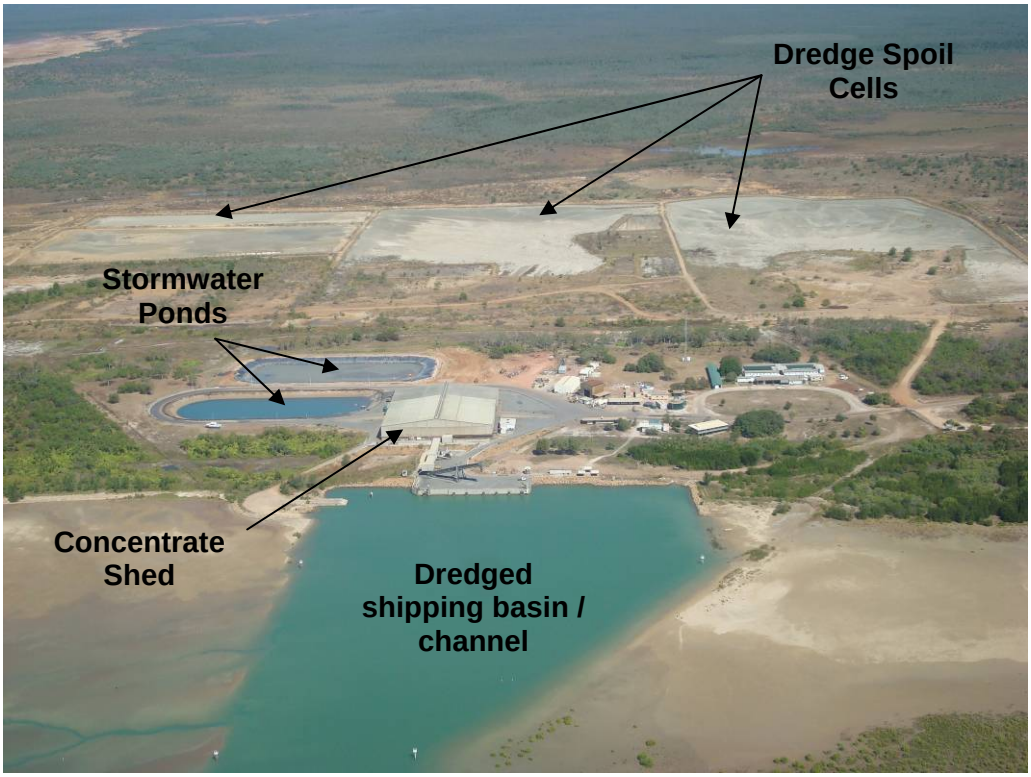


Plate 52 Aerial view of the Bing Pong Port facilities, facing south west. Photo: Independent Monitor

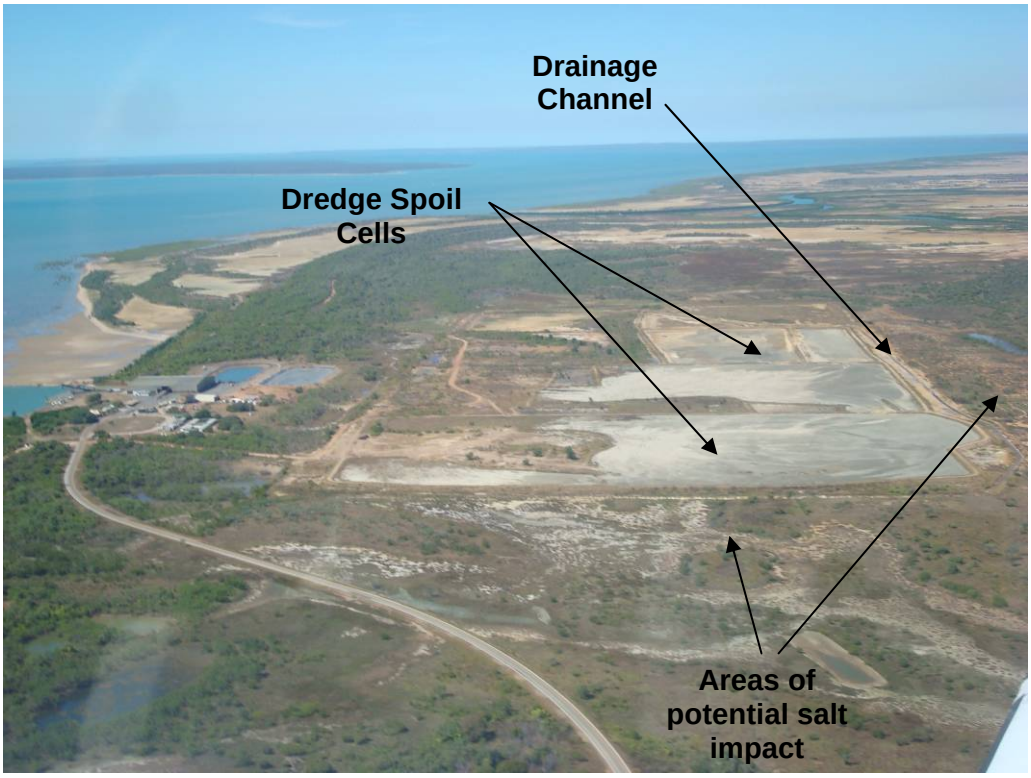


Plate 53 Aerial view of the Bing Pong Port facilities, facing south east. Photo: Independent Monitor

Plate 54 Erosion of dispersive embankment fill at the dredge spoil cells. Photo: Independent Monitor

Plate 55 Lateral drainage channel at the dredge spoil cells. Photo: Independent Monitor

As noted in the previous Independent Monitor report, it is apparent that the dredge ponds were not constructed to a design and are simple earth walls scraped up from surrounding material (Plate 54), with the result that the bunds that were created are permeable and highly dispersive. The dredging together with the annual wet season has resulted in a high local

groundwater table that disturbs the natural drainage regime and impacts vegetation. Due to the nature of construction, surveillance and constant maintenance is required to ensure the ongoing integrity of the ponds.

It is recommended that piezometers be installed around the facility and that survey monuments are installed on the embankment crest, both the piezometers and survey monuments should be monitored at least quarterly as well as after heavy rainfall events.

The existing drain around the facility needs to be cleaned out to allow the free flow of water (see Plate 55). In addition, an engineered spillway should be designed and constructed to allow water to be drained out of the ponds in a safe manner after prolonged or heavy rainfall or dredging activities.

MRM have since advised that further works have been planned for September 2011, which include the stabilisation of the walls and reinstatement of the perimeter drain where required.

9.8.5 Conclusions and recommendation

The following conclusions were reached and recommendations made in the Independent Monitors Audit in 2010:

- establish a geotechnical monitoring program for the Bing Bong spoil dump. This program should identify potential failure locations and establish a timetable for remediation works; and
- develop a method of removing the stored water in the dredge spoil dump in order to mitigate the risk of overtopping and reduce the head driving the saline seepage into the surrounding environment.

If further dredging is required, review the suitability of the containment structure. Although no dredging has been conducted since the previous audit, this recommendation is still in force should future dredging be required.

To assist MRM in achieving these objectives, the key recommendations which require immediate attention are listed in Table 11 (Section 11). Other geotechnical recommendations made in this section can be completed as part of on-going site improvement and do not require immediate attention.

9.9 Review of geochemical monitoring

9.9.1 Review of OEF geochemical monitoring

Currently waste rock is being actively placed in the north overburden emplacement facility (OEF). Potentially acid forming (PAF) waste is segregated and stored separately from the non acid forming/acid consuming (NAF/AC), waste which is used as encapsulation material.

MRM have advised that waste classification is undertaken based on the waste ‘block model’, which was developed based on geological logging and interpretation of stratigraphic units. This model is used as the basis for identification of NAF and PAF by pit technicians utilising the Daily “Dig” map for each bench within the Pit, and once blasted, the material is visually checked for classification. While the IM acknowledges the skill and geological knowledge of the MRM Pit geologists, the IM considers that this visual method presents the potential for misclassification of material.

Notwithstanding, the following waste identification and management procedures are implemented.

The waste rock characterisation at MRM is based on the geochemical assessment of diamond drill core samples from the 2002 feasibility drilling—35 holes for 1106 samples—that specifically targeted hanging-wall and footwall waste lithologies. Most samples were quartered HQ3 or HQ core, sampled and composited over five metre lengths within already identified geological domains associated with the host rock containing the HYC mineralisation (Gary Taylor MRM, memo 5 June 2009).

In the initial acid base assessment these samples were analysed for total S%, sulfate, total C%, pH, ANC, NAG4.5, NAG 7.0, to develop the acid base account (ABA) and metals: Pb, Zn, Cu, Fe, Ag, Al, Cd, Tl and Mn; to identify the potential composition of any metal leachate that may be generated through weathering of the out of pit placement of the overburden or waste rock.

URS documented the geochemical characteristics of potential overburden generated from the proposed open-cut and developed the management strategies for overburden placement. In 2007, seven follow-up HQ diamond holes—355 samples—specifically targeting hanging-wall lithologies, were drilled to infill gaps in the "overburden geochemistry knowledge" in the 2002 database. The aim of the drilling program was to increase the data density and improve the reliability, validation, of the block model in the hanging-wall waste domains. The 2002 sampling and analysis criteria were applied to the 2007 drill holes, although they were never used as part of the ongoing URS kinetic leach column studies.

Using samples from the 2002 drilling program, kinetic leach column studies were conducted by URS from 2002 to 2007. A total of 29 columns form the basis of the kinetic database for overburden and tailings geochemistry. The data is summarised in Table 10.

In 2005, URS submitted their final report on "Geochemical Assessment of Overburden and Tailings Materials Including Conceptual Design of Overburden Emplacement Area". This report listed the results for nine columns that were maintained for a period ranging from 11 to 24 months duration.

In November 2007, URS submitted the Stage 5 Project Review of the Kinetic Leach Column Project and updated and refined their conclusions from the 2005 report, namely:

Hanging-wall lithologies:

- **upper pyritic shale:** high metal and sulfate concentrations in leachate; brackish to saline EC; acidic pH; high total sulfur; moderate ANC; and was classed as **PAF**;
- **bituminous shale:** some metal exceedance: Cd and sulfate; increasing EC; low pH; high total sulfur; moderate ANC; and was classed as **overall PAF**;
- **lower pyritic shale:** some minor metal exceedance: Se and sulfate; slightly brackish EC; neutral pH; low to high total sulfur, high ANC; and was classed as **NAF.**

Footwall lithologies -

- **lower dolomitic shale:** low metal and sulfate concentrations in leachate; low EC; neutral pH; elevated to high total sulfur; elevated to high ANC; and was classed as **NAF**; this unit appears to be footwall and immediately adjacent to the ore-body and has elevated sulfide sulfur concentration;

- **W-fold shale:** low metal and sulfate concentrations in leachate; low EC; neutral pH; low total sulfur, minor elevated total S concentration; elevated ANC ; and was classed as **NAF**; and
- **Teena dolomite:** low metal and sulfate concentrations in leachate; low EC; neutral pH; very low total sulfur; high ANC; and was classed as **NAF.**

The overburden emplacement facility design for managing PAF waste rock was developed by MRM/URS and comprises:

- construction of a NAF/AC base capped by a clay seal to form the foundation of the PAF cell;
- PAF waste is dumped within the PAF cell;
- clay is loosely dumped to form outer walls of the PAF cell (5 m thick);
- the top of the PAF cell is a 0.6 m thick compacted clay layer;
- the flat surfaces of the cells and bases are sloped toward the PAF pond; and
- NAF/AC waste forms the 20 m thick rock armouring of the placed clay wall of the PAF cell.

The placement of clay is designed to reduce/limit/minimise infiltration of rainfall that can transport any weathering/oxidation products generated by the placed PAF material that is covered by the clay.

Some fundamental components of a successful design for containment for the PAF waste include the:

- NAF/AC waste must be correctly characterised and identified in-pit prior to placement on the OEF to ensure release of metals, sulfate and acidity from the placed OEF is minimal;
- PAF waste is covered prior to the wet season to limit water storage within the PAF cell; and
- clay layer is armoured prior to wet season to minimise erosion and exposure of the underlying PAF material.

Table 10 provides a summary of the material used in the kinetic test work. The total sulfur content is variable from negligible to 20% S. The review of the kinetic test work found that some of the material classed as NAF may be borderline PAF at the best and may need to be reclassified as PAF. Note the colour scheme in the Table is arbitrary.

9.9.2 Recommendations for waste rock management

The design of the northern OEF, in particular the PAF cell, is supported, although it is a bold attempt to solve the problem of reducing rainfall infiltration in an active waste rock dump during construction. Observations indicate that a review of rock classifications is required as well as some modification to procedures if the goals for the containment and minimisation of acid/metal/sulfate leachate generation from the OEF and similar structures during mining and post mining, as set out in the design of the OEF, are to be achieved.

A review of the classification of NAF waste is required as the sulfur content is very high—often >5% total S. This material generates a neutral pH leachate, but with high sulfate and metals caused by an acid drainage reaction. Due to the low solubility of the carbonates, the acidity from metal sulfide oxidation precedes the dissolution of the neutralising carbonate. There is also the potential for bypassing of the neutralising mineralogy.

There is also a need to review the mineralogy of the NAF, PAF and AC waste to determine what minerals are present, including carbonates, dolomites, sulfides and sulfates. It is noted that there are a lot of carbonate nodules present in the host rock sequence and the lead zinc deposits are known to contain siderite and manganese siderite. Both these carbonates are net neutral, therefore it is possible that the acid neutralisation capacity maybe overstated.

However, the acid neutralisation capacity is easy to check by undertaking a mineralogy investigation of the potential waste rock (NAF/AC) and using the correct ANC analysis to account for the presence of siderite. For example, the total acid neutralising capacity can be measured by the modified Sobek method (ANC_{SOBEK}), which utilises digestion of a pulp sample with 0.5 M HCl; the sample is then back-titrated to measure the amount of acid consumed by reaction with the sample and provides the total ANC in kg H2SO4/tonne. In order to determine what proportion of the ANC_{SOBEK} may be reactive; readily available, or available to neutralise acid under expected field conditions, use the reactive ANC test based on the British Columbia Research Inc Test (chemical) procedure for evaluating acid production potential of ore and waste rock (Mills et al., 2005); and the acid base characteristic curve methodology (AMRIA, 2002).

If an end dumping procedure is used, the placement of clay on a slope is difficult to engineer and it is better to build on horizontal layers of paddock dumping across the face of the PAF cell. A careful watch of the QA/QC of the clay placement needs to be maintained to ensure that the designed material thickness over the slope is achieved. Also, the clay cover needs to be armoured prior to the wet season as, during the site visit, some rilling was observed on an exposed clay face of one of the PAF cells in the OEF.

The Independent Monitor recommended the commencement of the construction of larger kinetic cells or columns on site, but this was rejected by URS, the MRM consultants. While some of the arguments offered by URS have merit they do not account for the fact that the laboratory based leach columns tested only one range of particle size: <5-10 mm. The surface area of the current column material is significantly higher than what is generated during mining and may not be a true reflection of the reactivity of the waste rock types under oxidising conditions.

Review and analyse selected waste rock samples for sulfide sulfur as well as total sulfur. All hanging wall material should be considered to be PAF.

TABLE 10 REVIEW SUMMARY OF KINETIC COLUMN TEST WORK CHARACTERISTICS AND REACTIVITY

Column	Sample Name	Description	Total S %	Class	Re-Class	Comment
1	TP4/6-12	Laboratory column - highly weathered siltstone	3.3	NAF	IND	Reactive, Low SO4, Low Acidity
2	TP4/13-18	Laboratory column - partially weathered siltstone and predominantly fresh siltstone	20	PAF	PAF	Reactive, high SO4, high acidity
3	PER 1	Laboratory column leach test results for sample PER 1 (NAF) hanging wall overburden material - upper pyritic shale 45-50 m	4.78	NAF	PAF	Reactive, high SO4, high acidity
4	PER 2	Laboratory column leach test results for sample PER 2 (PAF) hanging wall overburden material - upper pyritic shale 25-30 m	10.1	PAF	PAF	Reactive, high SO4, high acidity
5	PER 3	Laboratory column leach test results for sample PER 3 (NAF) hanging wall overburden material - bituminous shale 100-105 m	4.43	NAF	IND	Reactive, elevated SO4, increase acidity
6	PER 4	Laboratory column leach test results for sample PER 4 (PAF) hanging wall overburden material - bituminous shale 90-95 m	13.3	PAF	PAF	Reactive, elevated SO4, increased acidity
7	PER5	Laboratory column leach test results for sample PER 5 (NAF) hanging wall overburden material - lower pyritic shale 125-130 m	5.79	NAF	IND	Reactive Low SO4, Low Acidity
8	PER 6	Laboratory column leach test results for sample PER 6 (PAF) hanging wall overburden material - lower pyritic shale 115-120 m	8.03	PAF	PAF	Reactive Low SO4, Low Acidity
9	PER 7	Laboratory column leach test results for sample PER 7 (NAF) hanging wall overburden material - lower dolomitic shale 52.8-53.6 m	1.93	NAF	IND	Reactive Low SO4, Low Acidity
10	PER 8	Laboratory column leach test results for sample PER 8 (NAF) footwall overburden material - W-fold shale 115.1-115.7 m	0.073	NAF	NAF	unreactive
11	PER 9	Laboratory column leach test results for sample PER 9 (NAF) footwall overburden material - Teena dolomite 133.6-134.9 m	0.075	NAF	NAF	unreactive
12	PER 10	Laboratory column leach test results for sample PER 10 (NAF) diversion material - dolomitic sandstone 11.1-12.4 m	0.096	NAF	NAF	unreactive
13	PER 11	Laboratory column leach test results for sample PER 11 (NAF) diversion material - breccia 7.5-9.2 m	0.002	NAF	NAF	unreactive

Column	Sample Name	Description	Total S %	Class	Re-Class	Comment
14	LAB 1	Laboratory column leach test results for sample Lab 1 (PAF) lower pyritic/dolomitic shale	20.1	PAF	PAF	Reactive high SO4 high acidity
15	LAB 4	Laboratory column leach test results for sample Lab 4 (NAF) upper pyritic/dolomitic shale	4.4	NAF	IND	Reactive elevated SO4, increase acidity
16	LAB 5	Laboratory column leach test results for sample Lab 5 (AC/PAF/AC) AC cooley dolomite/PAF lower pyritic/dolomitic shale /AC W-fold shale	7.1	PAF	PAF	Reactive high SO4 high acidity
17	LAB 6	Laboratory column leach test results for sample Lab 6 (AC/PAF/AC) AC cooley dolomite/PAF upper pyritic/dolomitic shale /AC W-fold shale	4.02	PAF	PAF	Reactive high SO4 high acidity
18	SITE 2	Site column leach test results for sample Site 2 (PAF) lower pyritic/dolomitic shale	11.8	PAF	PAF	Reactive high SO4 high acidity
19	SITE 4	Site column leach test results for sample Site 4 (NAF) lower pyritic/dolomitic shale	4.4	NAF	IND	Reactive elevated SO4, increase acidity
20	SITE 6	Site column leach test results for sample Site 6 (PAF) upper pyritic/dolomitic shale	10.9	PAF	PAF	Reactive high SO4 high acidity
21	SITE 7	Site column leach test results for sample Site 7 (NAF) upper pyritic/dolomitic shale	4.9	NAF	IND	Reactive elevated SO4, increase acidity
22	SITE 9	Site column leach test results for sample Site 9 (AC/PAF/AC) AC cooley dolomite/PAF lower pyritic/dolomitic shale/AC W-fold shale	10.16	PAF	PAF	Reactive elevated SO4, increase acidity
23	SITE 10	Site column leach test results for sample Site 10 (AC/PAF/AC) AC cooley dolomite/PAF upper pyritic/dolomitic shale/AC W-fold shale	3.72	PAF	PAF	Reactive high SO4 high acidity
24		URS laboratory column leach test results hanging wall overburden material - upper pyritic shale 45-50 m PAF	4.78	PAF	PAF	Reactive high SO4 high acidity
25		URS laboratory column leach test results hanging wall overburden material - bituminous shale 100-105 m PAF	4.43	PAF	PAF	Reactive high SO4 high acidity
26		URS laboratory column leach test results hanging wall overburden material - lower pyritic shale 125-130 m NAF	5.79	NAF	IND	Reactive Low SO4, Low Acidity

Column	Sample Name	Description	Total S %	Class	Re-Class	Comment
27		URS laboratory column leach test results hanging wall overburden material - lower pyritic shale 115-120 m PAF	8.3	PAF	IND	Reactive Low SO4, Low Acidity
28	TAILINGS SLURRY	URS laboratory column leach test results tailings slurry PAF	10.63	PAF	PAF	Reactive high SO4 high acidity
29	FIRED TAILINGS	URS laboratory column leach test results fired tailings Walco 8338 PAF	10.3	PAF	PAF	Reactive high SO4 high acidity

Notes:

1. **red highly reactive PAF;**
2. **purple less reactive PAF;**
3. yellow borderline PAF;
4. **blue NAF**; and
5. **IND** is indeterminate waste class where the net acidity is >-10kg/t and <+10kg/t H_2SO_4.

9.9.3 Review of tailings geochemical monitoring

In 2009 the Independent Monitor requested that additional monitoring be undertaken to address an urgent issue, that of tailings leachate from TSF Cell 1 entering Surprise Creek. This issue was reported to MRM and the Department of Resources under section 6.4 of the Independent Monitoring Assessment Conditions (IMACs). In this correspondence it was noted that:

A review of tailings geochemistry results in 2007 and 2008, indicate that, based on sulfur analysis, up to 20% sulfides could be present and the NAPP calculations show that substantial acidity is produced and the tailings could rapidly become acidic. The pH of the tailings at discharge was acid for most of 2008, with a pH for a month (30/09/08) being as low as 2.4. Clearly, recently deposited tailings have a strong capacity to produce acid.

The NAG results, however, are not acidic. This can be explained by the fact that NAPP reports all S as sulfides and does not consider the presence of oxidised sulfur (sulfates) or non-acid producing sulfides, primarily galena and sphalerite. Therefore, relying on either NAPP and uncalibrated NAG to predict future behaviour of the tailings is dangerous. Calibration was supposed to be occurring but the results have not yet been presented.

It is now apparent that more acid is being generated than predicted by the NAG test, but less acid than predicted by NAPP.

All the groundwater monitoring of seepage of leachate from the tailings was done on the basis of neutral leachate, using assumed geochemical values. As the tailings surface drainage is acidic it is reasonable to expect the tailings leachate has or could go have gone acid. The time for non-reactive leachate substances to reach the creek was about 18 months. In 2005, URS modelled the leachate migration from the No 1 Cell tailings dam. The model mostly used assumed values which could make it less suitable for accurate predictions of future behaviour. No modelling has been done for acidity or metals to travel to the creek. It was assumed the tailings would not become acid and the models and mitigation measures were undertaken on this basis. The migration of an acid front could be days away from discharging at the spring or Surprise Creek River bank or it could be 20 years. The acid front could be degrading the geopolymer.

Additional investigation is required to delineate when the acid and the following metal leachate plumes will discharge to Surprise Creek and at what rate and concentration. Once this is known the impact on the creek can be predicted and mitigation measures designed.

The Independent Monitor is concerned that the rate of generation of acid and metals; the quantity of acid; the driving head; the rate of migration and the attenuation factor in the soil; are not known and therefore appropriate mitigation measures cannot be designed.

This letter also recommended that a series of tests be undertaken and MRM commissioned Golder Associates for the work, which was undertaken in late 2010, and presented in the report titled *McArthur River Mine Hydrogeochemical Investigation of the Tailings Storage Facilities* (Golder report dated 17 June 2011). The following discussion is a review of this work.

The Golder report contains many errors in calculation and in transcription, as well as use of the wrong analytical tests and assumptions. Because of these errors, the data is not compatible between and, sometimes within, tests. In addition, as a result of these errors, the conceptual model is not correct and the resultant solute transport analysis is not representative of site conditions.

Some of these errors may have been due to Golder not having access to earlier studies. A thorough review of earlier documents has revealed the following conditions and characteristics that would most certainly change the tenor of the interpretation and conclusions of the Golder report:

- tailings runoff water has been acid since as early as 2005 and elevated zinc breakthrough was evident in Surprise Creek as earlier as July 2006 (Appendix I, Soil Con Systems, June 2007,);
- it was also noted that old creek beds pass under the tailings dam and these have a measured permeability of 86 m/day (Soil Con Systems, April 2007, p.12);
- the tailings dam at its closest is within 50 metres of Surprise Creek and the tailings are now 10.5 metres thick, with a surface approximately 15 metres above the creek;
- the gradient has been at its steepest for the last six years and has had a water level in the dam set at about one metre above the tailings surface. This is equivalent to a gradient of about 0.2; and
- other historical information records that a sulfate plume was detected in the creek within 18 months of the tailings dam commencing operations, when the tailings would have been less than two metres thick and the gradient about 0.1.

The Golder report (2011) uses a permeability of 1.73 m/day, a gradient of 0.04 and a zinc and lead breakthrough estimated to be 100 to 200 years from commencement. The actual gradient can be measured by the fall and distance from MW3 to Surprise Creek and this measurement should be used when the conceptual flow model is updated and observations used to check solute flow velocity equations, prior to updating or running any solute transport models.

The Golder report concludes the tailings will remain neutral for years to decades and in so doing imply that the tailings will eventually become acid. Using as input the current concentrations of lead, zinc and cadmium in the tailings porewater, Golder suggest it will be years to decades before lead and zinc concentrations in Surprise Creek may lead to adverse environmental impacts, however, modelling was not done on concentrations of these metals when the tailings become acid. Golder note that the objective of a closure strategy should be to reduce oxidation and maintain saturation of the tailings, however, given the location of the dam on a flood plain in the monsoonal tropics with a gravel underdrain, this will be a very difficult objective to achieve.

Nevertheless, given these limitations, Golder recommend that mitigation strategies should be undertaken, including reprocessing the tailings and at the same time undertaking remedial works to create an impermeable liner to intercept the seepage.

It is currently unknown when the tailings mass will consume all the buffering capacity, however, undertaking an acid/base balance using only the XRD mineral data, provides an interesting clue. The samples that have negative net acid generation potential (NAGP) at 4.2 m and 6.2 m were anomalous in either having 150% of dolomite compared with the other samples or in having half the pyrite. If these samples are not considered in the data set, it is clear that when the tailings were first deposited they would not produce acid leachate. After roughly 2.5 metres of tailings deposition a change occurred either in the geology, more pyrite, or in improved milling achieving better mineral recovery. As the deepest tailings have the highest concentrations of zinc and lead, the latter seems likely. The tailings being deposited at present will produce smaller quantities of acid with time. A change must also have occurred in the top 2.5 metres of tailings, possibly in the composition of the ore, as the tailings deposited during this period have substantially more pyrite and less dolomite, than the tailings deposited earlier, and will potentially generate substantial acidity when the

buffering capacity of the tailings has been depleted. The tailings data indicate two changes in milling and, though the original tailings will not generate acidic leachate, the tailings deposited over the last five years will.

However, as discussed above, current evidence is that the tailings deposited over the last five years will generate acid, both TSF Cells have been designed on the basis that acidic leachate will not occur.

Planning for the long term acidification of these tailings and mitigation of acidic seepage is likely to be the most significant issue for mine closure.

As the recommendations of the Golder report are not inconsistent with those of the Independent Monitor, a full discussion on the technical details of the errors in the Golder report is not included but can be provided if required.

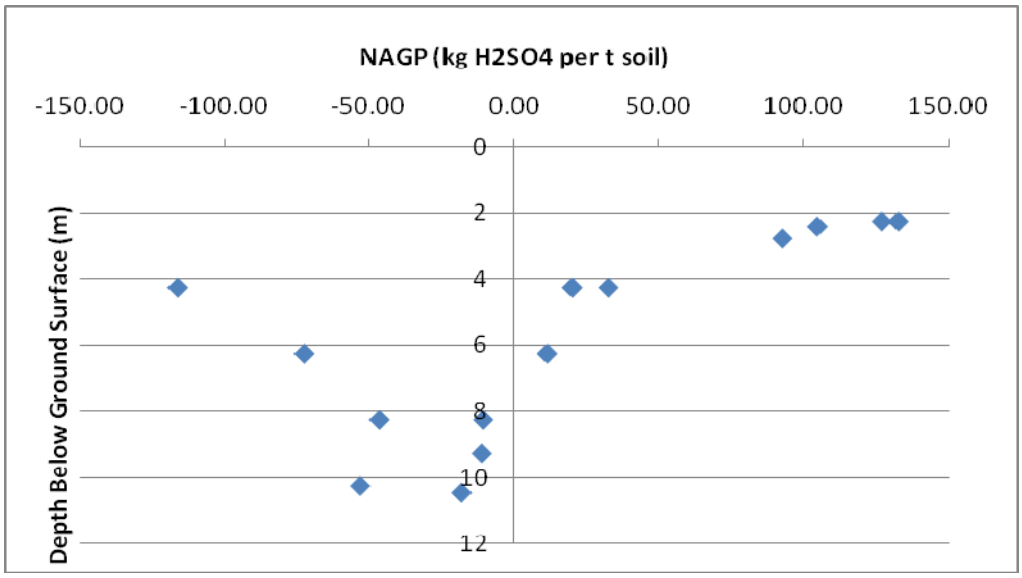


Chart 5 Net Acid Generation Potential calculated from mineral percentage developed from XRD Data provided in Golder's Report, *Hydrogeochemical Investigation of the Tailings Storage Facilities* 2011.

Tailings geochemical monitoring recommendations

- MRM should correct errors in the conceptual model of seepage from TSF Cell 1;
- accelerate leaching trials on current tailings to establish the number of pore volumes required to consume buffering capacity;
- evaluate and design a tailings seepage and closure management system, including in the evaluation the possibility of recovering the tailings from TSF Cell No 1; and
- investigate and discuss when and where seepage will occur from TSF Cell 2, and what the likely impacts will be.

9.10 Review of surface water hydraulics

9.10.1 River diversion channel erosion and sedimentation

The 2008/2009 MMP report covered this issue in considerable depth, however it is not addressed at all in the 2009/2010 report except under 'Closure planning', in which references

are made to the use of the water sled system for irrigating the revegetation works along the McArthur River diversion and proposed protection of the McArthur River and Barney Creek diversion channels with rock lining. It is unclear what rock lining works, in addition to that which is already in place, are being proposed. Apart from some repair work near the upstream start of the McArthur River diversion and at the Barney Creek/Surprise Creek confluence, it is noted that no further rock lining work was undertaken during this audit period.

Since the latest water management plan (WMP 2010/2011) includes a section on diversion channel erosion matters, which did not feature in the previous WMP report, we assume that successive WMP reports, rather than MMP, reports will be covering these items in future.

McArthur River diversion channel erosion monitoring
The Independent Monitor has reviewed a MRM 'proposed river works' memo dated 22 April 2010 which mostly focused on erosion issues in the most upriver portion of the river diversion channel. While the coverage of the identified erosion areas in the memo was appropriate, its consideration of erosion and associated potential works elsewhere along the diversion channel was limited to one photographed location (near chainage 2000 m) and a rather vague statement that in some locations there is the potential for a mixture of clean rock and soil to be placed to rectify erosion.

No documentation which separately details a review of erosion issues along the whole length of the diversion channel has been sighted and it is considered that it would have been appropriate for the April 2010 memo to be expanded so as to document these findings.

Despite the volume of photographs which were taken after each of the past several wet seasons, we note that none of these historic records have been used in this audit period to document and comment on instances of McArthur River diversion channel bank erosion. For example, see Plate 56 and Plate 57, which demonstrate just one instance of the significant change in batter conditions. A similar comment to this was also made in the previous Independent Monitor Audit report.

In response to the previous IM audit report, MRM advised (reference MRM letter 24 August 2010 to EES) that the May 2010 aerial photography would be used to draw comparisons of erosion along both diversion channels. Since the aerial photography provides an overall view of the channels, the IM agrees that this is desirable and supports the information provided in the 250 metre interval photographs. Additionally, the IM also encourages the use of the accompanying ALS ground truth data to map changes in the diversion channel batters.

Moreover, future reporting of erosion trends should include discussion of the relative magnitudes of flows in each wet season.

MRM's agreement is noted (reference MRM internal memo by Gary Taylor dated 14 February 2011) that it will extend the coverage of the 250 metre interval photographs to include the 'opposite' banks of both Barney Creek and McArthur River.

Plate 56 View of eastern batter slope scour at river channel chainage 1750m; taken March 2009. Photo: Independent Monitor

Plate 57 View of eastern batter slope scour at river channel chainage 1750m; taken March 2010. Evidence of significant scour during 2009/2010 wet season flows compared with the 2009 photograph, see Plate 56). Photo: Independent Monitor

Barney Creek diversion channel erosion

Despite the significant erosion observed at the Barney Creek confluence with Surprise Creek, which occurred during the 2009/2010 wet season, there is no evidence of any erosion trend monitoring undertaken for Barney Creek during the 2010 operational period.

Despite the volume of photographs that were taken after several past wet seasons, it is noted that none of those historic records were used during this audit period to monitor the Barney Creek diversion channel.

Downstream river sediment monitoring
Following the previous IM audit report, MRM advised of a number of intended actions, including several relating to the monitoring of the potential sedimentation zone downstream of the diversion. The intended actions were as follows:

- the Environmental Monitoring Manual would be updated to define clearer guidelines for the taking of dry season (low flow) photographs. MRM saw the series of photographs as being a tool for capturing sedimentation trends in that section of the river and made the commitment that the trends/changes would be "identified and discussed in future Water Management Plans"; and
- the number of photographic reference points would be increased by as many as ten; with the extra locations being downstream of the Glyde River confluence.

The IM acknowledges the inclusion of these commitments in the 2010/2011 MMP report together with the commitment to upgrade the MRM Environmental Monitoring Technical Manual (2010) by specifically including the details of the photographic reference points.

As was discussed with MRM staff during the May 2011 site visit, it is important that not only the downstream photographs are taken at times of very low flow, when the channel bed is exposed, but to make possible meaningful comparison, the photographs are taken at exactly the same location and with exactly the same orientation. It is therefore strongly recommended that a series of posts or a similar method be used to mark the locations and that staff also carry copies of past photographs when taking new photographs to ensure the photograph orientations are consistent.

9.10.2 Review of river flow and water resource reporting

The Independent Monitor considers that the 2010/2011 WMP is a far more complete document than the previous WMP report and it is recommended that the comments made in this audit report be addressed in future WMP reports to increase its completeness.

The stated purpose of the 2010/2011 WMP is to provide "a planning document outlining objectives for water management moving forward and reporting on water management activities from the previous operational period".

These commitments are welcomed and, together with the provision of a formal reporting mechanism for both charting new directions and reporting on previous commitments and actions, are expected to result in a more holistic reporting approach to water management matters.

Review of river flow reporting
The previous WMP (2009/2010) includes a set of annual plots of water level and flow for both the upstream and downstream McArthur River gauging stations, and water levels for both the Barney Creek gauging station and the early warning flood station. It is considered that the WMP would be improved by the adoption of the same twelve month time axis plot presentation for all four stations.

While the upstream and downstream station plots of water levels and flows are free of some of the inconsistencies which were noted in the 2010 Independent Monitor Audit, there are still significant concerns.

Principally, the last audit report expressed concern about the downstream station flows being about twice the magnitude of the upstream station flows, even though the difference in their respective catchment areas was only about 30%. The 2010/2011 WMP report includes various pieces of flow information from which the following can be ascertained:

- the 2008/2009 wet season peak flow was 220% greater at the downstream station, while the 2009/2010 peak flow was 160% greater;
- similarly, during the series of smallish storm hydrographs recorded in January 2010 and also in the larger flood events recorded in March 2010 and April 2010, the two flow plots indicate that the peak flows at the downstream station were more than 200% greater than those at the upstream station; and
- the plot of upstream station flows indicates that the river flow between July 2009 and January 2010 and again after April 2010, was almost constant and typically about 200 m^3/s. However, during the same periods, at the downstream station the flow was typically substantially less than 100 m^3/s, that is, typically about 50% of the flows at the upstream station.

These variable trends have not been addressed or discussed by MRM in the WMP.

Furthermore, a sample review of the 1/1/2010 and 2/1/2010, hourly flow data for the upstream and downstream stations shows that initially the downstream station had slightly larger flows but by late on 1/1/2010 the upstream flows were about twice as much as those passing the downstream station. By the next day, the upstream flows were about three times the magnitude of the downstream flows.

These observations suggest that the recording of water levels and/or the various rating tables , which convert the water levels to flows, are inaccurate.

While the 2010/2011 WMP includes separate tables for the 2008/2009and 2009/2010 wet season flows and design flood flows for three locations along the McArthur River, it fails to link the two sets of data. The WMP report would be improved by comparing those historic flows with the range of design flows. For example, reporting how the 2008/2009 wet season peak flow was slightly smaller than the design five year flow, and the 2009/2010 wet season peak flow was slightly larger than the design five year flow, would not only provide the reader with an appreciation of the relative magnitude of past wet season flows, but also provides the context for discussing channel erosion. This approach was also recommended in the last IM audit report.

While the 2010/2011 WMP report also makes mention of the 100 year McArthur River flood level (39.5 m RL) at the mine, it does not identify its relative datum nor relate it to the flow depths recorded at any of the McArthur River stations. During the May 2011 site inspection, the IM discussed with MRM staff that the same datum that is used throughout the mine project should also be used to relate the zero reading values for all the various gauging stations.

Commitments were made in the 2010/2011 WMP report to use specialist services to survey and calibrate all four flow stations during the, then upcoming, 2010/2011 wet season. The first of the related reports (ALS Environmental, 2011), which looks at the potential water level versus flow relationship for the Barney Creek station, has been sighted. It is important to note that the report recognises that the position of the station, just downstream of the creek's confluence with Surprise Creek, means that in high flow periods the water level at the station is likely to be impacted by concurrent flood flow conditions.

However, the ALS Environmental, 2011 report recognises that a flow relationship based purely on Barney Creek flows would not be valid and proposes that "calibration with discharge measurements" are in order to ascertain whether there are errors in the initial theoretical flow relationship. This proposed action is seen to be nonsensical since potential impact from the river will vary over a wide range of flood scenarios, meaning that a single

flow relationship curve cannot be developed for the Barney Creek station. MRM are aware of this and are looking at the potential relocation of the Barney Creek gauging station to the highway bridge crossing upstream.

Recording accurate water levels is also an important issue. A recent report (Greenspan, 2011), in which a number of significant problems were reported regarding the recording of water levels and/or in the performance of related equipment at all four gauging stations has been reviewed by the IM. One significant problem noted was the reported recording of a "zero" water level, due to a "depleted gas bottle" at the early warning flood station for a considerable period during 2010. The number and nature of the problems identified in the Greenspan report are of significant concern.

Given the concerns expressed in both the 2009 and 2010 Independent Monitor Audit reports, and again in this report, the MRM's commitment to either improve and/or develop flow measurements for all four stations is timely. However, at the time of writing of this report, the IM was advised that the ALS Environmental report on measurements and other related activities undertaken during the 2010/2011 wet season had not yet been received by MRM.

Flood warning system
The current early flood warning system is described in section 2 of the 2010/2011 WMP. With regard to this system, both the 2009 and 2010 Independent Monitor Audit reports recommended the upgrading of information associated with the flood forecasting river station because, by themselves, the levels do not allow early identification of potentially critical flooding at the mine. That is, there needs to be a connection developed which relates water levels recorded at the early flood warning station to various flood damage/hazard bench marks at the mine.

It is noted that, while work related to flow gauging and rating table relationships for various MRM river stations has been commissioned, no results relating to the early flood warning station nor any subsequent revision of either the "Early flood warning system procedure" or the "Site emergency response plan" documents have been provided.

Process water system
The 2010/2011 WMP reports how contingency measures for the APP and CRP water storages include redirecting process waters back to the mining area ponds. Also, the WMP refers to the ability to pump from the APP pond "to the mine in an emergency situation". It is presumed that the reference to "an emergency situation" corresponds to a situation where any spill from the APP would enter Barney Creek. However no formal or informal documentation of the procedures which deal with the "contingency measures" have been sighted.

Water management infrastructure
The network of silt traps and bunding that has been constructed to assist with water management is described in the 2010/2011 WMP. Figure 3-3 in the WMP has the title of "Location of silt traps at MRM" which implies that the figure shows the complete network of traps, however, although the text makes references to additional traps built in 2009 along both sides of Barney Creek and also to other traps located "between the mine levee wall and each re-channelled section", these are not included in Figure 3-3. It is recommended that future WMP reports include a figure which shows, with labels, the complete network of traps.

It is noted that the additional Barney Creek traps were constructed by MRM in response to elevated silt readings "in both surface water and fluvial sediments" and this is seen to be a very good example of where the reviewing/interpreting of recorded data has led to corrective action being undertaken.

The WMP describes the sediment trap reporting as occurring “monthly during the dry season and after any rain event” with observations recorded on MRM VI0016 inspection form. In fact this comment reflects the introduction of a new recording/reporting system which commenced in November 2010, and which is seen to be a positive response to the lack of such a system that was identified in both the 2009 and 2010 Independent Monitor Audit reports.

With regards to the Bing Bong port facility and its principal run-off pond, the WMP report refers to the current mist spray and sprinkler systems which help to lower the water level in the pond by increasing the evaporation losses. The report asserts that the system “has increased evaporation by approximately 5% and therefore significantly reduced the risk of overflows” from the pond. How it was determined that the change in the evaporation system has “significantly reduced” the risk of overflows is unclear, further, this pond is not mentioned in the OPSIM model reporting.

Sub-section 3.6.19 of the WMP contains details of installed and proposed evaporative fans which, when operational, will serve to increase evaporative losses and therefore assist in lowering storage levels. It is noted that approval was gained from the DoR for the installation of three fans in the pit floor, while the proposed installation of six fans at Cell 2 of the TSF has been conditionally approved by DoR for a 12 month trial. As well as noting the need to address the various trial conditional requirements, the IM notes that MRM is committed to undertaking a detailed assessment of the pit floor fans during the 2011 dry season. While, to date, some indicative evaporation rates have been calculated, as presented in Table 3-1 of the report, it is noted that the rainfall information in that table is erroneous. That is, the monthly values listed in the table have been entered against the wrong sequence of months compared with the average monthly totals presented earlier in Table 2-1.

Sub-section 3.6.21 describes the potential use of sprinklers to increase water usage of both contaminated and clean water. Regarding their control, it is noted that the report uses similar words to the automated weather station control system that is intended to govern the operation of the evaporative fans. Since any shortcomings in the control system may result in contaminated water spray entering clean areas, it is recommended that details of the system, including its alarm reporting, be provided to the DoR for review.

9.10.3 Review of river water extraction

Both the 2009 and 2010 Independent Monitor Audit reports made comments about systems that existed then for extracting water from the McArthur River.

Concern was expressed in the 2009 audit report about the gaps in the procedures for both monitoring and measuring river flows and reporting how much water was being extracted. In the 2010 audit report it was recognized that the water extraction system changed in March 2010 when the irrigation sled system came into operation, but also identified improvements that were considered necessary to the system of reporting the flows extracted from the river. Principally, the recommendations concerned the documentation of each coincident river level/flow rate on the reporting form, together with the recording of each occurrence of pumping, rather than just weekly totals.

Unlike the WMP 2009/2010 report, the WMP 2010/2011 report makes no reference to the extraction system. Since there is no reference elsewhere to changes which may have taken place in the extraction reporting process, this is seen to be a shortcoming. Through discussions with MRM staff it was understood that improvements to the sled water use reporting system were intended, but this had not yet happened.

9.10.4 Diversion channel photographic monitoring

The 2010/2011 WMP report refers to the on-going practice of regularly taking a series of photographs at 250 metre intervals and at river tributary chute/confluence locations. It notes that the last set of photographs was taken in March 2010, as was also recognised in the 2010 Independent Monitor Audit report. MRM staff advised that the post wet season photographs would be taken once the last of the wet season flows had passed through the river and creek systems in order to record channel base conditions with as little water as possible in the base.

While the process of taking the series of diversion channel photographs has been clearly explained, it is disappointing that the WMP report does not include any descriptions relating to a review of what the photographs show.

9.10.5 Impact of the 2009/2010 wet season flows

The 2010 Independent Monitor Audit report documented the significant 2009/2010 wet season erosion that occurred in the Barney Creek batter slope just opposite the Surprise Creek channel confluence. While the WMP reports that the eroded batter area was rehabilitated in July 2010, it is noted that the report does not describe the rock material, the source and rock size, that was used for the repair work. It is recommended that these details relating to future protective works be included in the following WMP report.

In the previous Independent Monitor Audit report a recommendation was made to use aerial laser-derived ground levels to monitor erosion/sedimentation trends in the diversion channels and to monitor changes in bed conditions in the McArthur River downstream of the diversion. It is understood that MRM is still considering that recommendation.

9.10.6 Review of water balance and OPSIM modelling

Water balance modelling

In the introduction to the WMP report reference is made to the importance of the OPSIM modelling “to assess and investigate future water management issues” and, furthermore, that its ongoing development and refinement “is an integral part of the overall continual improvement of the MRM water management strategy”. However while chapter 3 of the report provides a detailed description of all the various elements which together make up the MRM water management system, the presentation of findings at the end of the report should be clearer.

While there were a substantial number of recommendations listed in the OPSIM, July 2009 report (Water Solutions, 2009), the WMP report does not refer to them, nor does it make any associated comment about what related changes were subsequently made to the model. While it is acknowledged that the OPSIM report, Water Solutions, 2010, is included in one of the accompanying appendices of the WMP, there is no linkage of its findings back into the main report. Since water usage issues are clearly of very considerable importance to the mine, this is a significant omission and yet, to date, the OPSIM report findings do not appear to have been gathered up in any other MRM document.

A 15 March 2011 MRM letter sent to DoR, in which MRM identifies the actions that will be followed with the regard to the OPSIM report recommendations, has been reviewed by the IM. Consequently, it is recommended that these commitments and subsequent follow-up actions should be included in the next WMP report, wiht similar reporting continuing in each subsequent WMP.

As with earlier versions of the OPSIM modelling reports, the changes made to the model since the last report are listed. It is noted that the list of changes in the 2011 report includes

the, new, Pete's Pond storage but it is unclear to the reader whether or not the construction of this storage has come about through the recommendation in the 2009 OPSIM report for consideration of an additional mine water storage in the open cut pit levee area.

Differences between the WMP report and the OPSIM report
The following differences are noted with regard to data presented in the above two reports:

- since the February 2011, OPSIM report states that metered data was not provided, it lists and adopts *nominal* extraction rates for the Emu and Mimex bore fields, however, in its section 3.4, the same report lists Emu and Mimex flow meter data as having been provided to them for the period from January 2009 to March 2010. Moreover, it is noted that the WMP report lists *average* flow rates for both bore fields for 2007, 2008 and 2009/2010. It is unclear why the 2009-2010 metered data was not used in the OPSIM modelling;
- in its Appendix A, the OPSIM report defines the storage capacities, up to their respective spillway levels, of Pete's Pond and Van Duncan's Dam as 49 ML and 16 ML and the accompanying volume tables are described as being "updated based in information provided by MRM". However the WMP report lists the capacities as 121 M and 21 ML respectively. It is not clear why there are such discrepancies, especially for the Pete's Pond size. Also, the WMP report refers to the water being pumped to the CRP or APP or, alternatively, pumped to Cell 2 of the TSF. This is consistent with the OPSIM operational schematic diagram, yet in its operational guidelines table the OPSIM report makes no reference to pumping to either the CRP or APP, but it does refer to the potential to pump to 'Cell 3' of the TSF. Presumably the reference to 'Cell 3' should read 'Cell 2';
- the descriptions of various APP outflow pumping regimes in the WMP report subsection 3.6.1, is very different from Figure 5.1 of the OPSIM report and also from Table 5.2 in the OPSIM report;
- in its Appendix A, the 2011 OPSIM report defines the CRP emergency storage capacity, up to spillway level, as 42.7 ML and the accompanying volume table is described as being "updated based in information provided by MRM". However the WMP describes the CRP capacity as being reduced from 35.62 ML to 27.03 ML following the placement of the clay lining, and subsequent as-built survey which was undertaken in February 2010. It is not clear to the reader whether the CRP and CRP emergency storages are one and the same storage and if so why the storage capacities are so different;
- it is also unclear why various catchment areas documented in the OPSIM and WMP reports are not consistent between the reports. For example, VDD (15.6 ha and 11.2 ha), APP (13.5 ha and 12.5 ha), PP (1.9 ha and nil), open cut pit (180.2 ha and 128 ha), southern PAF sediment dam (56 ha and 38 ha), Old McArthur River channel (179.9 ha and 210 ha); and
- there are differences in the two reports over the number, size and capacity of pumps which serve to dewater the underground mine

Review of February 2011 OPSIM report
The report notes that the amount of monitoring data which was provided by MRM was less than in previous years.

It goes on to say how MRM are in the process of establishing a monitoring network which will incorporate all major site water transfers. The Independent Monitor was briefed on this networking task during the 2011 mine inspection and considers that, in addition to assisting with daily operational decision making, the transfer data sets will be a substantial asset in the

on-going refinement of the OPSIM model with a subsequent improvement in the accuracy of, and confidence in, the model's forecasting predictions.

Observed WMD storage volumes are well recorded in Figure 5.3, however a similar level of accuracy is not found in the recording of Cell 2 storage volumes in Figure 5.2. With regard to the latter storage, the IM disagrees with the conclusion that, just because a good fit was achieved at the very end of the 16 month long verification period, a "reasonable overall agreement" has been achieved.

It is further noted that the report draws attention to the use of average system demand and transfer rates in the verification model and that "intermediate disparities are thus expected to be attributed to fluctuations in actual system demands and rates". However, earlier in the report it is stated that the available flow meter readings were processed "to give average daily rates". Consequently, it is considered that the adoption of a more selective data processing approach may have generated monthly or seasonal trends, which might then have improved the performance of the model over the verification period. An example of this is the highly variable underground dewatering record shown in Figure 3.3, but the adoption of an average dewatering rate in nearby Table 3.5. Hopefully the provision of real time data series from the new MRM monitoring network in the near future, will mean that current reliance on average transfer rates can be discontinued.

The rate at which TSF Cell 2 is filling with tailings and predictions as to when it is likely to reach its capacity, are major outputs from the OPSIM model. In this regard it is noted that the 2011 OPSIM report has assessed the tailings density to be higher at 1.5 tonnes/m^3 than that which was derived in the 2009 report, 1.3 tonnes/m^3. The assessment of the life of TSF Cell 2 would have more credibility if the sensitivity of that density value had been tested in the modelling.

Key outputs from the modelling are presented in chapter 6, however, although in several cases the findings are quite different to those presented in the 2009 report, there is no accompanying explanation for the changes. One example is that the 2011, Figure 6.2 graph of wet season groundwater flow, plots variability distinctly lower than the graph presented in the 2009 report.

In another example, in Table 6.2 the statistics regarding risk of spillway discharge at the six listed storages are found to be quite different from the findings provided in the 2009 report. Consequently, the assessment in the 2011 report of a lower risk of WMD spill, is presumably a function of such factors as less spill modelled from neighbouring Cell 2 together with changes made to the WMD catchment hydrology model, as recommended in the 2010 Independent Monitor Audit report. Given that items such as the risks associated with potential spill regimes are very important outputs from the modelling, the IM considers that future reporting would be significantly improved by the inclusion explanations as to why the latest predictions are seen to be superior to earlier reported results.

There are additional concerns regarding shortcomings in the report, as follows:

- numerous cases of errors in the cross-referencing of report chapters;
- while the 2011 report Appendix A appears to have been included in response to one of the 2010 Independent Monitor Audit report recommendations, there are several concerns regarding its contents. First, not all storages are documented; secondly, there are separate storage relationships defined for what are described as 'Old McArthur River (South)' and 'Old McArthur River (North)', yet the report itself only makes reference to the one Old McArthur River waterway storage; thirdly, the storage relationship provided for Cell 2 is identical in every way to the details for the VDD

storage; fourthly, the lack of an Appendix A storage relationship with the WMD means that there is a significant difference in the quoted WMD capacity between the 2009 and 2011 reports—that is, approximately 2300 ML versus 1835 ML respectively—and it is not verifiable. Furthermore, it is unclear why each of the stage-storage-volume tables use quite unrealistic extrapolations for defining each relationship beyond the spillway level;

- there are errors regarding the reporting of MRM operational guidelines for the various storages. For example, in Table 5.2 the report states that the WMD for the TSF is only receiving inflows from its own catchment and from Cell 2 spill, whereas section 3.10.1 states that the WMD "currently receives pumped inflow from the APP and Pete's Pond", which is erroneous. Moreover, also in Table 5.2, there are numerous references to 'Cell 3' which should read 'Cell 2'. In another example, the section 4.1 description of the March 2009 to June 2010 period of modelling does not include the Old McArthur River seepage contribution.

The 2010 Independent Monitor Audit report recommended a number of changes to the OPSIM reporting and the following comments are directly relevant to those 2010 findings:

- presentation of adopted evaporation rates has been significantly improved in the 2011 SPSIM report;
- the type of hydrologic catchment adopted for the WMD catchment has been corrected; and
- much improved and long term gathering of water level data has greatly assisted the process of verification modelling of both the WMD and Cell 2 storages.

With regard to future OPSIM reports, the following recommendations are made:

- because each OPSIM report includes large amounts of data and descriptive information, documentation about what modelling parameters or data sets have been changed can be buried. Each successive OPSIM report would be more easily read if it highlighted the changes made to the model since the previous round of modelling. One way of doing this would be to use the 2011 report dot-point method of documenting periodic changes in the underground inventory (reference section 4.1);
- attempt make presentation of important findings much clearer; and
- greater care in the elimination of errors in consistency of quoted data values, descriptions of operational guidelines, cross referencing of tables and sub-headings, and so on.

9.10.7 Review of diversion channel construction works

Construction reporting

The 2009 Independent Monitor Audit report noted that details of the construction process had not been sighted. In addition, it was recommended that hydraulic modelling of the as-constructed diversion works should be undertaken.

Subsequently, the 2010 Independent Monitor Audit report reviewed a March 2010 Connell Hatch report titled "Construction Report – Levee & diversions McArthur River Mine Expansion Project" and a number of concerns about the lack of construction detail in the reporting of both the river and creek diversions were noted. No response to these concerns has been forthcoming from MRM.

Additional flood modelling
As detailed in the 2009 and 2010 audit reports the Independent Monitor reiterates the recommendation that the diversion channel works should be tested by inserting as-built channel cross sections into the detailed design hydraulic model, together with associated reporting as to how the as-built channels compare with the various project commitments and design intents. It is noted that MRM has made no commitment regarding the recommendation but is prepared to investigate options for the hydraulic assessment, although no time frame has been nominated for any investigation.

Modelling of the erosion occurring during previous wet seasons due to an overland flow path between the original McArthur River channel and the diversion channel was recommended but has not been undertaken. Such modelling would serve to inform the design of works to address historic as well as potential erosion impacts. While the IM notes that significant rock placement work was undertaken prior to the 2010/2011 wet season, some additional erosion, as detailed in section 5.1 of this report, occurred close to the diversion channel during that wet season. The earlier audit report recommendation that the flow path be incorporated into the as-built diversion channel model is reiterated.

Future reporting
As documented in the 2010 Independent Monitor Audit report, there is a Public Environmental Report commitment that another river diversion report be prepared in 2011 and it is recommended that the shortcomings listed above be addressed in the 2011 report.

9.10.8 diversion channel observations

McArthur River Channel
The upstream portion of the diversion channel was inspected during the May 2011 site inspection, which covered from chainage 0 m to chainage 1800 m but could not go beyond because post wet season vehicular access was not possible.

During the inspection, MRM staff advised that, although the total rainfall during the 2010/2011 wet season had been much greater than during the 2009/2010 wet season, the peak flood flows were not as high in the 2010/2011 wet season. Not surprisingly, the erosion of the eastern batter of the channel was similar to what was observed during the May 2010 visit. This is depicted in the standard series of 250 metre interval photographs taken from the western channel edge. For example, Plate 58 shows the similarity between the May 2011 eastern batter conditions near chainage 1750 m and those photographed in March 2010. Plate 60 also shows only minor changes as a consequence of the 2010/2011 wet season.

Works were undertaken during 2010 to address extensive scouring issues associated with the overland flow path between the Old McArthur River channel and the diversion channel at approximate chainage 500 m – 600 m, see Plate 59. Works also addressed some localized scouring on the western overbank area, approximate chainage 300 m, all of which was documented in an April 2010 MRM internal memo prepared by Garry Taylor. The areas covered by these works, which consisted of significant rock emplacement, were again inundated during the 2010-2011 wet season. During the May 2011 inspection it was noted that:

- the works near chainage 300 m had addressed the prior scour problem and had not been damaged by the subsequent wet season flooding;
- the flow path works near chainage 500 m – 600 m had mainly worked very well such that, where the rock had been placed, there were no signs of the rock having been moved or otherwise displaced, see Plate 61 and Plate 62. However the works

themselves had not extended sufficiently in a southerly direction with the result that new erosion occurred at an additional spill point back to the diversion channel; and

- there was some minor erosion at the toe of the mine levee wall, also associated with the same flow path towards the diversion channel, see Plate 64.

Plate 58 View of eastern batter slope scour at river channel chainage 1750 m; taken June 2011. There is very little change as a result of 2010/2011 wet season flows (compared with 2010 photograph, see Plate 57). Photo: Independent Monitor

Plate 59 Aerial view of the McArthur River diversion channel showing the direction of the overland flood flow path from the old river channel to the diversion channel. Post 2010/2011 wet season scour was observed at the toe of the mine levy and over the area over which the water passed. Photo: Independent Monitor

2011

2010

Plate 60 Example of relatively minor bank erosion in the McArthur River diversion channel taken at the same location in 2011 (top) and 2010 (bottom), showing little change). Photos: Independent Monitor.

Plate 61 View of rock work placed in the foreground and background in 2010 to address scour along the overland flow path from the old McArthur River channel to the diversion channel. Photo is taken looking towards the old channel alignment. The mine levee wall can be seen behind the trees to the right. Photo: Independent Monitor

Plate 62 View of rock-lined chute at the diversion channel built as part of 2010 works to address scour along the flow path from the old McArthur River channel to the new diversion channel. Photo: Independent Monitor

Plate 63 Evidence of scour associated with the 2010/2011 wet season overland flow from the old McArthur River channel about to spill into the diversion channel, located just to the right out of the photo. The photograph location is just south of scour repair works placed along the flow path in 2010. Photo: Independent Monitor

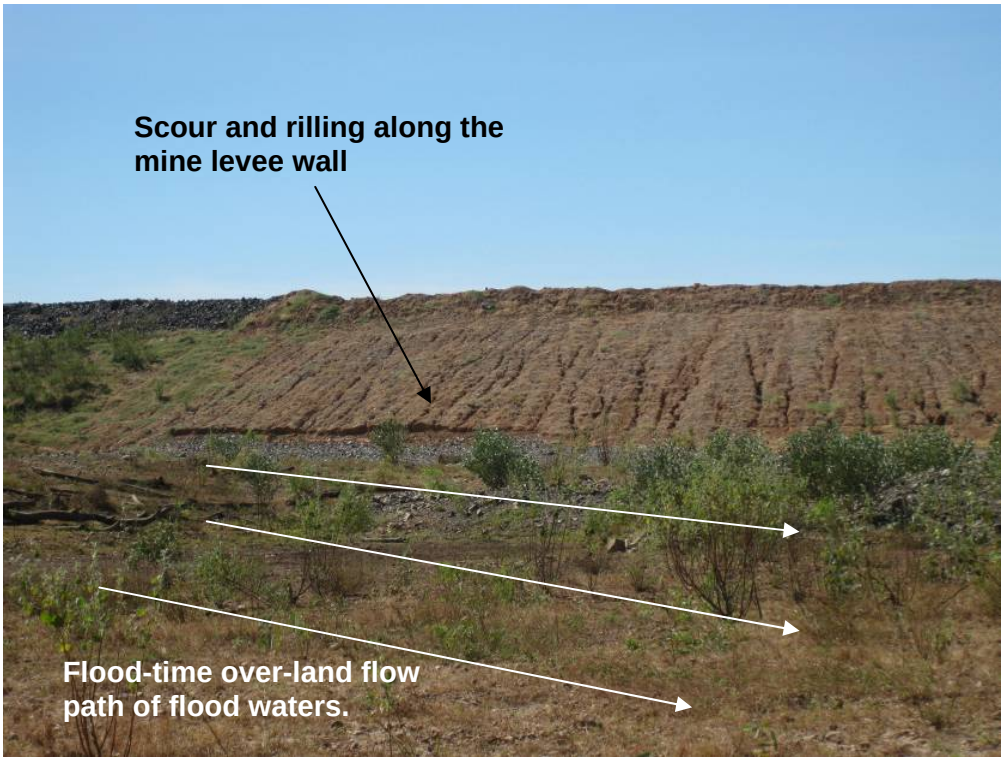


Plate 64 Minor erosion at the toe of the mine levee wall due to flood flow from original McArthur River channel being conveyed overland towards the diversion channel. Photo: Independent Monitor

The southern spill point erosion was pointed out to MRM staff and it was agreed that rock protection works were needed at that location.

While the as-built chute works at the point of spill back into the diversion channel coped well with the 2010/2011 flows, see Plate 62, it is unknown how much larger flows the chute works will be able to cope with.

Significant deposits of sand were observed at several eastern chute locations, but it was difficult to ascertain whether the sand represented a deposition of material on top of the original scour protection rock work or whether some of the rock works had been washed away, leaving behind rock remnants which were subsequently covered with sand. As was recommended in the 2010 Independent Monitor Audit report, all chutes should be inspected after each wet season in order to assess the amount of change which has occurred since the previous dry season.

Ponded water was observed in the depression between the toe of the mine levee wall and the diversion channel. MRM staff advised that this was due to an old access track which still crossed the depression and it was agreed that the access track would be breached so that the ponding would no longer occur.

Plate 65 June 2011 view looking upstream along the Barney Creek diversion channel. Photo: Independent Monitor

Barney Creek channel

The Barney Creek diversion channel, see Plate 65, was inspected from its upstream end to the point where the MRM OEF haul road crosses the channel. No signs of any erosion were observed and the 2010 dry season rock works had successfully addressed the batter slope erosion which had occurred opposite the Barney Creek/Surprise Creek confluence, see Plate 66.

Plate 66 Looking downstream along Barney Creek diversion channel at Surprise Creek confluence. 2010 rock armouring of channel batter slope opposite Surprise Creek entry (to address 2009/2010 wet season scour) is shown in right hand portion of photo. Photo: Independent Monitor

Diversion Channel erosion reporting

At the time of the inspection, documentation of post 2010/2011 wet season channel erosion had not yet been prepared. The Independent Monitor looks forward to reviewing the upcoming document and notes the MRM commitment to use aerial photography/ALS data as well as review successive series of 250 metre interval photographs to report on existing and new areas of erosion.

It is anticipated that, following the commencement of opposite bank photography by MRM, the report will also provide some initial McArthur River western batter and Barney Creek southern batter comments.

10 OTHER SITE INSPECTION OBSERVATIONS

10.1 Supplies warehouse and store yard

Hydrocarbon storage areas were inspected by the Independent Monitor this year to confirm the observations of the site inspection by the DoR in May 2010 (refer section 7.2.1) and follow up on their recommendations for hydrocarbon management. The storage shed and yard appeared to be neat and tidy, and the personnel appeared to be well informed about the risks associated with the hazardous chemicals they manage in this area.

The following observations and recommendations are made in order to improve environmental performance and decrease the risk of an adverse environmental incident:

- install collapsible bunding at the entry to the waste oil pad (pictured in Plate 67) should be replaced as soon as possible—staff advised that this had been ordered, and a sump installed at the rear of the pad;
- the ULP bowser and associated underground fuel storage tank, approximately 11 000 L) appears to be more than 20 years old. Therefore, fuel line integrity testing should be carried out to ensure that subsurface hydrocarbon contamination is not occurring;
- efforts should be made to reduce the soil dust blowing from the yard with the potential to spread any soil-borne contaminants to other areas of the site; and
- as previously recommended by DoR and acknowledged by MRM staff, fixed bollards should be placed in front of the ULP pump to prevent accidental damage by vehicles.

Plate 67 Waste oil stored in IBCs in the store yard. The collapsible bunding shown in the foreground is in need of replacement, and no sump exists in the concrete containment pad. Photo: Independent Monitor

10.2 Mining workshops

Vehicles and other equipment are serviced in these workshops adjacent to the PACRIM yard and they were inspected by the IM in May 2011. Previously, they were inspected by the DoR in May 2010. Many of the same observations as the DoR were made by the IM, including:

- likely hydrocarbon contaminated soil at the entry to the workshops (Plate 68);
- vehicle oil/fuel being allowed to drip onto the floor of the work area while machinery was being worked on; and
- oil storage areas at the rear of the workshops did not have secondary containment

In addition, it was noted by the IM that:

- concrete around the workshop area was in good condition, which reduces the risk of soil contamination beneath the concrete;
- there was grey dust, probably from the PACRIM crusher, on the concrete pavement near the workshops;
- MRM staff advised that these workshops will eventually be moved to the OEF. Consequently, prior to this move, an investigation of the spatial extent of possible hydrocarbon contamination in soil around the workshops, should be undertaken to identify what areas will require disposal or remediation.

Plate 68 Vehicle workshop area with possibly impacted soil at the front entrance. Photo: Independent Monitor.

10.3 Bing Bong Port site inspection

10.3.1 Inspection of the Aburri loading procedure

In 2010, anonymous claims were made in the media that concentrate dust had been spilt and washed off the Arburri Barge during cleaning (Langford, 2010). Inspection of the facility by the IM during the loading process revealed that it was entirely closed, with no observable

dust on the pavement or coming from the loading plant. Only a small amount of concentrate falls from the lowest end of the loading conveyor onto the hardstand during loading and is promptly collected after the completion of loading.

Although the possibility that small amounts of concentrate have been accidentally spilled through previous loadings cannot be ruled out, observation by the IM indicate that the loading plant and procedures are satisfactory and that there is minimal opportunity for concentrate to escape during loading as long as procedures are followed correctly. Review of the marine sediment and seawater monitoring undertaken by MRM indicate that the programs are generally appropriate (section 9.6).

10.3.2 Additional Bing Bong Port surface runoff pond

During the May 2010 inspection, the Independent Monitor inspected an additional surface runoff pond being installed adjacent to the existing Bing Bong surface runoff pond. This extra storage pond was initially constructed as a matter of urgency during the 2009/2010 wet season to cope with the excess runoff being collected at the facility.

This year, the final construction of the additional Bing Bong surface runoff pond was inspected. It is noted that this storage pond also proved useful in the 2010/2011 wet season, as unusually high rainfall meant that above average volumes of runoff were collecting in both ponds. Despite this, MRM were forced to truck runoff water from Bing Bong to the TSF to prevent an overflow of the ponds.

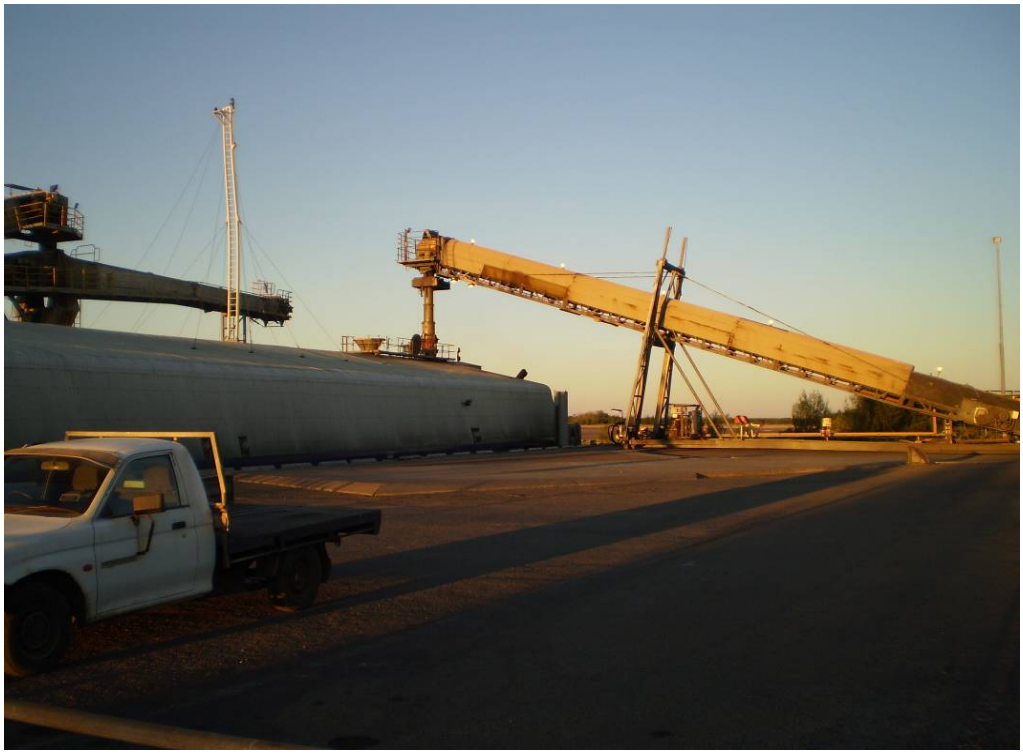


Plate 69 Aburri Barge being loaded with concentrate from a conveyor as observed by the Independent Monitor team on 30 May 2011. Photo: Independent Monitor.

Plate 70 Additional surface runoff dam constructed at Bing Bong Port. Photo: Independent Monitor.

11 SUMMARY OF RECOMMENDATIONS

TABLE 11 SUMMARY OF RECOMMENDATIONS AND TIMEFRAMES

Surface water monitoring – section 9.1.1	**Priority level**
Quality assurance and control reporting should be presented and discussed. As described in previous Independent Monitor reports, a discussion on the quality, precision, accuracy and reproducibility of results is an essential component of water monitoring. The aspects of the QA/QC reporting should include comparison of field to laboratory results—TDS/EC, field pH to laboratory pH—relative percent differences between discrete and intra-laboratory blind duplicate samples; and findings of the laboratory's own quality control reporting.	Medium
Data collected during 'cease to flow' times should be provided on the trend charts in the report as these can demonstrate whether these spikes are only associated with cease to flow occasions, or are part of a longer term trend in changing water quality.	Lower
Adjustments to the surface water monitoring program should be implemented by adding sampling points directly under the bridge over Surprise Creek, downstream from TSF Cell 1 at the location of the salt crystals observed by the NT Environment Centre, and also additional sampling points on the drainage line where the seepage incident from the NOEF was reported by MRM to DoR.	Lower
Groundwater monitoring – section 9.2.6	**Priority level**
A separate and robust hydrogeological and hydrogeochemical model and report for the TSF should be developed and updated annually. It is recommend that this report be provided as an appendix to MRM's annual WMP and the findings incorporated into the body of the report, including actions to address the recommendations made.	**High**
Groundwater contours in each separate formation, but particularly the bedrock and the alluvium, need to be drawn at least bi-annually—at the end of wet and end of dry seasons. These can also be used as a check against the predicted drawdowns in the updated URS groundwater model. Separate groundwater contours should be drawn for the TSF, the regional monitoring network and Bing Bong. These will enable more precise interpretation of groundwater flow direction(s) and hydraulic gradients and, in turn, provide visual representation of the significant factors in groundwater impacts from the operations. This is a recurring recommendation by the Independent Monitor and why it has not undertaken has not been adequately addressed by MRM.	**High**
Quality control and quality assurance has not been presented or discussed for groundwater monitoring. A discussion on the quality, precision, accuracy and reproducibility of results is an essential component of groundwater, and water monitoring reporting in general. This includes, but may not be limited to, a discussion on the comparison of field and laboratory measurements—pH in the field and laboratory, TDS/EC ratios—relative percentage differences between discrete and intra-laboratory blind duplicate samples; and findings of the laboratory's own quality control reporting.	Medium
Dust Monitoring – section 9.3.8	**Priority level**
Reduce the potential for dust emissions at the mine site and Bing Bong Port including: increasing concentrate moisture, reducing concentrate stockpiles, increasing the use of water sprays and water trucks, implementing a spilt concentrate recovery program and increasing training of MRM staff.	**High**
Works towards the completion of agreed measures should commence in the following reporting period— that is, placing a vegetation barrier between the ROM pad and main road, implementing an extraction system in the Bing Bong concentrate shed, repairing the damaged Bing Bong shed walls and increased use of the street sweeper.	**High**

Dust Monitoring – section 9.3.8 (continued)	Priority level
Improve reporting of dust monitoring by providing laboratory QA/QC data, updating maps and standards referred to, statistical analysis of trends and detailed discussions of results and the effectiveness of mitigation measures.	Medium
Investigate the option of applying a commercially available dust stabilization product to aid in dust mitigation. However, the use of such a product should be carefully assessd and planned to ensure that it does not adversely affect the environment.	Lower
Soil monitoring - section 9.4.4	**Priority level**
Improved reporting of soil monitoring is required see section 9.4.4.	**High**
Temporal monitoring and assessments should be undertaken and discussed to evaluate whether soil contamination is occurring, and sources of contamination.	**High**
Soil results need to be assessed in line with depositional dust metal concentrations and fluvial sediment concentrations to establish causes and potential transport mechanisms.	**High**
Determine site-specific trigger levels and cease applying HIL concentrations as trigger levels up to which contamination is not considered an issue.	Medium
Determine background concentrations of metals and other analytes in soil.	Medium
Field QA/QC needs to be undertaken to provide robustness and reliability to the data collected. This is part of industry standards and has been recommended by the Independent Monitor in past audits.	Medium
Discussion needs to be provided in future MMPs with regard to all parameters analysed—soil pH, electrolytic conductivity, particle size distribution and major cations: sodium, calcium, magnesium and potassium.	Medium
Whenever elevated or unusual metal concentrations are recorded, MRM should undertake further investigation, such as further sampling in nearby areas or isotope analysis, to determine the causes of the contamination and limit further impacts.	Medium
Analysis of the potential for soil issues such as erosion, salinity and sodicity, should be undertaken.	Lower
Charts provided need to include data from previous years in order to assess long term trends.	Lower
Consider undertaking soil sampling at areas outside the mining lease, ideally in both upwind and downwind locations, to assess whether any mining impacts are occurring outside the mine site due to wind or water transport and deposition.	Lower
Fluvial sediment - section 9.5.4	**Priority level**
No study has yet been conducted to determine background heavy metal concentrations. This is vital for determining suitable targets for mine closure planning and for the protection of local stream biota.	Medium
MRM should implement field QA/QC in future monitoring rounds to add rigour and reliability to the data.	Medium
While the assessment of sediment concentrations against ANZECC/ARMCANZ (2000) ISQGs is useful, MRM need to assess all data collected for particle size, pH and metal concentrations in fine fractions, to draw the most accurate conclusions	Lower
Toxicity testing has not been undertaken for sediments exceeding the ISQGs thresholds. It is recommended that this be undertaken for future monitoring as directed by ANZECC/ARMCANZ (2000).	Lower
Seawater and marine sediment monitoring – section 9.6.5	**Priority level**
Ensure that laboratory transcripts, chain of custody forms and QA/QC interpretation of results are provided in future water management plans or associated marine monitoring reports.	Medium

Seawater and marine sediment monitoring – section 9.6.5 (continued)	Priority level
Ensure that the chosen ANZECC/ARMCANZ (2000) 95% of protection level values for seawater are protective of key ecosystem species and provide an explanation into why this level was chosen.	Medium
Long-term trend analysis should be provided in the water management plan.	Medium
Samples at either side of the transects outside the swing basin should be collected and analysed to assess the lateral extent of heavy metal impacts. In addition, transect samples already being collected as part of the marine monitoring program should be analysed individually and not composited.	Medium
Given that slightly elevated nickel levels were found in sediment samples collected in the trans-shipment area, it is recommended that this analyte be added to all future monitoring programs.	Medium
Lead isotope ratios of suspended sediments in the McArthur River delta and at Bing Bong should be continued.	Medium
Monitoring of the McArthur River delta sediments east of Bing Bong should be undertaken as the potential for impact exists at this location.	Medium
MRM should ensure that seawater samples collected as part of the monthly seawater monitoring are filtered so as to assess the dissolved metal phase concentrations, which will give a more indicative picture of water quality (except when evaluating suspended sediments).	Lower
Include the results of analyses undertaken using the DGT methodology in future WMPs. This should include the presentation of all results, trend analysis and conclusions.	Lower
Mine site flora monitoring (terrestrial) – section 9.7.3	**Priority level**
MRM should focus on achieving a species diversity along the diversions that more closely resembles the original river channels as per commitments in the 2009-2010 MMP (MRM 2009b, pg 38). MRM agree with this recommendation and have indicated that increasing of species diversity will be a focus of attention during 2011 and 2012 (MRM 2010c section 6.8, Crawford, J, pers. comm. 2011, Rehab plan-plant density excel sheet).	**High**
MRM should persist with successful planting of cane grass and freshwater mangroves on the McArthur River diversion as these species have been identified as key habitat plants for riparian birds. It is not clear at this stage how MRM will achieve a greater number of these species on the diversions—that is the amount of cane grass that will actually be available for transplanting from future mine pit clearing.	Medium
The vegetation monitoring program undertaken by CDU on the McArthur River diversion should be expanded. Currently, samples are collected from a length of approximately 1.2 km from a total of 11 km on both sides of the diversion and this sampling strategy may not be representative of conditions along the entire length of the channel.	Medium
Comparison of actual data versus baseline and analogue sites data for Barney Creek should be expanded in the annual revegetation monitoring reports.	Medium
MRM should include a status update in the MMP on the major areas to be rehabilitated, such as the OEFs, indicating whether they are still operational, the areas that have been completed and when rehabilitation is likely to commence.	Medium
It is recommended that MRM provide information and a map for the topsoil section of the MMP describing current stockpile locations, future areas requiring topsoil and from where the soil will be sourced.	Medium
The 2009-2010 and 2010-2011 MMPs (MRM 2009b pg 113, MRM 2010c pg 148) state that native and exotic grasses will be sown on the TSF for rehabilitation. The Independent Monitor recommends against the use of exotic species for rehabilitation.	(Longer term)
Mine site fauna management/monitoring – section 9.7.4	**Priority level**
Plant additional cane grass on the McArthur River diversion for the purple-crowned fairy-wrens.	Medium

Mine site fauna management/monitoring – section 9.7.4 (continued)	Priority level
Exclude cattle from areas of sensitive rehabilitation.	Medium
Focus on achieving desired species diversity along the diversions that resembles the original river channels	Lower
Continue macroinvertebrate monitoring for effects of mine operations and diversions on biota.	NA
Continue to monitor and add large woody debris into the diversions as required.	NA
Bing Bong flora monitoring – section 9.7.5	**Priority level**
Maintain the functionality/integrity of the perimeter spoon drain to reduce the risk of saline concentrated seepage causing dieback in vegetation surrounding the dredge spoil.	**High**
Commission a suitable contractor to commence revegetation studies and interpret orthophoto vegetation mapping such as making renewed efforts to attract a PhD student. This should include ground surveys of species composition, dieback areas and reference sites in vegetation studies.	**High**
Create a dredge management plan well in advance of scheduled dredging operations. MRM have been delaying the creation of dredge management plans until just prior to commencement of works. This is of concern to the Independent Monitor as a lead-up time is required to determine and implement best practice management, such as engineering works and the collection and propagation of local seed.	Medium
Bing Bong fauna monitoring – section 9.7.6	**Priority level**
Old tyres at the waste dump at the mine should have drainage holes inserted to prevent them becoming mosquito breeding sites.	Medium
The Independent Monitor recommends against spraying the dredge ponds with insecticide as this may have further negative impacts on other invertebrates and the surrounding environment.	Medium
Nine days after each of a selected number of heavy rainfall events, MRM should carry out larval counts of mosquitoes from the dredge ponds in the wet season.	Lower
As described in the mosquito monitoring report (Department of Health 2011), MRM is to fill in artificial dips where water ponds around the mine in the dry season.	Lower
Marine monitoring – section 9.7.7	**Priority level**
Future seagrass monitoring should continue to be undertaken at the end of the dry season to avoid the confounding associated with seasonal variations—that is, fluctuations in extent related to seasonal changes rather than long-term trends.	Medium
Inclusion of seagrass control sites beyond any potential influences of the port operations to provide a more thorough assessment of changes of seagrass distribution and cover within the current study area.	Lower
Should a large disturbance to seagrass communities be identified, a post disturbance survey should be conducted in order to assess whether these changes relate to natural disturbances or Bing Bong operations.	Lower
To avoid confusion, the organisms examined for heavy metal contamination should be referred to as gastropods or bivalves rather than molluscs. Both groups are molluscs but are described separately in the Annual Marine Monitoring Report (Parry, 2011a).	Lower
Tailings storage facility – geotechnical recommendations – sections 9.8.1 and 9.9.3	**Priority level**
Install piezometers in embankments and carry out a comprehensive dam safety review including stability analysis of the embankments, especially the southern embankment of TSF Cell 2 where water is ponding against the embankment.	**High**

Tailings storage facility – geotechnical recommendations – sections 9.8.1 and 9.9.3 (continued)	**Priority level**
Prior to the imminent wet season, carry out a review of the available capacity to store tailings and process water and rainfall runoff while maintaining sufficient freeboard. Prior to being used to predict required capacity, the water balance model will require detailed calibration.	**High**
Inspect seepage outfall drains and clean any that are blocked to ensure free flow of seepage.	**High**
Remove the temporary bund in the spillway.	**High**
Remove excess water from the facility.	**High**
Install bund or secondary containment pipe on the pipeline ramp to the TSF.	Medium
Additional, less urgent, geotechnical recommendations are provided in section 9.8.1	Medium
Overburden emplacement facility – section 9.8.2 and 9.9.2	**Priority level**
Construct a top cover over the OEF prior to the wet season.	**High**
Review classification method for indentifying NAF waste. There is potential for bypassing the neutralising mineralogy.	**High**
Review the mineralogy of the NAF and PAF and AC waste to determine what minerals are present including carbonates, dolomites, sulfides and sulfates.	**High**
Produce a technical specification for clay placement and maintain am higher level of supervision for clay placement.	Medium
Improve compaction and moisture control for basal clay liner and lateral clay covers.	Medium
Place a paddock dumped cover over basal clay liner and lateral clay covers on completion of compaction of clay.	Medium
Rather than the end dumping procedure, MRM may consider horizontal layer paddock dumping across the face of the PAF cell. Monitor the QA/QC of the clay placement to ensure that the design material thickness is maintained over the slope. Armour the clay cover prior to the wet season.	Medium
Reconsider the implementation of larger kinetic cells or test columns on site.	Medium
Review and analyse selected waste rock samples for sulfide sulfur as well as total sulfur.	Medium
Additional, less urgent, geotechnical recommendations are provided in section 9.8.2	Medium
Tailings storage facility geochemical recommendations – section 9.9.3	**Priority level**
Correct errors in the MRM conceptual model of seepage from TSF Cell 1.	**High**
Accelerate leaching trials on current tailings to establish the number of pore volumes required to consume buffering capacity.	Medium
Evaluate the possibility of recovering the tailings from Cell No 1 for inclusion in the design the tailings seepage and closure management system.	Medium
Investigate and discuss when seepage will occur from TSF Cell 2 and where it will go to determine what the likely impacts will be.	Medium
Bing Bong dredge spoils – section 9.8.4	**Priority level**
A geotechnical review of embankment stability is required prior to the imminent wet season.	**High**
Clean out existing drain to allow free flow of drainage.	**High**
Install piezometers and survey monuments for the geotechnical monitoring program to be implemented.	Medium

Bing Bong dredge spoils – section 9.8.4 (continued)	Priority level
Install an engineered spillway before the imminent wet season.	Medium
River diversions – section 9.10	**Priority level**
Use the same RL datum throughout the mine project to relate the zero reading values of all the various gauging stations.	Medium
Use the May 2010 aerial photography to draw comparisons of erosion along both diversion channels. In addition, use of the accompanying ALS ground truth data to map changes in the diversion channel batters.	Medium
Improve the presentation of the Barney Creek gauging station and early warning flood station data by the adoption of the same twelve month time axis plot presentation for all stations.	Medium
A series of permanent posts or a similar system be installed and recorded on a map to define the exact locations and orientations from which photographs are taken to ensure consistency for comparison. In addition, when taking new photographs, staff should carry copies of past photographs to ensure this consistency.	Medium
Discuss the variable trends in gauging station readings in the WMP report.	Medium
Include in future WMP reports a map which plots labels the complete network of sediment traps.	Medium
Following future protective works, in the immediately following WMP report, include details about rock types, their source and sizes are used for the repair work.	Medium
Incorporate the overland flow path between the old McArthur River and the diversion into the work as-built diversion channel model.	Medium
Include discussion of the relative magnitudes of flows in each wet season in future reporting of erosion trends.	Lower
In future, compare historic flows with the range of design flows by linking the data sets for the 2008/2009, 2009/2010 and 2010/2011 wet season flows and the design flood flows for three locations along the McArthur River.	Lower
Supplies warehouse and stores yard – section 10.1	**Priority level**
Replace the collapsible bunding at the entry to the waste oil pad (pictured in Plate 67) as soon as possible and install a sump at the rear of the pad.	**High**
Because the ULP bowser and associated underground fuel storage tank appear to be more than 20 years old, fuel line integrity testing should be carried out to ensure that subsurface hydrocarbon contamination is not occurring;	Medium
Place fixed bollards in front of the ULP pump to prevent accidental damage by vehicles.	Medium
Keep dust generation in the store yard to a minimum with increased use of the water truck.	Lower
Mining workshops – section 10.2	**Priority level**
Prior to future relocation of the workshops, investigate the spatial extent of possible hydrocarbon contamination in soil around the workshops to delineate which areas will require disposal or remediation.	Lower
Mining management plan improvements – section 6.4	**Priority level**
That MRM's next MMP acknowledge and address the significant issues indentified by the Independent Monitor in this audit report to show that MRM does take the IM's findings and recommendations into consideration in the monitoring and management of the MRM operation.	Medium
That MRM prepare detailed annual reports for each monitoring program, setting out its application according to scientific conventions, quality control documentation and detailed discussions of results and measures for improvement, possibly as a summary in the MMP, with the full reports provided as appendices. This should be discussed with the DoR.	Medium

12 CONCLUSIONS

The Independent Monitor acknowledges that the environmental performance of the McArthur River Mine is improving and MRM have shown a willingness to improve their environmental monitoring based on recommendations made in previous years.

Some monitoring programs are considered to be operating generally well, including:

- flora and fauna;
- surface water; and
- fluvial sediment.

To some degree, the reporting in the MMP is improving and the WMP is an improved document. However, there are many improvements still to be made to bring many monitoring programs up to the leading practice level (DRET, 2011).

Two urgent issues raised by the Independent Monitor in 2009, under section 6.4 of the Independent Monitoring Assessment Conditions (IMACs), remain as significant issues in this audit.

Monitoring and corrective measures of the Bing Bong dredge spoils are preventing the spread of vegetation dieback, however recent investigation into the seepage from TSF Cell 1 has confirmed that acid sulfate, zinc, lead and perhaps cadmium contamination, has impacted macroinvertebrates in Surprise Creek. The investigation also indicates that the acid buffering capacity of the tailings will be exceeded and acid seepage will occur. Soon after this acidity is produced, high metal levels in the leachate could also be expected to reach Surprise Creek. Therefore, long term seepage prevention is required. The re-processing of tailings in TSF Cell 1, as suggested by a consultant to MRM, may be the best option.

In this audit, there were no issued identified that were regarded as requiring urgent notification under IMACs, however the following issues are considered to be significant and require immediate action towards rectification:

- just as it did last audit, the volume of water stored in TSF Cell 2 remains a concern. There is considered to be an ***extreme*** risk of embankment failure or overtopping of the spillway;
- the visual method of classifying NAF/PAF waste rock is of concern because of the potential for miss-classification;
- as discussed above, seepage from the TSF Cell 1 into Surprise Creek continues to be a significant issue;
- fugitive dust emissions from the PACRIM area, and to a lesser extent the Bing Bong concentrate storage shed;
- the structural integrity of the Bing Bong dredge spoil pond walls;
- the slow progress of revegetation on the McArthur River diversion; and
- concerns about the inadequacy of reporting of many routine monitoring programs, including the lack of:
    - scientific method;
    - background data and site-specific trigger levels;

- QA/QC reporting;
- adequate discussions of results;
- temporal trends analyses; and
- discussions regarding contaminant sources and mitigation measures.

Numerous other issues that require rectification to improve environmental performance are provided within the recommendations summary, section 11, Table 11, with priorities levels clearly indicated.

13 LIMITATIONS

This report has been prepared by Environmental Earth Sciences VIC, ABN 13 109 404 024 in response to and subject to the following limitations:

1. The Independent Monitor Assessment Conditions (IMACs);
2. The specific scope of services set out in the contract issued by the Department of Resources– Document KO7-0065;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences VIC, which consent may or may not be given at the discretion of Environmental Earth Sciences VIC;
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works, being the McArthur River Mine and Bing Bong Port facilities, Northern Territory (“the site”); and
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities.

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15 GLOSSARY OF TERMS

The following descriptions are of terms used in the text of this report.

Acid neutralising capacity (ANC), the natural resistance of a soil to acid generation. It is the number of moles of protons per unit mass of soil required to raise the pH of the soil by one pH unit. ANC is measured as percentage of $CaCO_3$.

Acid sulfate soil (ASS), soil containing iron sulfides deposited during either the Pleistocene or Holocene geological epochs (Quaternary aged) as sea levels rose and fell.

Acidify, addition of acid to lower pH.

Alluvial, describes material deposited by, or in transit in, flowing water.

Aquifer, rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Background, natural level of a property.

Baseline, initial value of a measure.

Bio-availability, amount of a substance able to be assimilated during the digestion process of an organism.

Borehole, an uncased well drill hole.

Buffer, ionic compound, usually a salt of a weak acid or base, added to a solution to resist changes in its acidity or alkalinity and thus stabilise its pH.

Cation exchange capacity (CEC), maximum positive charge required to balance the negative charge on colloids (clays and other charged particles). The units are milli-equivalents per 100 grams of material or centimoles of charge per kilogram of exchanger.

Clay, soil material composed of particles finer than 0.002 mm. When used as a soil texture group such soils contain at least 35% clay.

Composite sample, bulking and thorough mixing of soil samples collected from more than one sampling location to form a single soil sample for chemical analysis.

Conductivity (EC), conductivity of water is an expression of its ability to conduct an electric current. This property is related to the ionic content of the sample, which is in turn a function of the total dissolved (ionisable) solids (TDS) concentration. An estimate of TDS in fresh water can be obtained by multiplying EC by 0.65.

Contaminant, generally, any chemical species introduced into the soil or water. More particularly relates to those species that render soil or water unfit for beneficial use.

Contamination, is considered to have occurred when the concentration of a specific element or compound is established as being greater than the normally expected (or actually quantified) background concentration.

Dilution, the mixing of a small volume of contaminated leachate with a large volume of uncontaminated water. The concentration of contaminants is reduced by the volume of the lower concentrated water. However the physical process of dilution often causes chemical disequilibria resulting in the destruction of ligand bonds, the alteration of solubility products and the alteration of water pH. This usually causes precipitation of various species by different chemical means.

Discrete samples, are samples collected from different locations and depths that will not be composited but analysed individually.

Dissolved oxygen (DO), oxygen in the gaseous phase dissolved in water. Measured either as a concentration in mg/L or as a percentage of the theoretical saturation point, which is inversely related to temperature. At 19, 20 and 21 degrees Celsius, the oxygen concentrations in mg/L corresponding to 100% saturation are 9.4, 9.2 and 9.0 respectively.

Drawdown, lowering of a water table by pumping from one or more wells.

Electrolytic conductivity (EC), measure of the extent to which water conducts an electrical current and is related to the total concentration and relative proportions of the dissolved ionised substances within the water, and the temperature at which the determination is made.

Flow path, direction in which groundwater is moving.

Fluvial, material deposited by, or in transit, in streams or watercourses.

Fracture, break in the geological formation, e.g. a shear or a fault.

Gradient, rate of inclination of a slope. The degree of deviation from the horizontal; also refers to pressure.

Groundwater, water held in the pores of an aquifer.

Hydraulic head, the sum of the heads (potentials) at a point in an aquifer.

Heavy metals, all metallic elements whose atomic mass exceeds that of calcium (20) and includes lead (Pb), copper (Cu), Zinc (Zn), cadmium (Cd), and tin (Sn).

Hydrocarbon, molecule consisting of carbon and hydrogen atoms only, such as found in petroleum.

Infiltration, the passage of water under the influence of gravity, from the land surface into the subsurface.

Ion, an ion is a charged element or compound as a result of an excess or deficit of electrons. Positively charged ions are called ‘cations’, while negatively charged ions are called ‘anions’. Cations are written with superscript ‘+’, whilst anions use ‘–’ as the superscript. The major aqueous ions are those that dominate total dissolved solids (TDS). These ions include: Cl^-, SO_4^{2-}, HCO_3^-, Na^+, Ca^{2+}, Mg^{2+}, K^+, NH_4^+, NO_3^-, NO_2^-, F^-, PO_4^{3-} and the heavy metals.

Leachate, is water that has flowed through waste or other material and liberated soluble molecules to form leachate.

Net acid generation potential (NAGP), this is the difference between the TOS and ANC reported on a kilogram H_2SO_4 production per tonne of soil.

Oxidation, originally referred only to the addition of oxygen to elements. However oxidation now encompasses the broader concept of the loss of electrons by electron transfer to other ions.

Permeability, property of a porous medium relating to its ability to transmit or conduct liquid, usually water, under the influence of a driving force. Also referred to as 'hydraulic conductivity'.

Piezometer, a cased borehole with a short slotted screen for measuring standing water level (SWL), which represents a potentiometric surface or elevation of the water table; also used to obtain samples of groundwater for quality assessment.

pH, the logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity.

Potentiometric surface, the water level that represents the standing or total hydraulic standing head. In an aquifer system it represents the levels to which water will rise in tightly cased walls, e.g. a cased borehole.

Precipitation (chemical), there are two types of precipitation, pH dependent precipitation and solubility controlled precipitation. As the pH is raised beyond a threshold level the precipitation of metal cations such as oxy-hydroxides and hydroxides occurs. As the pH is raised further precipitation continues until there are very few metal cations remaining in solution. This reaction is entirely reversible. Solubility controlled precipitation occurs between two ions when, at a given temperature and pressure, the concentration of one of the ions exceeds a certain level.

Putrescible waste, food waste, waste consisting of animal matter, including dead animals or animal parts, or biosolids categorised as Stabilisation Grade C in accordance with the criteria set out in the Biosolids Guidelines.

QA/QC, Quality Assurance/Quality Control.

Recovery, rate at which a water level in a well rises after pumping ceases.

Remediation, restoration of land or groundwater contaminated by pollutants to a state suitable for beneficial uses.

Siderite, carbonate form of iron (Fe^{2+}), chemical composition $FeCO_3$. Commonly found in presence of sideroplesite ($MgCO_3$) in carbonaceous rocks, or as precipitation from carbonaceous groundwater.

Suspended solids (SS), matter which is suspended in water which will not pass through a 0.45 µm filter membrane.

Topsoil, part of the soil profile, typically the A1 horizon, containing material which is usually darker, more fertile and better structured than the underlying layers.

Total dissolved salts (TDS), these comprise dissociated compounds and un-dissociated compounds, but not suspended material, colloids or dissolved gases.

Turbidity, describes the degree of opaqueness produced in water by suspended particulate matter.

Water table, interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is the response of Environmental Earth Sciences to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences VIC. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences VIC disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences VIC disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences VIC's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

APPENDIX A RISK ASSESSMENT TABLES

TABLE 12 RISK MATRIX

Consequence		Likelihood (regardless of potential time latency)				
		1	2	3	4	5
		Certain	Likely	Possible	Unlikely	Improbable
1	Catastrophic	2	3	4	5	6
2	Major	3	4	5	6	7
3	Moderate	4	5	6	7	8
4	Minor	5	6	7	8	9
5	Insignificant	6	7	8	9	10

TABLE 13 RISK RATING EXPLANATIONS

Risk Matrix result	Risk Rating	Description
2 to 3	E	**Extreme-** Immediate intervention required to eliminate or reduce risk at a Senior Management/ Government level.
4 to 5	H	**High Risk -** It is essential to eliminate or reduce risk to a lower level by the introduction of monitoring and assessment measures implemented by senior management.
6 to 7	M	**Moderate -** Corrective action required, and monitoring and assessment responsibilities must be delegated.
8 to 10	L	**Low Risk -** Corrective action should be implemented where practicable, and risk should be managed by routine monitoring and assessment procedures.

TABLE 14 KEY TO RISK TABLE (TABLE 15)

Location of impact	
RI	Regional impact (>2km radius outside mining lease)
OM	Impact outside mine lease area - (<2km radius)
WM	Wide impact within mining lease boundaries
L	Localised area within mining lease boundaries
P	Small point source within mining lease boundary
Potential Duration of impact	
G	Geological long term (>100 years)
L	Long term (30- 100)
M	Medium term (5-30 years)
S	Short term (1-5 years)
E	Ephemeral/seasonal impact

TABLE 15 RISK REGISTER – ORDERED BY RISK RANK

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
3	**TSF**	3.2	Geochemical	3.2.1	Acid/ metals leaching from TSF into surprise creek	L	RI	Known conduit to Surprise Creek, Capacity of tailings to go acid has been confirmed, but no quantification or timing has been determined through investigation.	Seepage recovery bores Shallow Cut-off barrier (Ineffective) Monitoring of surface water and groundwater and incoming tailings. Completion of clay cap of cell 1.	2	1	3	E	Ascertain velocity of groundwater (and acid and dissolved metals). Establish long-term oxidation rate of tailings Response to monitoring results of current tailings. Geochemistry of tailings is yet to be understood. Acid production must be considered within the Mine Closure Plan. Establish likely metal and acid concentrations in Surprise Creek, Consider recovery of tailings.
3	**TSF**	3.4	Geotechnical	3.4.5	Overtopping of TSF Cells leading to embankment failure.	M	OM	Spillway under designed for flood event. Temporary bunding in spillway should not be placed as reduces capacity of spillway to discharge during a rain event.	Inspections and OPSIM modelling undertaken annually.	1	2	3	E	Increase freeboard on dam required. MRM have plans to raise this. IM has no details on this, however. Increase design storage allowance. Additional water reduction incl. Cell 1 runoff diversion from entering Cell1. temporary bunding should not be placed in spillway. Spill rating should be confirmed.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
3	**TSF**	3.3	Leachate/seepage	3.3.1	Dry Season discharge of seepage containing salt, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.	S	OM	Seepage from TSF into surprise creek.	TSF geopolymer barrier; TSF design; Seepage monitoring, surface water and groundwater monitoring, plus other flora/fauna studies in Surprise creek.	3	1	4	H	Undertake further investigation into TSF seepage monitoring and mitigation; undertake periodic visual inspections of Surprise Creek and surrounds to monitor and assess flora health. Subsurface cut-off drain.
3	**TSF**	3.4	Geotechnical	3.4.1	Cell 1 embankment fails - spillage into Surprise Creek	M	OM	Poor Design, construction and/ or maintenance; Significant Storm Event, Seismic Event	Daily MRM visual inspections, AWA annual inspections (not complete/unsatisfactory), Monitoring from recovery wells d/s of embankment. Clay capping of Cell 1 complete.	1	3	4	H	AWA 2010 report does not consider embankment stability - this should be investigated. Further piezometers should be installed embankment and tailings. Design should be investigated for adequacy.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
3	**TSF**	3.4	Geotechnical	3.4.3	Cell 2 embankment fails- Stability failure.	M	OM	Poor Design, Poor Construction, Poor Maintenance, Significant Storm Event, or Seismic Event. Elevated water pressure in embankment.	Daily MRM visual inspections, AWA annual inspections, Monitoring from recovery wells d/s of embankment. Changes to spigot locations means tailings now placed against embankment first	1	3	4	H	Design report does not match what has been constructed Additional Piezo monitoring needs to installed, some installed but inadequate to fully characterise phreactic surface within the embankment Stability monitoring of embankments. Consideration of additional drainage prior to raising. Consider relocating decant location to centre to reduce risk of failure.
3	**TSF**	3.4	Geotechnical	3.4.4	Cell 2 Embankment failure due to scouring at toe of embankment.	M	WM	Wet season flooding - Creek at Western corner of Cell 2 scours out toe of embankment and causes collapse.	None known.	1	3	4	H	A flood route study should be conducted to assess velocities and requirement for erosion protection along embankment toe.
5	**PACRIM and ROM**	5.1	Dust emissions	5.1.1	Contamination of surface soils, vegetation, sediment with salts, heavy metals	L	RI	Spread of zinc and lead laden dust from mining operations and Pacrim yard/ROM Pad.	Dust monitoring program and dust mitigation measures including water sprays and upgrading of Pacrim conveyors. Sediment monitoring in streams and delta	3	1	4	H	Dust mitigation practices should increase for the ROM/ Pacrim. Monitoring should consider long term trends to assess effectiveness of measures.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
1	**Bing Bong dredge spoil**	1.1	Drainage	1.1.1	Migration of saline/ hypersaline seepage causes local and regional vegetation die-back surrounding the dredge spoil.	M	RI	Drainage and seepage occurring into adjacent land due to seepage through pond wall. Blockage of drain to sea.	Drain to sea was established in 2009/2010, but needs repairing due to erosion. Land survey undertaken in 2010.	2	3	5	H	Monitor re-growth in areas around spoil piles for signs of stress and dieback. Ongoing monitoring and maintenance of berm walls and drains. Remove water from the spoil as quickly as possible.
1	**Bing Bong dredge spoil**	1.2	Geotechnical	1.2.1	Catastrophic failure of dredge pond walls leading to inundation of adjacent areas with saline material.	M	OM	Failure of pond walls/bund as a result of poor design and construction of the dam walls/bund. Overtopping and failure of walls may also occur due to high rainfall.	Infrequent inspections undertaken by Bing Bong personnel. Commitment to undertake rehabilitation trials. Culvert system installed to allow water to drain off top of dredge spoil and back out to sea. Dry cells do not pose as significant a risk of failure as wet cells.	2	3	5	H	Conduct more frequent inspections of containment pond walls. Manage future placement of dredge spoil to reduce the pressure on pond walls. Increase drainage from the containment ponds to prevent saturation of wall and piping failure. Assess suitability of existing drain pipes/culverts to cope with high rainfall events to remove water quickly. Ongoing monitoring and maintenance of culverts and drains to ensure that water in spoil ponds is flowing freely to drainage ditches. Increase free-board to allow for design storm (as per design criteria) and confirm or re-assess the current rainfall and evaporation data and water balance.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
2	**Bing Bong Port**	2.2	Surface water	2.2.1	Overflow of Bing Bong surface runoff pond (BBSRP) containing metals and acid contaminates surrounding environment .	M	Loc	High rainfall/ storm event, or failure to clean out sediment from pond. Mismanagement of water volumes	2 Additional adjacent containment ponds. BBSRP maintenance program. Annual OPSIM modelling undertaken. Evaporation of pond water through use of pond water as dust suppression across site. Annual marine heavy metal monitoring. Removing runoff from shed roof removes 1.8Ha from system (with first flush system). Trucks transporting water to TSF.	3	2	5	H	BBSRP should be cleaned out on a regular basis and emptied as far as practicable prior to the wet season. The final constructed runoff ponds will be reviewed by the Independent Monitor.
3	**TSF**	3.3	Leachate seepage	3.3.2	Wet Season discharge of seepage containing acid, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.	S	RI	Pump back from seepage recovery system ceases during wet season due to inundation of pumps during flood events	TSF geopolymer barrier; TSF design; Seepage monitoring, surface water and groundwater monitoring, plus other flora/fauna studies in Surprise creek.	4	1	5	H	Subsurface drainage to be installed with submersible pumps to allow continuous pumping or seepage to be intercepted prior to leaving facility through installation of line of interception bores upstream of embankment

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
3	**TSF**	3.4	Geotechnical	3.4.6	Failure of water Management Dam due to overtopping of spillway	M	OM	Under-design for potential flood event. Water dam undersized and/or spillway under-designed. Rating of spillway unknown (this information has not been provided to the IM).	Pumps and syphons on wall to remove water.	2	3	5	H	Verification of spillway ratings and capacity.
3	**TSF**	3.4	Geotechnical	3.4.7	Lack of capacity to contain storm events	M	OM	Embankments and spillway not raised to sufficient height prior to upcoming and subsequent wet seasons	Dam safety audit conducted annually. Existing water balance	2	3	5	H	Detailed verification of stored volume of water on facility to be conducted (bathymetric survey and tailings beach survey). Consider downstream construction of centre embankment between Cell 1 and 2 to allow this to be raised when large pond present, with associated relocation of decant to centre embankment.
4	**OEF**	4.2	Geotechnical	4.2.1	OEF wall fails	M	WM	Abnormal storm event, poor construction	Visual inspections of wall condition	1	4	5	H	"As-built" construction reports of final structure.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
5	**PACRIM and ROM**	5.1	Dust emissions	5.1.5	Soil contaminated with heavy metals migrates off-site due to runoff by heavy rains during the wet season and causes pollution and loss of fauna outside of mining lease	L	OM	Spread of concentrate laden dust from mining operations and Pacrim yard/ROM Pad.	Monitoring of heavy metal concentrations in soil. Dust monitoring program. Sediment monitoring program. Upgrading of sprays and Pacrim conveyors	3	2	5	H	Increase density of soil investigations. Assess the need to remediate areas with elevated heavy metal concentrations. Develop site specific criteria for the protection of local biota.
6	**Mine site**	6.1	Groundwater	6.1.1	Degradation of groundwater, surface water and land quality within the mine site	M	OM	Long- and short-term generation of acidic and/or saline leachate from tailings and waste rock	Groundwater, surface water, tailings and waste rock monitoring, checking procedures, kinetic testing of materials with uncertain classification	2	3	5	H	Improved understanding of historic and current water geochemistry and trends, with particular focus on the TSF, OEF(s), and regional monitoring networks. Re-evaluation of current OEF materials characterisation identification and OEF design in light of proposed mine expansion.Understanding of aquifer and solute transport.
6	**Mine site**	6.4	Security bonds	6.4.1	MRM Closes unexpectedly, leaving OEF, TSF, river diversions, and mine site rehabilitation unfinished.	L	RI	Unexpected mine closure Inadequate planning Inadequate bond.	Revegetation has started on river diversions Monetary bond (However, may be inadequate). Progressive cap of TSF Cell 1.	2	3	5	H	OEF should be progressively rehabilitated or sealed. Solution to the TSF Cell 1 seepage issues must be determined.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
8	**River diversions**	8.1	Fauna	8.1.1	River diversions create physical /biological barrier to fish migration.	M-L	RI	Loss of in-stream habitat, reduction in water quality. Altered stream flow. Increase in predation	Freshwater Sawfish Monitoring and Management Programme in place. Revegetation of diversions to increase shade in the future. Addition of large woody debris to improve fish habitat	3	2	5	H	Large woody debris - monitor and add annually, if necessary.
8	**River diversions**	8.2	Rehabilitation	8.2.1	Slow revegetation on diversion channels.	S	WM	Large floods in wet season cause erosion and soil redistribution on unvegetated areas. Cattle and donkey damage.	Re-channelling erosion assessment prepared in years 1,3,5 and 10 and as required until mine closure; fences in place to keep cattle and donkeys out (however these are damaged annually by seasonal flooding).	3	2	5	H	Maintain rehabilitation efforts. Target planting efforts at soil pockets resulting from flood water redistribution of soils. Perimeter fence re-designed, installed and maintained to keep cattle out. Cattle mustering
8	**River diversion**	8.3	Weed Management	8.3.1	Increase in spread of listed Northern Territory noxious weed species, particularly along the River diversions.	M	RI	Historical mining and pastoral activities. Uncolonised bank and bed of river diversions. Weed Management Plan not implemented during shutdown (Dec 2008-Feb2009)	Weed Management Plan in place and carried out with liaison form NRETAS Weeds District Officer.	3	2	5	H	Continue to invest effort into weed control.

Asset #	Asset	Consideration #	Consideration	Risk #	Risk Issue- Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
2	**Bing Bong Port**	2.5	Dust migration	2.5.1	Spilling of concentrate dust during barge load out causes contamination of marine and terrestrial sediments with metals	L	Loc	Spread of zinc and lead-laden dust from ship-loading operations.	Dust monitoring programme and dust mitigation measures. Annual marine monitoring of heavy metals in seawater and sediments Fully contained conveyor system observed by IM during load out - 1/6/11	3	3	6	M	Further investigation into dust levels at Bing Bong should be undertaken. Dust Monitoring and management system requires upgrading. Lead isotope monitoring. Potential dust monitoring on channel markers.
1	**Bing Bong dredge spoil**	1.1	Drainage	1.1.3	Creation of acid sulfate soils by the excavation of the outer spoon drain, which causes acid leachate that affects flora/aquatic fauna.	M	Loc	Excavation of spoon drain exposes acid sulfate soils	None	3	3	6	M	Soil monitoring include ASS analysis Soil baseline survey expansion
	Bing Bong dredge spoil	1.2	Geotechnical	1.2.2	Cattle degrade the structure of the BB Dredge spoils and cause dredge material to flow from the cells	S	OM	Cattle	Inadequate fencing	3	3	6	M	Improve fencing Muster cattle out of area.
1	**Bing Bong dredge spoil**	1.3	Dust migration	1.3.1	Development of salt loads in vegetation, soils and sediments surrounding the Dredge Spoil.	L	OM	Onshore placement of contaminated sediments from dredging.	Increased grasses help stabilise the spoil.	3	3	6	M	Additional dust monitoring sites should be installed around dredge spoil area adjacent to remnant vegetation to assess off-site impacts. Monitor vegetation surrounding the spoil. Commencement of revegetation trials.

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10	**Transhipment Area**	10.1	Heavy metals	10.1.1	Bioaccumulation of metals in seawater, sediments and biota in Transhipment area. Unknown sub-lethal/ chronic effects, effects on higher trophic species (including humans)	L	RI	Contamination from load out operations	Seafloor sediment heavy metal monitoring programme in Transhipment area.	3	3	6	M	Continue to monitor periodically
2	**Bing Bong Port**	2.4	Fauna	2.4.2	Bioaccumulation of metals in seagrass and molluscs in vicinity of load out facility. Effects further along food chain. Unknown sub-lethal/ chronic effects	M	Loc	Dust migration, Spillage of ore	Annual marine monitoring programme. Dust monitoring programme and dust mitigation measures.	3	3	6	M	Monitor elevated levels of metals from ore derived sources. Analyse and report on samples from Barramundi tissue and mud crabs from SEPI/MR estuary area.
2	**Bing Bong Port**	2.5	Dust migration	2.5.4	Dust migration from Bing Bong storage shed cause heavy metal contamination of marine sediments and seawater in Bing Bong Port, which may potentially affect local biota	L	Loc	Concentrate dust from Bing Bong concentrate storage shed transported by winds and runoff	Dust suppression sprays in operation across the site. Annual marine monitoring of heavy metals in sediments and monthly monitoring of seawater	3	3	6	M	Continued dredging of swing basin to remove localised contaminated sediment. Further investigation should occur regarding why mine-sourced lead and other metal concentrations have been found to increase in marine sediment at Bing Bong since 2004. Dust audit.

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3	**TSF**	3.4	Geotechnical	3.4.2	Over-flow of Cell 1 due to inadequate spillway.	S	Loc	Under-designed for Flood event	Identified in AWA annual inspection that it is unclear if the spillway has been adequately designed.	3	3	6	M	IM Has not received spillway report. Dam safety review did not mention this issue..
3	**TSF**	3.4	Geotechnical	3.4.8	Excess water accumulating on facility using up available storage capacity	S	Loc	Poor water balance modelling which does not allow site to verify likely inflows and outflow in real time	Water balance model established but not accessible for site personnel.	3	3	6	M	Water balance model should be available to facility operators to input site data and verify available capacity. Volume of storage within WMD to be confirmed to allow emergency transfer of water to WMD if required.
3	**TSF**	3.5	Pipeline to TSF	3.5.1	Pipeline foundations fail over river, rupturing pipe resulting in discharge of tailings into Barney Creek.	S	Loc	Flood event undermines footings.	Daily monitoring during wet season to inspect pipeline integrity.	2	4	6	M	Regular monitoring should identify any gradual deterioration of footings before it has potential to damage pipeline. It is understood that a bund is to be constructed around the pipeline on the TSF abutment to contain any leaks over the crossing and that this should also contain any leaks a result of failure of the pipeline footings

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4	**OEF**	4.1	Flora/fauna	4.1.1	Development of salt and/ or heavy metal loads in vegetation, soils and sediments causes vegetation dieback.	M	OM	Poor dust management and controls on OEF.	Dust monitoring program and dust mitigation measures such as water trucks. Annual macroinvertebrate sampling in Barney/Surprise Creeks	3	3	**6**	M	Regular visual inspections of vegetation condition. Continue with macroinvertebrate sampling
4	**OEF**	4.2	Geotechnical	4.2.2	Erosion of capping and outer batter during wet season	S	Loc	No designed water management measures on top surface to discharge incidental rainfall	None, erosion visible at time of inspection	4	2	**6**	M	Surface water control to be constructed at the start of each wet season to divert water flows off waste dump without causing erosion.
4	**OEF**	4.2	Geotechnical	4.2.3	Failure of basal encapsulation layer to prevent seepage.	L	OM	Clay layer compacted moisture condition and then left exposed which will allow desiccation of clay and potentially erosion thereby reducing effectiveness of clay liners.	Limited QA/QC testing	3	3	**6**	M	Only prepare a small area in front of PAF waste placement or paddock dump a layer of PAF waste over completed clay layer to reduce evaporation losses from clay and erosion risk. Or should consider base up construction.

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4	**OEF**	4.2	Geotechnical	4.2.4	Failure of basal encapsulation layer on slopes thereby allow water to enter the waste	L	OM	Poor placement method of placing clay on a slope, limits ability to tightly control quality. Clay layer compacted moisture condition and then left exposed which will allow desiccation of clay and potentially erosion thereby reducing effectiveness of clay liners.	Limited QA/QC testing, plus some areas covered with shallow NAF layer	3	3	6	M	Place clay on outer batter slopes in horizontal layers, 300mm vertical thickness and compact and moisture condition, with immediate placement of NAF layer outside of clay to reduce erosion and desiccation risk. Or should consider base up construction.
4	**OEF**	4.3	Geochemical	4.3.1	PAF material being placed on outer batter	L	OM	Lack of sulfur grade control. Misclassification of material due to siderite (iron carbonate) leading to an overestimation of neutralising capacity	Block model classification of PAF / NAF. Post placement sampling of grab samples.	3	3	6	M	Grade control of all blast hole samples, validation of acid neutralising capacity.
4	**OEF**	4.3	Geochemical	4.3.2	Neutral drainage / metallic drainage from NAF waste placed outside of encapsulation	L	OM	Lack of detailed kinetic testing of all waste types / confirmatory testing of leach potential (NAG / Distilled Extract). No grade control testing of waste	Block model classification of PAF / NAF. Post placement sampling of grab samples.	3	3	6	M	Grade control of all blast hole samples, validation of acid neutralising capacity and leachability.

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5	**PACRIM and ROM**	5.1	Dust emissions	5.1.2	Dust blown from ROM Pad and Pacrim yard causes loss of water and sediment quality and loss of flora/ fauna in Barney creek.	M	Loc	Fugitive dust emissions from Pacrim Yard and ROM Pad.	Dust mitigation measures at mine site including Water spray trucks. Introduction of double-lipped rubber lining to sides of Pacrim conveyors.	3	3	6	M	Heavy metal concentrations have increased at some Barney Creek sediment sampling sites. Upgrading of crusher should decrease dust levels at monitoring locations in the area and thus mitigate input to the creek. Monitoring should consider long term trends to assess effectiveness of measures. Consider long term option of moving the ROM/PACRIM
5	**PACRIM and ROM**	5.1	Dust emissions	5.1.3	Dust blown from ROM Pad and Pacrim yard causes loss of water and sediment quality and loss of flora/ fauna in The McArthur River	L	Loc	Fugitive dust emissions from Pacrim Yard and ROM Pad.	Dust mitigation measures at mine site including Water spray trucks. Introduction of double-lipped rubber lining to sides of Pacrim conveyors.	3	3	6	M	Dust mitigation measures should be increased around ROM Pad/Pacrim yard. Upgrading of crusher should decrease dust levels at monitoring locations in the area and thus mitigate input to the creek. Monitoring should consider long term trends to assess effectiveness of measures. Consider long term option of moving the ROM/PACRIM

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6	**Mine site**	6.2	Groundwater Dependent Ecosystems	6.2.1	Depression of groundwater pressures and degradation of groundwater quality due to over-extraction .	L	OM	Depression of groundwater pressures and degradation of groundwater quality due to over-extraction .	Groundwater monitoring.	3	3	6	M	MRM should undertake studies on Groundwater Dependent Ecosystems to assess effects of mining operations. Can be integrated in upgrading of groundwater models. Consider long term option of moving the ROM/PACRIM
8	**River diversions**	8.1	Fauna	8.1.2	Impact on riparian bird populations	M	Loc	Fragmentation of habitat, unsuitable habitat on diversions for riparian birds, reduction in water quality	Seasonal monitoring of riparian birds, targeted revegetation species used along diversions	3	3	6	M	Continue revegetation efforts. Use species mix similar to original channel. Add favoured bird habitat species such as cane grass, Barringtonia and Pandanus. Exclusion of stock from revegetation areas.
8	**River diversions**	8.2	Rehabilitation	8.2.2	Difficulty in recreating riparian vegetation communities	S	Loc	Selection of inappropriate species, cattle grazing, weed invasion, plant supply difficulties (cultivation from seed not possible, seed collection issues)	Annual vegetation monitoring, opportunistic trials, desired seed mix and density lists, large-scale tubestock planting over consecutive years, irrigation system, placement of LWD in diversions to reduce stream flow, weed control.	3	3	6	M	Specific monitoring targeting preferred rehabilitation species could be useful. Increase survey sites on MR, reference plots on Barney Creek and comparison to baseline data.

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8	**River diversions**	8.4	River diversion design performance	8.4.1	Flooding within mine pit	S	Loc	Very rare flood event (>500 years ARI)	Monitoring of flood warning station intranet information (with accompanying basic action plan).	1	5	6	M	Current flood warning scheme does not address/flag such an abnormal event. It is recommended the scheme be amended to address the very rare events. It is also recommended that the flood warning scheme also be improved to relate early warning river levels to imminent flooding of other potentially critical site infrastructure elements. Site Emergency Response Plan document needs to be ungraded with regard to flooding.

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8	**River diversions**	8.4	River diversion design performance	8.4.2	Erosion at toe of mine levee wall and along unplanned overland flow path from the old McArthur River Channel into diversion channel.	E	Loc	Flood flows returning to river from the direction of the remnant river channel.	Flow path conditions are examined after each wet season. (After erosion experienced in 2009-2010 wet season, rock armouring works were considered to be necessary to address that scour and they were subsequently undertaken in 2010.)	3	3	6	M	Following completion of the 2010 rock armouring works it was found that the 2010/2011 wet season flows spread out beyond the limit of the rock armouring work with accompanying scour impacts. Previous recommendation - that for long term scour protection, hydraulic flood modelling should be undertaken (through including this flow path explicitly in the HEC-RAS flood model) to quantify flow velocities over a range of flood events - remains unchanged.
8	**River diversions**	8.4	River diversion design performance	8.4.3	Ponding of water between channel and mine bund leading to increased seeapge through shallow soil zone and mobilisation of salts	L	Loc	Poor drainage design and bunds formed by mine access roads	Small diameter pipes (<100mm) pipes to allow drainage	4	2	6	M	Reshape area to ensure no ponding of water occurs.

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9	**Sir Edward Pellew Islands (SEPI) and McArthur River Estuary**	9.1	Heavy metals	9.1.1	Bioaccumulation of metals in seawater, sediments and biota in vicinity of SEPI and MR estuary. Unknown sub-lethal/ chronic effects, effects on higher trophic species (including humans)	L	RI	Contamination from McArthur River upstream mine activities or Bing Bong Port operations	Annual mollusc (gastropods and bivalves), seagrass and sediment monitoring program	2	4	6	M	Analyse and report on samples from Barramundi tissue and mud crabs from SEPI/MR estuary area. Continue monitoring
9	**Sir Edward Pellew Islands, McArthur River and Bing Bong Port**	9.2	Vibrio bacteria	9.2.1	Vibrio bacterial infection of local people	E	RI	Unknown. Possibly contamination by sewage.	Vibrio monitoring	3	3	6	M	The study should be repeated in the wet season in order to determine whether there are any changes in the Vibrio diversity associated with the substantially different environmental conditions of the wet season.

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1	**Bing Bong dredge spoil**	1.4	Revegetation	1.4.1	Failure of revegetation on dredge spoil causes habitat loss or alteration and dust potential.	M	Loc	Spoil material unsuitable for vegetation establishment. Revegetation trial cancellation by student. Inappropriate or inadequate research. Severe weather. Ongoing dredging.	Previous monitoring by orthophoto mapping and ground truthing of vegetation. CDU PhD student was to commence revegetation trials on a section of the spoil.	4	3	7	M	Continue to monitor surrounding vegetation by aerial mapping and visual inspections. Conduct rapid, ground surveys of vegetation annually. Continue with rehabilitation of dredge spoils - utilise landscaping of cells to promote veg growth despite future dredge plans. Student has failed to start the trials at CDU, so MRM should contract the work to another party.
2	**Bing Bong Port**	2.1	Groundwater	2.1.1	Impact on groundwater quality and beneficial uses, from hydrocarbons, reagents and other liquid products used or stored at Bing Bong Port.	M	Loc	Vehicle movement over sub-surface fuel and liquid pipelines, corrosion of infrastructure, accidents and spills.	Groundwater and surface water monitoring. Inspection procedures of pipelines and infrastructure. Incident report forms Groundwater bores have been installed at BB, analysis for TPH, BTEX should be conducted annually to determine presence of dissolved hydrocarbons in groundwater.	4	3	7	M	Integrity testing of fuel tanks and pipelines should be undertaken in conjunction with a hydrocarbon audit of the facilities once every 5 years. If infrastructure older than 10 years, a soil investigation should be undertaken around the infrastructure to determine any contamination.

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2	**Bing Bong Port**	2.3	Flora	2.3.1	Loss of seagrass outside the channel which may affect seagrass dependent communities or populations (e.g. dugongs).	M	WM	Loss of seagrass from dredging operations. Turbidity from Regular Aburri passage. Sedimentation cyclones or severe weather.	Annual seagrass monitoring program.	4	3	7	M	Continue with current monitoring. Make clear distinctions between channel and adjacent areas in terms of seagrass loss. Establish control site as recommended in Seagrass Monitoring Report. A post disturbance survey should be conducted if a large disturbance event impacts seagrass communities. This would distinguish natural from anthropogenic disturbances.
2	**Bing Bong Port**	2.4	Fauna	2.4.1	Bing Bong Port operations negatively impact important migratory bird populations. Lethal or chronic sub-lethal effects to migratory birds	L	RI	Heavy metal bioaccumulation in food sources of migratory birds caused by dust migration or concentrate spillage from Bing Bong Port operations	Monitoring of heavy metals in sediments and biota. Yearly Migratory Bird Surveys. Dust monitoring and control measures implemented.	3	4	7	M	Further reduce dust emissions from Bing Bong Port (e.g.. By enclosing concentrate shed) Continue monitoring migratory bird populations.
2	**Bing Bong Port**	2.5	Dust migration	2.5.2	Spilling of concentrate dust during trans-shipment operations causes contamination of marine sediments with metals	L	OM	Concentrate fallout during trans-shipment operations	Monitoring of marine sediments in trans-shipment area. Aburri barge is periodically washed down and material collected in a sump.	3	4	7	M	Continue assessment of sediments in the trans-shipment area. Lead isotope monitoring.

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3	**TSF**	3.1	Dust migration	3.1.1	Development of salt and/or heavy metal loads in vegetation, soils and sediments surrounding the TSF	M	OM	Poor dust management and control	Dust monitoring programme and dust mitigation measures proposed and actual rehabilitation trials (TSF Cell 1). Cell 1 now capped.	3	4	7	M	Continue rehabilitation of Cell 1 to cover exposed tailings. Recommence watering of Cell 1 until capping is completed. Dust still possible from Cell 1 cover - should maintain good condition.
3	**TSF**	3.1	Dust migration	3.1.2	Dust contamination of Surprise creek causes loss of flora/ fauna or bioaccumulation of metals within tissues. Dust migrates downstream.	M	WM	Dust blown from TSF towards Surprise Creek.	Clay cap of Cell 1 Rotation of watering in Cell 1. Monitoring of invertebrates in Surprise Creek Water quality and Chemical monitoring of surface water.	3	4	7	M	Establishment of vegetation cover on Cell 1
3	**TSF**	3.5	Pipeline to TSF	3.5.2	Pipeline on ramp to TSF failure - discharge to surprise creek..	S	Loc	Pipeline not bunded	visual inspections.	4	3	7	M	Bund pipeline or secondary containment.
4	**OEF**	4.2	Geotechnical	4.2.5	Formation of preferential pathways for oxygen to enter the dump	L	OM	End tipping waste from high tip head, leads to segregation of PAF waste with coarse material at base of tip face.	None	4	3	7	M	Place all PAF waste as paddock dumps or reduce the tip head height down to 5m to reduce segregation of PAF waste. Or should consider base up construction.

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4	**OEF**	4.3	Geochemical	4.3.3	Increased rates of oxidation of placed waste and increased metal, acid and salt loads in seepage	S	Loc	No capping placed over top of completed waste dumps	None, except truck compaction of top surface, however waste is competent rock and therefore will do little to limit infiltration.	4	3	7	M	Top capping layer should be placed immediately on completion of waste dump area and preferably interim caps should be placed prior to each wet season.
5	**PACRIM and ROM**	5.1	Dust emissions	5.1.4	Bioaccumulation of metals in flora and fauna within or around river diversions.	M	WM	Dust from mining operations and changes to creek flows. Elevated metal concentrations at downstream monitoring sites at FS03 and FS05.	Sediment monitoring program, vegetation monitoring, monitoring of heavy metals in fish, macroinvertebrate monitoring, water monitoring	3	4	7	M	Dust mitigation measures should be reassessed to increase frequency of water spraying at Rom pad and Pacrim yard, for example.
5	**PACRIM and ROM**	5.2	Structural Design	5.2.1	Erosion of bund wall causes release of contaminated water into Barney Creek	S	Loc	Abnormal storm event	Regular inspections of condition	4	3	7	M	Complete quantified design of water flows (determine likely volumes), and design spillway (protected low point) to prevent total loss of bund / road and release of large volume of contaminated material and to prevent Barney Creek scouring out bund.

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6	**Mine site**	6.1	Groundwater	6.1.2	Complete depressurisation of aquifers, reduction in yield and water quality affecting regional groundwater and groundwater dependent ecosystems	M	OM	Excessive drawdown of aquifers due to dewatering for mine pit and water supply	Groundwater monitoring. Evaluation of groundwater model.	3	4	7	M	Calibration of the groundwater modelling undertaken in 2006 (EIS) should be undertaken annually and the model re-run every 3-5 years.
6	**Mine site**	6.1	Groundwater	6.1.3	Impact on groundwater quality and beneficial uses from hydrocarbons, reagents and other liquid products used at the Mine.	M	P	Vehicle movement over sub-surface fuel and liquid pipelines, corrosion of infrastructure, accidents and spills.	Groundwater and surface water monitoring; various inspection procedures of pipelines and infrastructure; incident report forms.	4	3	7	M	Integrity testing of fuel tanks and pipelines should be undertaken in conjunction with a hydrocarbon audit of the facilities. Risk assessment of potential sources of spills and leaks should be conducted following the audit, and re-evaluation of management and mitigation procedures.

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6	**Mine site**	6.3	Water extraction from the McArthur River	6.3.1	Water extraction impacts aquatic flora and fauna due to lack of water availability	E	OM	Over-extraction reduces dry season flows in river	Pump flow meter monitoring system with reference to Upstream River Station real time data to achieve adherence to earlier extraction limits imposed by DRDPIFR). Annual aquatic fauna surveys	4	3	7	M	2010 IM Audit report recommended improvements in the recording of extracted flows and as at June 2011 MRM staff advised that while changes (including the reporting procedures) were proposed they had not yet been implemented. It is important from the view point of the imposed extraction limits that the quality of data from the Upstream River Station is satisfactory.
6	**Mine site**	6.5	Waste oil and fuel storage containment	6.5.1	Spill of hydrocarbons from waste oil storage area, refuelling lines or tanks.	S	P	Existing bunding damaged. No self bunded pallets, No sump, failure of bunding, fuel likes or tanks.	None operational	4	3	7	M	Replace inflatable bunding or consider self bunded pallets with roof to keep rainfall out. Hydrocarbon Audit and integrity testing of fuel tanks and lines.
7	**Mine Site and Bing Bong**	7.1	Environmental monitoring programs	7.1.1	Incomplete QA/QC procedures result in errors in datasets and thus potentially wrong management actions	S	WM	Insufficient QA/QC procedures in environmental monitoring programs	Limited QA/QC procedures are currently being undertaken	4	3	7	M	Ensure QA/QC procedures meet environmental industry standards

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1	**Bing Bong dredge spoil**	1.1	Drainage	1.1.2	Acid production from Dredge spoil material causes acidic drainage, which causes acidic leachate that affects surrounding vegetation.	L	OM	Dredging of sulfidic sediments that oxidise.	Spoon drain may act to divert and acidic seepage away from the surrounding landscape.	3	5	8	L	Characterisation of dredge material/ test dredge spoil material for Acid Sulfate Soil occurrence/ potential.
7	**Mine Site and Bing Bong**	7.1	Environmental monitoring programs	7.1.2	Inadequate analysis, discussion of monitoring results causes environmental issues to be overlooked or remain unmitigated.	M	WM	Inadequate reporting. Lack of human resources or certain technical skills in-house.	Independent Monitor Program Department of Resources check monitoring	4	4	8	L	Ensure complete scientific and comprehensive reporting is undertaken for each monitoring program. Analyse and discuss trends in data, sources of contamination and mitigation measures for preventing environmental harm. Contract out reporting or data analysis to suitably qualified external consultants if the technical expertise or human resources are not available in-house.
1	**Bing Bong dredge spoil**	1.5	Weeds	1.5.1	Habitat alteration due to weed infestations on dredge spoil/rehabilitated areas.	M	RI	Insufficient weed management.	Weed inspections by District Officer and MRM staff. Parkinsonia biological control trials ceased and Parkinsonia exterminated Control of weeds as per the Weed Management Plan.	4	4	8	L	Regular monitoring and control of weeds.

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2	**Bing Bong Port**	2.5	Dust migration	2.5.3	Dust blown from Bing Bong Port facility causes loss of water and sediment quality and loss of flora/ fauna in St Edward Pellew Islands	L	Loc	Fugitive dust emissions from concentrate shed and during loading of vessels	Monitoring of sediment and seawater within the estuary and St Edward Pellew Islands. Improved concentrate loading practices.	4	4	8	L	Dust mitigation measures should be increased at Bing Bong. Ventilation and vacuum system to be implemented as soon as practicable within the concentrate shed. Street sweeper should be employed.. Monitoring should consider long term trends to assess effectiveness of measures. Further dust monitoring on channel markers.
3	**TSF**	3.6	Rehabilitation	3.6.1	Stockpiled topsoil not available for rehabilitation of tailings dam or waste dumps.	L	P	Topsoil not used progressively, not labelled or mapped, used for wrong purpose or buried.	2010/11 MMP describes some areas where topsoil will be stripped from and areas that will require topsoil in the future.	4	4	8	L	Include in the MMP a map and brief description (possibly a photograph) of current topsoil stockpiles. Signs on topsoil stockpiles in the field.
8	**River diversions**	8.4	River diversion design performance	8.4.4	Sudden and significant flood-induced channel bank erosion/collapse leads to unexpected increase in flood level	S	Loc	Flood event	Taking of photographs - post wet season - along one bank (at 250 metre spacing). MRM recent commitment to also take photographs from opposite bank (as recommended previously in IM Audits)	4	4	8	L	Review of evidence of erosion shown in photograph series. Recommended utilisation of annual aerial survey plans to assess on-going changes in bank and bed levels which would then potentially trigger the need for assessment of potential bank instability.

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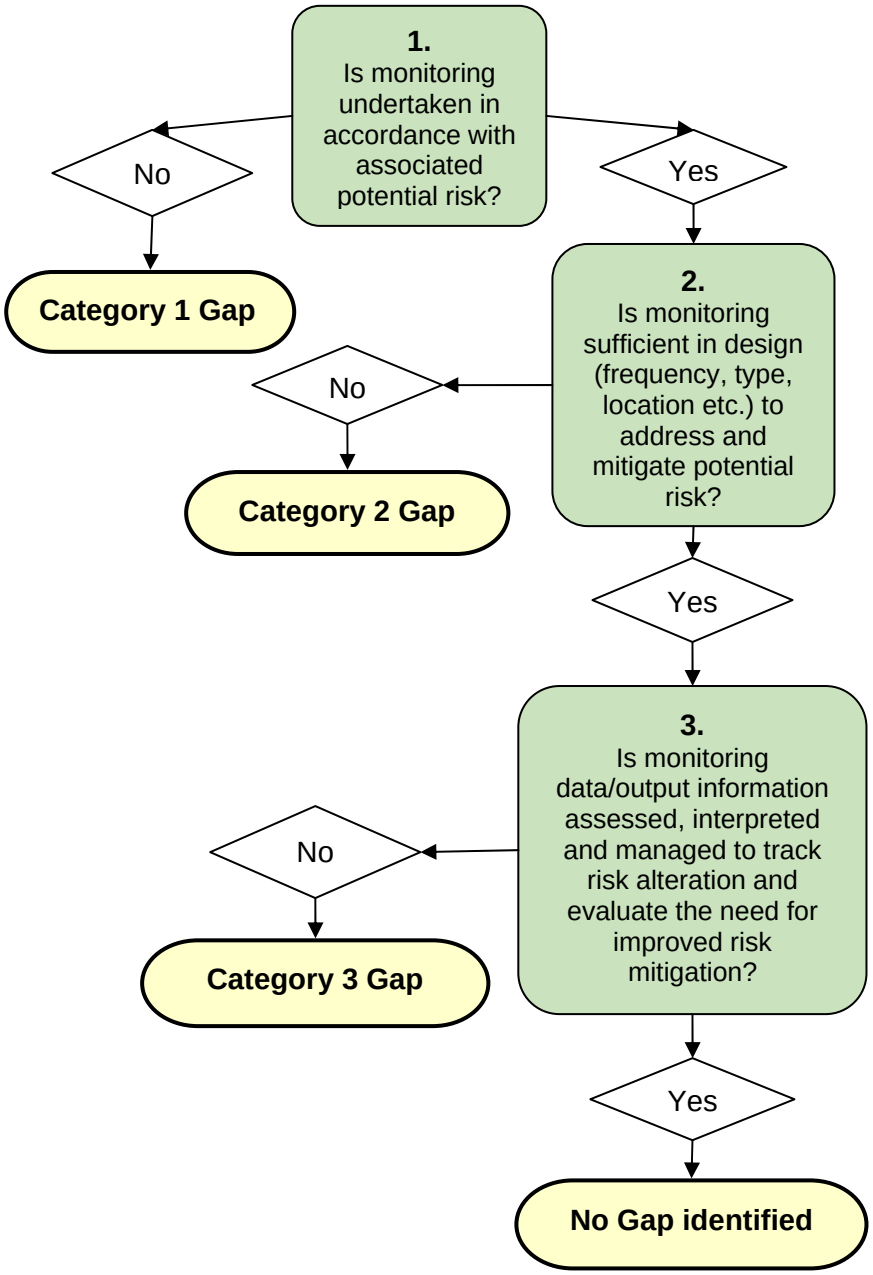
6	**Mine site**	6.6	Clean Green status of cattle	6.6.1	Intake of heavy metals from mine dust on vegetation may accumulate in cattle and affect clean green status of product for NT	M	P	Contaminated vegetation.	Dust monitoring,	4	5	**9**	L	Desk top assessment to determine potential impact on cattle economy of pastoral properties of bio-accumulation of heavy metals in livestock.
5	**PACRIM and ROM**	5.2	Structural Design	5.2.2	Failure of pump within ROM Pad sump area during heavy rainfall event causes sump water to flow towards Barney Creek.	S	Loc	Abnormal storm event and pump or power failure.	Regular inspections have been carried out since February 2009	5	5	**10**	L	It is understood that MRM have constructed a storage that is larger than previous. It is anticipated that the storage within the ROM would not overtop rapidly and that there would be enough time to deploy a substitute pump in case of failure. However, analysis of the storage size against design rainfall events should be undertaken to give an estimate of the duration the ROM storage could run for without a pump, before overtopping occurs.

APPENDIX B GAP ANALYSIS FLOW CHART AND TABLE



Independent Monitor Gap Analysis Process Flowchart.

TABLE 16 GAP ANALYSIS REGISTER

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Waste rock	Inadequate geochemical analysis and confirmation testing of waste rock and tailings.		x		The Independent Monitor is concerned that the type of visual classification undertaken to identify NAF and PAF may not be adequate. Site discussions with the Mining Manager indicate that an understanding of the current waste characteristic contents of the OEF is not well understood compared with the original OEF design. A waste rock block model should be constructed and independently reviewed.
Tailings geochemistry	Acid/base accounting.		x		The Independent Monitor advises that results be reviewed annually in terms of initial projections of tailings geochemistry, acid production and long term weathering effects.
Tailings Geochemistry	Inadequate IMACs section 6.4 Notification follow-up		x		The Independent monitor advises that the seepage prediction investigation work was not appropriately targeted to ensure a valid assessment of the time prediction for when the system will go acid, and travel time to Surprise Creek.
Civil works	Inadequate monitoring of diversion channel bank erosion/slumping.		x		Photograph now being collected on both side of channel. It is further recommended that Lidar survey is collected over the diversion channel and overlain on previous data to determine erosion and deposition locations
Civil works	Lack of hydraulic engineering assessment of as-built diversion channels.	x			As-built details of channel cross sections should be inserted into design hydraulic model and results compared with design basis. Report should include a detailed comparison of any differences reported by the two models and the associated implications of those differences.
Civil works	Inadequate clay lining materials testing / compaction test results for OEF.		x		Testing has been conducted of the clay liner but no indication of when testing was conducted in relation to covering of clay to prevent desiccation. No reconciliation of rate of testing i.e. one test per 5000m3 of material placed. Also no comprehensive construction report only raw results, a construction report giving details of when, where and what was tested and the pass / fail rate should be conducted annually.
Civil works	Absence of as-built drawings for OEF foundation, and geotechnical verification of foundation grades, topsoil, and any foundation soft spots to be removed.	x			Without this information it is not possible to verify that the OEF foundation has been correctly constructed.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Civil works	No information is available on the current stability of the Cell 1 or Cell 2 embankments.	x			A 'Dam Safety Review' for the TSF (including WMD) has been conducted but the major item to be addressed (embankment stability) has not been addressed.
Civil works	Incomplete/not provided information on the design and construction of the water management dam (WMD) at the TSF.	x			Technical drawings, specifications and as-built reports for the WMD should be provided as part of the next Audit, and monitoring for geotechnical stability should be incorporated into mine management practices.
Civil works	Apparent lack of a Dam Emergency Response Plan for the TSF.	x			No Dam Emergency Response plan or operating manual has been sighted by IM
Civil works	Lack of regular embankment quantified monitoring system for the TSF	x			Limited piezometers have been installed in the inactive cell 1, no piezometers in the active cell (Cell 2). Survey prisms have been installed but no monitoring data has been seen by IM, it is recommended that these are monitored at least every six months and prior to and immediately after any construction works. Should be surveyed once a year or monthly. It is understood that these works are to be completed during 2010.
Flora/fauna	Vegetation monitoring along the diversions - insufficient vegetation monitoring sites on the MR diversion, analogue sites for Barney Creek and comparison to baseline data.		x		Include more reference sites, more sites along the McArthur River diversion and more comparison to baseline data (particularly Barney Creek)
Groundwater	Impacts of mine and TSF on local and regional groundwater.		x		Annual hydrogeological and hydrological "stand-alone" monitoring reports should be prepared by suitably qualified professionals to evaluate effects of seepage, and drawdown on aquifers, etc. Annual results should be compared against conceptual models.
Surface water	Fluvial sediment chemistry and physical particle size distribution has not been provided or interpreted within the AER (MRM, 2009a).		x		The Independent Monitor recommends that chemical and physical monitoring and interpretation of fluvial sediment data be included in subsequent Water Management Plans.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Rehabilitation	Lack of fencing maintenance to keep cattle from destroying revegetation along river diversions.		**x**		The IM has viewed evidence of MRM's planned re-fencing activities to minimise flood damage and improve access for repairs. The fence construction was begun prior to the wet season in 2010 and is planned to be finished in dry season of 2011
Surface water	Apparent discrepancies in water levels/flow values recorded at upstream and downstream McArthur River gauges (and other gauges)			**x**	Assessment of apparent discrepancies should be undertaken. While it is recognised that investigations have commenced regarding the accuracy of water level recordings and generation of and/or amendments to individual rating tables it is important that the investigations are thorough (and subsequent recommendations for improvements implemented). It is recognised that MRM are examining the potential to relocate the Barney Creek River Station to the highway bridge.
Surface water	IM has reported apparent errors in flows derived at either or both Upstream and Downstream McArthur River stations. Any significant errors in the rating table for the Upstream McArthur River station could result in incorrect triggering of opportunity to extract river flows (relative to compliance with Government approval for water extraction)		**x**		It is acknowledged that the river water level and flow details for the various river stations are currently being reviewed.
Surface water	Inadequate reviews of condition of/performance of sediment control structures.			**x**	It is recognised that a new reporting system commenced in late 2010. Its performance will be reviewed during the next audit period.
Surface water	Lack of warning system for an extreme flood event		**x**		The consequences of a flood which is similar in size or larger than that which would overtop the levee wall are very serious. The current flood warning water level data reporting system is advised to be upgraded such that the relative size of a flood coming down the McArthur River can be understood and urgently reported. While it is understood that currently there is work being done to update the accuracy of the various river stations it is unclear if work at the Early Flood Warning station will be sufficient to address the current lack of understanding of an impending very large flood.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Surface Water	Monitoring of water at the surface and within Tailings Cells 1 and 2.	x			Monitor pH of ponded water at the surface of the cells and from within piezometers within TSF.
Dust	Insufficient discussion/analysis in terms of temporal and spatial trends with regard to TIM, Pb and Zn results.			x	Assessment of temporal and spatial trends needs to be undertaken for all locations to gain further information as to whether mine generated dust is decreasing or if further measures should be implemented. Analysis is limited to some locations only.
Dust/ air quality	No continuous dust monitoring system currently in place for Total suspended particles (TSP)	x			Lack of continuous particulate monitoring does not allow the determination of volume of dust concentrations, nor allows correlating dust levels to wind direction or particular events.
Dust	Improper placement of dust gauges, and failure during the wet season.		x		There is a lack of dust gauges near the OEF and Southern side of McArthur River channel. Sample bottles have been noted to overflow during the wet season, which could affect the accuracy of the results. It is understood that MRM are planning to upgrade many of the dust sampling stations with dust samplers of a design that will not be affected by rainfall. It is recommended that the number of dust monitoring sites be increased to provide a greater sample size for analysis. Analytes requested are also not consistent between monitoring rounds - this is recommended to be rectified in subsequent dust monitoring events.
Soil	Insufficient number of sampling locations, which are also limited to dust locations.		x		The number of soil samples is currently considered to be insufficient considering the large area of the mining leases. It is recommended that additional soil monitoring locations be included in the soil monitoring program to increase the sample size. As soil is monitored at the dust monitoring locations, increasing the number of dust monitoring locations will also increase the number of soil monitoring locations. The IM recommends that a complete soil landscape study of the mine leases be conducted in the next 2-5 years to update the study already undertaken as part of the EIS for the Mine's expansion in 2007.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Soil	Insufficient number of sampling locations	x			The number of soil samples is currently considered to be insufficient considering the large area of the mining leases. As such, the spatial extent of MRM impact in terms of heavy metal enrichment of soils is currently unknown. It is recommended that a complete soil landscape study be conducted in the next 2-5 years so as to gain information of mining impacts to aid in the development of a sound mining closure plan. This study should be undertaken with high sampling density and should include the analysis of surface and subsurface samples as well as samples outside of the mining lease.
Soil	Lack of site specific trigger levels	x			MRM currently uses NEPM Human Heath Investigation levels (HIL) (NEPC, 1999) as trigger values for contaminants in soil. No site specific trigger criteria have been derived for the mine site. This is proposed in MRM's own current Preliminary Mine Closure Plan (March 2008). The Independent Monitor has repeatedly indicated to MRM the need to derive site-specific criteria for the protection of local biota. Once again the IM recommends that if site-specific values are not derived, then the NEPM Environmental (or Ecological) Investigation Levels (EILs) provide a more relevant (and conservative) criteria than HILs
Sediments	Lack of monitoring outside of swing basin	x			Samples at either side of the transects (outside the swing basin) should be collected and analysed to assess the lateral extent of heavy metal impacts. In addition, transect samples already being collected as part of the marine monitoring program should be analysed individually and not composited
Seawater	Results of analyses undertaken using the DGT methodology have not been provided			x	DGT results may provide valuable information into the bioavailable metal concentrations in seawater however; the Independent Monitor has not seen any results or discussion of these analyses. This should be provided in future WMPs.
Dust, Soil and Sediments	Background heavy metal concentrations have not been determined.		x		Determine background heavy metal levels as recommended in the Independent Monitor Technical Review in order to assess potential mining impacts and current conditions, and improve development of sit-specific criteria.
Bing Bong Port and McArthur River Delta					
Surface water	Lack of monitoring of seepage water through Bing Bong dredge spoil walls.	x			Monitor water quality and vegetation outside dredge spoil dam walls to ensure seepage is not causing impact to flora.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Surface water	Lack of monitoring to assess whether Dredge soil drain is effective in draining saline water from dredge ponds to sea as designed.	x			Confirm through surveys regular monitoring that dredge water and seepage drains flow to the sea.
Civil works	There is no documentation regarding design/construction or subsequent geotechnical monitoring of the Bing Bong Spoil Facility.	x			MRM are advised to reassess the strategy for the use of this facility, and then develop an engineered solution in the context of the proposed future usage.
Flora	Monitoring of vegetation outside dredge spoil has not been carried out in the reporting period.	x			Aerial photographs are available but have not been interpreted in a report. Aerial photographs to include surrounding vegetation and mangroves. Ground survey to include reference sites.
Flora	Trials for dredge spoil rehabilitation.	x			Proposal sighted, but has not been undertaken as yet. CDU student failed to commence study.
Fluvial Sediments	No monitoring of sediments within their McArthur River Delta		x		McArthur River Delta sediments should be included in the fluvial sediment monitoring program. Suspended sediments have not been reanalysed and monitored for lead isotopes to compare with the settled sediments on the delta floor.
Marine Monitoring	Physicochemical parameter monitoring at Bing Bong and Sir Edward Pellew Islands		x		Each sampling site is only sampled once without consideration to tides, currents, weather, daytime and other variables. This only provides a snapshot of the situation at sampling time. The data is not adequate for intended purposes. A sampling series should be conducted that provides a more useful data range.
Marine physico-chemical qualities	Data gathering does not produce comparable data to allow interpretation			x	Devise data gathering method, such as sampling from a particular site repeatedly over an extended time period to allow variability in data to be determined.
Fauna	Is there a need to look at impact of the mining and shipping operation on "clean green" quality of cattle?	x			A simple desk top assessment of the impact of mining and trans shipment ore on potential cattle intake of heavy metals, etc may show this is not an issue, but it would prevent questions being asked.
Total		**18**	**16**	**5**	

APPENDIX C DOCUMENTATION PROVIDED BY MRM

TABLE 17 DOCUMENTS PROVIDED TO THE INDEPENDENT MONITOR BY MRM

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Response to last audit recommendations	MRM has advised that following the last audit of the 2009 operational period, the Independent Monitor's recommendations were tabulated and a response for each was generated by MRM. Please provide this response table if available.	Memo to MRM managers on actions for 2010 audit dated 11/1/2011
		Memo to MRM managers for 2010 audit actions including Site Safe numbers dated 11/2/2011
		Reply letter to Independent Monitor advising of actions to be taken dated 24 august 2010
General reports	2009/2010 Mining Management Plan	2009/2010 Mining Management Plan
	2010-2011 SD Mining Management Plan	GEN-HSE-PLN-6040-0003 Mining Management Plan 2010-2011 I004 Rev 0.doc
	2010 Water Management Plan	091108 Water Management Plan (2009-2010) I001 Rev final
	2010/2011 SD Water Management Plan	GEN-SD-PLN-6040-0001 MRM SD ANNUAL PLAN 2011 I005 Rev 0
	Life of mine closure plan (if updated)	Xstrata Zinc MRM Closure Plan 2008
	Waste management plan (if updated)	GEN-SD-PLN-6040-0003 Waste Management Plan I003 Rev 0
	All environmental incident reports in the 2010 operational period	**Environmental incidents for 2010 Folder**
	All community complaints over the 2010 operational period	Community complaints over 2010 = White salt staining at Bourketown crossing and filter cloth material left on block on Carpentaria highway
	All updated management plans and procedures related to environmental monitoring and performance.	**Environmental Procedures Folder**
		GEN-ENV-PRO-6040-0001 MRM clearing permit procedure
		Clearing Permit Form
		GEN-ENV-PRO-0004 General spill response procedure
		GEN-ENV-PRO-0005 Clean Vehicle and Equipment Procedure
		GEN-ENVB-PRO-6040-0006 Concentrate Spill - trucking incident
		GEN-ENV-PRO-60040-0008 Management and Disposal of waste oils
		GEN-ENV-PRO-6040-0009 Management and Disposal of Waste Cooking oil
		GEN-ENV-PRO-6040-0010 Disposal of Aluminium cans
		GEN-ENV-PRO-6040-0011 Disposal of Scrap Metal
		GEN-ENV-PRO-6040-0012 Management of Contaminated Waste Disposal area
		GEN-ENV-PRO-6040-0013 Waste Refuse Facility Management

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
General reports (continued)		GEN-ENV-PRO-6040-0015 Tyre Management
		GEN-ENV-PRO-6040-0017 Fauna Management Procedure
		GEN-ENV-PRO-6040-0021 Putrescible Waste Facility Management
		GEN-ENV-PRO-6040-0022 Management and Disposal of Cardboard and Paper
		GEN-ENV-PRO-6040-0023 Management and Disposal of Lead Acid Batteries
		GEN-ENV-PRO-6040-0025 Disposal of Plastic
		GEN-SD-STD-6040-0010 Environment Biodiversity and Ecosystem Functions
		GEN-SD-PRO-0010 Environment Biodiversity and ecosystem Functions
	If possible, please provide a **list** of all existing management plans and procedures currently in use at MRM (whether updated during the monitoring period or not).	**Environmental Plans Folder**
		GEN-HSE-PLN-6040-0003 Mining Management Plan 2010-2011 I004 Rev 0
		GEN-HSE-PLN-6040-0004 SD Water Management Plan 2010-2011 I001 Rev 01
		GEN-SD-PLN-6040-0001 MRM SD ANNUAL PLAN 2011
		ADM-HSE-PLN-6040-0001 HSE Department Annual SD Plan
		GEN-ENV-PLN-6040-0005 Rechannel Rehabilitation Plan
		GEN-ENV-MAN-6040-0001 Environmental Monitoring Manual
		GEN-HSE-PLN-6040-006Weed Management Plan 2010 2011 FINAL
Surface water and artificial water monitoring	All surface water and artificial monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites.	**Surface Water Monitoring**
		Surface Water Raw Data Quarterly (As per given to DOR)
		Artificial surface Water Monitoring, Surface Water Monitoring and TPH water monitoring
		Submission forms
		Field Sheets
		Sample receipt Advice
		Chemical Analysis Report
		Inspections of Silt traps and Dams
	Updated OPSIM Modelling reports, and all other water balance data and reports	**OPSIM**
		July 2010 Draft OPSIM Report

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Surface water and artificial water monitoring (continued)		OPSIM Update and Review February 2011
		OPSIM Report Final
		Draft February water Balance
		Tailings Dam Pond Assessments
		OEF Ponds Assessment
	All external consultants' reports relating to surface water and artificial waters over the monitoring period.	**External Consultant Reports**
		Ecotox Program
		Ecotox Assessment
		Acid Mine Drainage research program
Groundwater monitoring	All groundwater monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites.	**GW Monitoring Data reports**
		Ground Water Raw Data Quarterly (As per given to DOR)
		TPH monitoring for two bores for 2010
	Information and rationale for any additional groundwater monitoring bores installed during the monitoring period.	New groundwater bores have been placed at Bing Bong to gain an understanding of groundwater. Additional peisometers have been placed around cell one at the TSF to conduct geochemistry work as per Independent Monitor recommendations
	All external hydrogeological consultants reports over the monitoring period.	Bing Bong Hydrogeological investigation Report
		Bing Bong Water Management Plan Final
		Coffey Consultants Groundwater Review 2010
		URS Development of a Water Management Plan 2009 (groundwater study)
		Bing Bong peiso location map
		TSF cell one peiso location map
Dust, soil and sediment monitoring	All dust, soil and fluvial sediment monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites at the Mine Site and Bing Bong.	**Monitoring of Dust**
		Raw Data for monitoring
		Sample submission forms for 2010
		Sample data forms for 2010
		Results for 2010

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Dust, soil and sediment monitoring (continued)		**Fluvial Sediment**
		Raw Data for monitoring
		Sample submission forms for 2010
		Sample data forms for 2010
		Results for 2010
		Soil Data
		Raw Data for monitoring
		Sample submission forms for 2010
		Sample data forms for 2010
		Results for 2010
	Bing Bong Dust Audit report.	**March 2010 Dust Audit Report**
		Field Sheet for Monitoring
		Simtars Analysis report
		Hygiene Monitoring Form dated March 2010
	Please provide information on any operational or infrastructure changes MRM has adopted to address dust migration at the Mine Site and Bing Bong Port.	Replacement roof for the Aburri outfitting invoices, Replacement of asphalt at Bing Bong, 2x photos
	Please provide information and rationale for any changes to monitoring procedures or additions to the dust soil or sediment monitoring locations.	At Bing Bong an additional dust monitoring location has been positioned to the North West as per Independent Monitor recommendations, Two other dust and soil sites have been established near the Northern OEF and an additional one has also been placed on the southern side of the McArthur River channel. Monitoring of these locations commenced in January 2011.
	Any external consultant's reports produced over the monitoring period.	November 2010 SIMTARS Program and review of Atmospheric Monitoring and Health Surveillance
Marine monitoring	All marine monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites including (but not limited to): - lead isotope and metal concentrations in suspended and beach sediments; - Metal concentrations in seawater, sediments and biota; and - water parameters collected during sampling, incl. Turbidity, pH, etc...	**Marine Surface Water**
		Raw data for Marine Water
		Sample submission forms 2010

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Marine monitoring (continued)		Field data forms 2010
		Results 2010
		Marine Sediment
		Raw data for Marine sediment
		Sample submission forms 2010
		Field data forms 2010
		Results 2010
	Please provide information and rationale for any changes to monitoring procedures or additions to marine monitoring	Additional work on the Vibrios project will be undertaken in the late wet season sampling as well, therefore to be conducted in 2011. The 2010 Annual Marine Survey also included the Transhipment area as a sampling program. As per Independent Monitor recommendations Barramundi have also been caught in the vicinity of the McArthur river mouth and are presently being analysed with CDU
	Any related external consultants reports produced over the monitoring period, including those conducted by academic institutions (i.e. Charles Darwin University).	**Annual Marine Program**
		Annual Marine Program 2009 Report
		Proposal for 2010 Annual Marine Program
		Proposal for 2010Transhipment area study
		Record of contact form for Sea rangers and Annual Marine Program
		Field work plan for 2010
		Email from David Parry on Conducting Marine Survey
		Photos of 2010 Program
		Vibrios Project
		Vibrios Proposal
		Vibrios Final Report
		Seagrass Monitoring
		Port Bing Bong Annual Seagrass Survey
		Coastal Monitoring using metal resistant Microbes
		Financial contributions
		ARC Report
		Meeting minutes

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Marine monitoring (continued)		3x presentations
		DGT Monitoring
		Sample submission forms
		Field data
		Miscellaneous fish monitoring
		Submission form for fish
Fauna monitoring	All fauna monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites, including (but not limited to): - endangered species monitoring; - migratory bird monitoring; - riparian bird monitoring along the McArthur River and Barney Creek channels;	Most data in regards to fauna monitoring is in the consultant reports themselves
	Any external consultant's reports produced over the monitoring period.	
		Migratory Bird Folder
		Migratory Bird February survey
		Migratory Bird April survey
		Mosquito Monitoring Folder
		Mosquito monitoring Report for 2009/2010
		Submission forms 2010
		Field sheets 2010
		Results from Entomology Branch 2010
		Registers
		Fauna Register
		Feral Animal Register
		Riparian Birds
		May Final Report
		October Final Report
		Fish Reports
		April/May Fish Report

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Fauna monitoring (continued)		September Report
		Metals In fish report 05-08
		Metals in fish report 2009
		Metals and Lead isotope ratios in fishes and Molluscs report Draft 2010
		Sampling Procedure for metals and lead isotope analysis in fishes and macro invertebrates of the McArthur River
		Wallabies
		Bing Bong Macropods final report June 2010
		Macro Invertebrate report 08-09
		Memorandum from EMS ecological Services
		2010 work completed but no report received yet
		Posters on fauna provided to community groups and public
		Birds of the McArthur River
		Freshwater fishes of the McArthur River
		Freshwater Macro invertebrates of McArthur River
		Frogs of the McArthur River
		Reptiles of McArthur River
		Migratory Birds Poster
		Sawfish Monitoring data poster
	Please provide information and rationale for any changes or additions to any fauna monitoring programs.	The wallaby survey conducted in 2010 will not be conducted again in 2011
Flora monitoring	All flora monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites, including (but not limited to): - riparian vegetation monitoring; - weed management; - revegetation along the McArthur River and Barney Creek diversions	**Weed Management**
		2010 Program
		Devils Claw aerial spraying
		Parkinsonia trial

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Flora monitoring (continued)		Weed control record sheets for 4rth quarter 2010
		Weed Pictures 4th quarter 2010
		NT Government reporting
		MRM Weed Management Register
		Rehabilitation
		Contractor documents
		Images
		Planting field sheets
		Registers
		Invoices for tubestock in 2010
		Sled flow meter readings for irrigation April-July
		Sled flow meter readings for irrigation October
	Any external consultant's reports produced over the monitoring period.	CDU 2010 Vegetation Monitoring Images
		CDU 2010 Vegetation Monitoring Report
	Please provide information and rationale for any changes or additions to any flora monitoring programs.	In the latest report a greater emphasis was placed on statistical interpretation
	Please provide an update and rationale regarding any changes to the river diversion revegetation and weed management approaches undertaken during the 2010 operational period.	Dry season planting occurred during 2010 with the use of a sled and water tank and irrigation lines. This method will be used again in 2011 as it proved to be effective in establishing several kilometres of rehabilitation on the top batter. With the introduction of and rehabilitation officer later in 2010 more focus has been placed on Weed management and rehabilitation. at Bing Bong as per Independent Monitor recommendations biological control ceased and all Parkinsonia was treated via chemicals
Tailings storage facility	All geotechnical, hydrogeological, and geochemical monitoring data, inspection reports and updated procedures.	MET-GEN-GDL-2800-0001 TSF Operating Guidelines
		Monitoring product Investigation Folder
		Raw data for Product Investigation
		Submission forms
		Sample analysis
		Collection sample sheets
Tailings storage		Receipt notifications

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
facility(continued)		Quality Control Reports
		Monitoring of Recovery Bores
		Recovery Bore Monitoring sheets
		Infrastructure inspections
		February 2010 inspection
		March 2010 inspection
		April 2010 Inspection
		May 2010 inspection
		June 2010 Inspection
		August 2010 Inspection
		September 2010 Inspection
		October 2010 Inspection
		Monthly Operating Reports
		January 2010 Report
		February 2010 Report
		March 2010 report
		April / May 2010 report
		June/July 2010 Report
		November 2010 Report
		December 2010 Report
		Allan Watson and Associates
		2010 Dam Safety Review Report
		Spillway Raise Report
		Tails dam monitor points map
		Excel spreadsheet of locations to monitor
		Spillway remedial works parts 1-3
		Concrete test results
Tailings storage facility		Clay test results

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
(continued)		Photos x6 of job being completed
		Investment Proposals and Scope of Works
		TSF Seepage Mitigation
		TSF Seepage and Water Management
		Daily inspections
		Records downloaded from Blackberry
		Correspondence
		Memo to other managers on site about water levels
		Tailings increased densities with attached spreadsheet
		Spillway email
		TSF Design and Build Reports
		bowen-geotech report amend
		Geotech Rept Tailings Dam Raises-MRM
		klibbereport-tailingsdamfailure_27Jan2003
		MaunsellMcRept_Stg3_Cell1_Design
		MaunsellMcRept_Stg3_Cell1_Spec_Drawings
		Stage 1 Construction Report-Rev
		STAGE 1 CONSTRUCTION SPEC
		STAGE 1 DESIGN REPORT
		STAGE 3 CONSTRUCTION SPECRevA
		STAGE 3 CONSTRUCTION SPECRevC
		Stage 3 Design Report RevA
	Any evidence of further hydrogeological investigations of mitigation measures at TSF Cell 1. Such as: - further drilling along the main salt breakthrough pathway to determine the degree of fracturing in the underlying rock (dolomite/shale); - understanding of the weathering behaviour of the tailings; - installation of a leachate collection trench/cut-off wall; and - infilling of the geopolymer barrier.	**Golders geochemistry Work**
Tailings storage facility		MRM TSF Geochemistry Proposal

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
(continued)		Drilling variance 1
		Drilling variance 2
		First Invoice for drilling and site testing
	All external consultants reports relating to the TSF, including: - Hydrogeological and water balance ("OPSIM") reports; - Tailings geochemistry reports - for all cells; - Geotechnical and closure/rehabilitation reports (internal and externally prepared).	**URS Reports**
		2010 Electromagnetic Survey
		TSF Seepage Report
	Evidence of actions undertaken to reduce the amount of water stored in Cell 2 since May 2010.	Under correspondence re thickening of tails to reduce water input
	Evidence as to whether the capping on Cell 1 has been completed and meets design specifications.	**TSF Rehabilitation folder**
		Lintin Geotechnical clay testing results
		Map location of test results
		Map of traffic plan for job
		JSA for clay capping
		Capping of cell one investment proposal
Overburden emplacement facility	All updated procedures, monitoring data, reports (incl. QA/QC), and interpretation relating to: - waste rock handling; - geotechnical monitoring; - testing of the clay liner.	MIN-TECPRO-1000-00150 EOM NOEF Sampling Procedure
		Clay Sampling
		QC testing results for 2010
		QC testing results for 2011
		Correspondence
		Email from Mining Manager about ground prep topsoil movement for NOEF
Overburden emplacement facility (continued)		NOEF Top soil
		OEF Excavation Depths
		Current Monitoring

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
		Groundwater sites
		Monthly Monitoring Reports
		2010 (Feb-Dec)
		2011(Jan)
		PAF/NAF Sampling
		Excel NOEF Sampling Data
		NOEF sample Points
		Proposed monitoring instrumentation
		Stability analysis
		Stability Analysis email and PDF
		Weekly Monitoring sheets for OEF
		2010 inspection reports
		Initial Ground truthing of ground below NOEF
		Soil/clay testing results
		OEF test pit logs
		General Mining inspections looking at ROM pad, Mine Levee wall, pit , topsoil stockpiles etc
		Inspections x4
	All external consultants reports prepared over the monitoring period, including Life of Mine closure plans (relevant to the entire operation), rehabilitation studies, etc.	In folder 2 Life of Mine Closure Plan
	Design reports and as-built reports relating to the OEF.	Final design for OEF
Bing Bong dredge spoil	All monitoring data, reports (incl. QA/QC), and interpretation relating to: - vegetation monitoring/surveys; - Accelerated salt leaching; - soil monitoring; - water monitoring; and -Geotechnical monitoring. At or surrounding the Bing Bong Dredge spoil.	**Monitoring of Dredge Discharge Point**
		Spocos submission forms
		Chemical Analysis Report

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
		Monitoring of Dredge Spoil Drain
		Submission Forms
		Field Sheets
		Lab Results
		Soil External to Spoil
		Raw Data
		Annual Submission Form
		Map of sampling sites
		Quality Control Report
		Certificate of Analysis
		Dredge Spoil cells
		Raw data for soil
		Soil Submission Forms
		Sample Receipt Advice
		Chemical Analysis Report
		Memo from Environment Technician in regards to not sampling last two cells due to unsafe conditions.
	Any available design reports, as-constructed reports, surveyed plans and photographs relating to the design and functioning of the Bing Bong dredge spoil pile walls and drain	Bing Bong Works Capital Investment Proposal approval
		Mapping of Bing Bong Vegetation Report
Bing Bong dredge spoil (continued)		**Emails on Bing Bong Job**
		Civil Works emails x3
		CDU new proposal for Enhanced vegetation development
	Examples of periodic dredge spoil site inspection reports and procedures	**HSEC Inspections**
		x 4 for 2011
		File Note march 2010 Inspection
	Details of any additional dredging, or civil works undertaken at the dredge spoil during the 2010 operational period	**Dredging Activities**

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
		Bing bong channel survey bathymetric survey
		Dredge Monitoring
		Turbidity readings at Ponds
		Turbidity readings at Dredge
	All external consultants' reports prepared over the monitoring period.	
River diversion performance monitoring - McArthur River and Barney Creek diversions	All updated procedures, monitoring data, reports, and interpretation relating to: - erosion monitoring; - inspections; - river gauging and flood event monitoring; - placement of large woody debris, and bank armouring; - overall diversion performance.	**Monitoring of Erosion**
		Barney Creek erosion Monitoring Photos
		McArthur River Erosion Monitoring Photos
		Lower McArthur River Monitoring Photos
		Channel Earth Works and Habitat Creation
		I& S Rehab invoice 1
		I& S Rehab invoice 2
		2x pictures of large woody debris
		JSA for place large woody debris in River
		Scope of works for remediation of Channel
River diversion performance monitoring - McArthur River and Barney Creek diversions (continued)		**Large Woody Debris**
		GEN-GEN-FRM-6040-0003 Large Woody Debris Placement I001 Rev0
		Gauging Stations
		Barney Creek Theoretical ratings
		Greenspan 2010 service Logs
		ALS Proposal to conduct physical gauging
		River Gauging 2010
		Upstream log
		Downstream log

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
	As built drawings of the river diversions (if updated)	Connell and Hatch As built report with Appendices
	Please provide information and rationale for any changes or additions to any diversion monitoring programs.	In 2011 additional photos will be taken at opposite banks as recommended by the Independent Monitor. This program will also be run later in the year to accommodate for less water in the channel
	Any external consultant's reports prepared over the monitoring period.	
Other audits	Please provide the environmental audit report, any feedback, and/or scope from the: - Commonwealth Government Audit of MRM in 2010; and - Department of Resources audit of MRM	**Department of Resources (June and December)**
		Draft audit report
		DOR letter notification for December MMP Compliance Audit
		Appendix of photos
		Draft compliance report
		letter providing draft report from DOR
		Final Audit Report
		email on draft
		Letter to DOR
		May Inspections
		May DOR inspection for MRM site
		May DOR inspection for Bing Bong
		Response to inspection comments
Other audits (continued)		**Commonwealth Audit**
		Letter to MRM on audit proposal
		Letter from MRM accepting audit
		Audit Plan
		Email requesting audit report

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
MRM Commitment items of the 2009 operational period for which evidence was not provided last audit.	Please provide results and analysis of monitoring the sedimentation zone at the Bukalara Range.	As written in last year's response this will be included in the general photographic monitoring as per the Barney Creek Channel and McArthur River channel with the addition of another 10 monitoring locations. Currently only a distance of approximately 3 kilometres is monitored downstream from the mine every 250 metres. As per the Independent Monitor recommendations where monitoring is conducted near the Bukalara range both sides will be photographed. As also suggested by the Independent Monitor photographic monitoring will take place later in the year where river levels are lower.
	Results or evidence of Installation of lysimeters in the OEF.	2x Emails to Coffey in regards to installation of Lysimiters,
		Capital Projects planned for 2011 including installation of lysimiters
	Results, analysis and locations of water quality and sediment monitoring at the OEF	Refer to Artificial Surface and Sediment testing water for codes (ASWOEF)
	Results and analysis of kinetic leach testing onsite and within laboratory columns.	Stage 7 KLC Program Update
		MRM KLC Stage 7 Proposal
		URS Invoice for KLC
	MRM's training records.	**Training and Competencies**
		Artificial sampling
		DGT sampling
		Dust and soil sampling
		Fluvial sampling
		Groundwater sampling
		marine sediment sampling
		Marine water sampling
		Natural surface water sampling
		Potable water sampling
		Product investigation sampling
MRM Commitment items of the 2009 operational period for which evidence was not provided last audit.(continued)		**MRM Training Sitesafe database records for all Environmental personnel**
		HSE Manager
		Environment Superintendent
		Environment Advisor
		Environment Technician

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
		Graduate Environment Officer
		Rehabilitation Technician
	Please provide evidence of progressive rehabilitation of the Northern OEF	Progressive rehabilitation is only in the form of clay and NAF/PAF layering. Currently there is no area closed off ready for rehabilitation
	Please provide evidence that fences have been relocated away from flood-damage areas, or relevant planning for such has commenced.	Change management form and clearing permit for new location of fence line
		Traditional Owner sign off and local pastoral sign off on fence location
		APPA certificate application
		APPA Certificate approval
		NT Fencing services quote and invoices
		flights details for fencers in 2010
		Invoice for AAPA clearance
Second request for documents		
Monitoring Area	**Query/ Requested documentation/evidence for 2010 Operation Period**	**Documents/evidence provided by MRM**
Geochemical monitoring (Peter Scott)	Golder report - Geochemical assessment of Cell 1	Full copy with analysis at back (107633048-003 R Rev0 Hydrogeochemical Investigation final)
	URS' kinetic testing reports for the waste rock columns. Reports going over the last couple of years.	Stage 1 URS Kinetic Leach Column Report
		Stage 2 URS Kinetic Leach Column Report
		Stage 3 URS Kinetic Leach Column Report
		Stage 4 URS Kinetic Leach Column Report
		Stage 5 URS Kinetic Leach Column Report
Geochemical monitoring (Peter Scott) (continued)		Stage 7 URS Kinetic Leach Column Report Program Update
		Stage 7 URS Kinetic Leach Column Report Program Update April 2011
		URS Advice on Large scale field weathering trials for waste rock Review
		Additional Waste Rock data
	Acid base accounting results for waste rocks and tailings	TSF data has been included in the MMP

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
Geotechnical monitoring (Tim Rowles/Theo Gerritsen)	Spillway Design Capacity Report	This information is included in the Allan Watson and Associates 2010 report
	Golder Associates Geochemical / Hydrogeological Report for TSF	As per above in Geochemcial Monitoring
	TSF operating manual and emergency response plan	MRM Emergency Response Plan GEN-GEN-PLN-6040-0001
		TSF Operating Manual MET-GEN-GDL-2800-0001
	TSF water balance report and ideally operating model	Final OPSIM Report
		Tailings Dam Pond assessments
	Any update to OEF design report (we have 2008 URS report)	No update as of yet planned for 2011
Groundwater Monitoring (Geordie McMillan)	URS (2010) McArthur River Mining Pty Ltd, Tailings and Water Management, Prepared for MRM, 3 August 2010.	Tailings and Water Management Report June 2011 URS
River diversions/ surface water hydraulics (Don Still)	The IM was advised during the recent site inspection that the TSF Cell 2 spillway was temporarily raised by half a metre (to RL 48.5m) prior to the 2010/2011 wet season and that the peak water level in Cell 2 during the wet season ended up being RL 47.7m (i.e. about 800mm below the temporary spillway level). What was the nature of the works which were undertaken to raise the spillway level to RL 48.5m?	A report has been included for the increase to the spillway
	The first round of documents included copies of the new reporting system for Sediment Trap & Dam inspections (which commenced in Nov 2010). Are there any 'old format'/miscellaneous reports re inspections undertaken during the current audit period? If there are, can copies be provided?	Old reporting in general inspections sent in original documentation. The new system of silt trap checking etc was done in the 10/11 wet season as that is when it is applicable
	The first round of documents included the Greenspan Nov 2010 report on the equipment at the various river gauging stations. The report documented a number of problems and included recommendations to address the problems. What has been MRM's response to the various recommendations made in that report?	Replacing all gauging stations with compressed air or radar facilities is still being investigated. Only maintenance work was carried out on gauging station prior to the wet season after the Greenspan report was received however physical gauging were conducted at all sites. Refer to 2x file notes on gauging stations
River diversions/ surface water hydraulics (Don Still) (continued)	The first round of documents included Water Solutions' OPSIM February 2011 report (dated 22 March 2011). Chapters 7 & 8 of the report list a number of recommendations. What has been MRM's response to the various recommendations made in that report? The same question of MRM was asked in last year's audit report re the earlier March 2009 OPSIM report, but the Independent Monitor did not receive any response from MRM.	Included is a letter sent to DOR based on the approval of the SD Water Management Plan
	Is the current edition of the Early Flood Warning System Procedure the one dated March 2009?	This procedure was valid into March however requires updating now
	Has the overdue ALS Environmental stream gauging report	Preliminary Report for Theoretical Ratings May-2011 It is included however is in draft

Monitoring Area	Requested documentation/evidence for 2010 Operation Period	Documents/evidence provided by MRM
	(originally expected to be provided to MRM in about February this year) been received by MRM? If so, can a copy be provided to the Independent Monitor?	form and further information is required
	Last year we sighted a MRM memo prepared by Gary Taylor and dated 22 April 2010 whose subject was "Proposed rehabilitation/erosion control works to be completed along the McArthur River channel". Has a similar post-2010/2011 wet season report been prepared? If so, can a copy be provided?	This hasn't been completed yet
	The 2010/2011 Sustainable Development WMP refers to the additional spray and water fountain systems and how weather information telemetered from a network of weather stations is directed to "a central controller". Does the controller system software automatically shut down the various spray and fountain systems if the weather conditions are unfavourable? What protection is there if the automated controller malfunctions?	This is to be implemented once fans have been incorporated at the TSF. A proposal from PAE Holmes has been accepted
	The 2010/2011 Sustainable Development WMP includes references to contingency plans such as redirecting process waters (from either the APP or CRP storages) to the mining area ponds. How are water management contingency plans such as these documented?	In the mining area Campbell scientific loggers are used through a telemetry system which records levels, inputs and outputs of most ponds, underground pumps and any dewatering occurring. Gauging station is also linked to this system. Currently in the Mill flow meter readings are taken manually and recorded monthly. These were presented in the first lot of documents.
General	Please provide the most recent version of the 2010/2011 MMP (after comments from the DoR).	MMP for 2010/2011
	Any other reports from external consultants or produced internally, that have been made available since the first request for documents in March 2011.	N/A
	Spill management plan for hydrocarbons, chemicals and concentrate (3 in total)	Major Concentrate Spill- Trucking Incident GEN-ENV-PRO-6040-006
		General Spill Response Procedure GEN-ENV-PRO-6040-0004
		Hazardous Substance Procedure GEN-OHS-PRO-6040-0005
Dust	Excel spreadsheet with data results for TIM and metals for all gauging stations from 2009/10.	Dust spreadsheet has been included
Flora and Fauna	No further specific documentation requested. - However if relevant reports have recently been made available, these could be provided.	Bing Bong Transhipment Anchorage 2010 Final report
Flora and Fauna (continued)		Annual Marine Monitoring Program Report
		Migratory Birds Northern Staging Survey and appendix

APPENDIX D DOCUMENTS PROVIDED BY THE DEPARTMENT OF RESOURCES

TABLE 18 DOCUMENTS PROVIDED TO THE INDEPENDENT MONITOR BY THE DEPARTMENT OF RESOURCES

Document Name	File Name	Date
Correspondence from: Cyrus Edwards	More Data Errors	13/01/2010
RE: Turbidity Data for Approval for Additional Dredging at Bing Bong		14/04/2010
RE: McArthur River Mine Project- 2009/2010 Mining Management Plan- Security Request		5/05/2010
Correspondence from: Cyrus Edwards, Matthew Bird	McArthur River Mine Quarterly Data 1Jan2010-31mar2010	10/05/2010
RE: 2009/2010 Mining Management Plan and Water Management Plan		27/05/2010
Correspondence from: Russell Ball, Gary Taylor	FW: MMP Amendment	1/07/2010
RE: Amendment to 2009-2010 Mining Management Plan Request for Additional Information		14/07/2010
RE: McArthur river Mine- Incorporating Ionic Balance into Operator Water Quality Reporting		6/08/2010
RE: Field visits at Mcarthur River Mine		9/08/2010
McArthur River Mine-2010 Water Management Plan		30/08/2010
RE: McArthur River Mine- Sustainable Development Water Management Plan		3/09/2010
RE: Amendment to 2009-2010 Mining Management Plan Request for Additional Information		6/09/2010
RE: McArthur River Mine- Mining Management Plan Acceptance		23/09/2010
RE: McArthur River Mine- Water Management Plan- Request for Additional Information for Approval		29/09/2010
Correspondence from: Gary Martin, Gary Taylor	RE: MMP due on the 30th of this month	28/10/2010
Correspondence from: Alana Mackay, Gary Taylor	FW: MRM water management plan and quarterly water quality data	4/11/2010
Correspondence from: Alana Mackay, Gary Taylor	FW: MRM water management plan and quarterly water quality data	11/11/2010
Correspondence from: Alana Mackay, Gary Taylor, Matthew Bird	FW: Quarterly Data	12/11/2010
McArthur River Mine- 2010/2011 Sustainable Development Mining Management Plan		11/11/2010
McArthur River Mine- 2009/2010 Sustainable Development Water Management Plan		12/11/2010
Attachment A: Evaporation Fan Proposal		
Correspondence from: Alana Mackay, Gary Taylor	FW: MRM water management plan and quarterly water quality data	18/11/2010
RE: McArthur River Mine- McArthur River Mining Pty Ltd		19/11/2010
RE: McArthur River Mine- 2009-2010 Sustainable Development Water Management Plan Amendment- Use of Evaporation Fans at the Tailing Storage Facility		26/11/2010
McArthur River Mine- 2009/2010 Additional comments for the Sustainable Development Water Management Plan		22/11/2010
Correspondence from: Alana Mackay	FW: McArthur River Mine- Water Management Plan	9/12/2010

Document Name	File Name	Date
Correspondence from: Anthony Bianco	Notice of Intent Submission- McArthur River Mine Phase 3 Development Project, Xstrata Zinc, 11 March 2011	11/03/2011
RE: McArthur River Mine- Water Management Plan Conditional Approval		2/02/2011
Amendment to Sustainable Development Water Management Plan- Proposal to remove water from the Water Management Dam		2/02/2011
RE: McArthur River Mine- Amendment to Sustainable Water Management Plan- Proposal to Remove Water from the Water Management Dam		2/02/2011
Correspondence from: Russell Ball, Gary Taylor	FW: Water Management Dam changes under discharge license 174	2/02/2011
Correspondence from: Alana Mackay	FW: Additional information request	4/02/2011
RE: McArthur River Mine- Amendment to Sustainable Water Management Plan- Proposal to Remove Water from the Water Management Dam		4/02/2011
Correspondence from: Alana Mackay, Gary Taylor	FW: Additional information request	3/04/2011
Correspondence from: Alana Mackay	FW: Department of Resources- response to remove water from the water management dam	4/02/2011
Amendment to Sustainable Development Water Management Plan- Proposal to remove water from the Water Management Dam (Additional Information requested)		3/02/2011
RE: McArthur River Mine- Amendment to Sustainable Water Management Plan- Proposal to Remove Water from the Water Management Dam (Further additional information requested)		18/02/2011
Amendment to Sustainable Development Water Management Plan- Proposal to remove water from the Water Management Dam (Further additional Information requested)		17/02/2011
Correspondence from: Russell Ball, Gary Taylor	FW: Additional information Required	18/02/2011
Amendment to Sustainable Development Water Management Plan- Proposal to remove water from the Water Management Dam (Further additional Information requested)		3/03/2011
Correspondence from: Gary Martin, Russell Ball	FW: Siphoning from the water management dam	10/03/2011
RE: McArthur River Mine 2010-2011 Mining Management Plan- Request for Additional Information		11/03/2011
Amendment to Sustainable Development Water Management Plan- Proposal to remove water from the Water Management Dam, Secondary strategy		10/03/2011
Correspondence from: Russell Ball, Gary Taylor	FW: Letter Re amendment to WMP-MRM	15/03/2011
RE: McArthur River Mine- Amendment to Sustainable Water Management Plan- Proposal to remove water from the Water Management Dam, Secondary Strategy		15/03/2011
Correspondence from: Alana Mackay	FW: Proposal to remove water from the WMD, secondary strategy- DoR responses	15/03/2011

Document Name	File Name	Date
RE: McArthur River Mine: Phase 3 Development Project NOI		16/03/2011
RE: McArthur River Mine: Phase 3 Development Project NOI		16/03/2011
McArthur River Mine- Sustainable Development Water Management Plan Additional Information		16/03/2011
Correspondence from: Alana Mackay, Gary Taylor	FW: Additional Information Required	17/03/2011
RE: McArthur River Mine- Amendment to Sustainable Water Management Plan- Proposal to remove water from the Water Management Dam, Secondary Strategy- Acceptance		18/03/2011
Correspondence from: Alana Mackay	FW: Water Management Dam- discharge flow rates and dilution ratios	17/03/2011
Correspondence from: Alana Mackay, Julie Crawford	FW: WMD discharge	18/03/2011
Correspondence from: Alana Mackay	FW: WMD discharge into Barney Creek- acceptance letter	18/03/2011
Correspondence from: Alana Mackay	FW: WMD discharge	18/03/2011
Correspondence from: Alana Mackay, Gary Taylor	FW: Dilution data	18/03/2011
Correspondence from: Gary Taylor	Evaporative Fans	25/11/2010
McArthur River Mine 2010/2011 Mining Management Plan- Request for additional Information		32/3/11
Field inspection report		29/06/2010
Field visit report		3/06/2010
RE: Authorisation 0059-02- Compliance- Final audit report		11/03/2011
Audits and Site Inspections Procedure		Oct 03- Sep04
Audit Checklist		Jul-04
Auditing Classifications		Jul-05
Document Review Procedure		Jan-10
Mining Management Plan Assessments Administrative Procedures for Existing Authorisations		24/03/2011
Administrative Procedures Checklist Existing Authorisations		24/03/2011
Procedures Manual Environmental Monitoring Unit		
Chapter 1.0 Preparing for a Field Trip, 1.1 Field Trip Paper Trail		
Chapter 1.0 Preparing for a Field Trip, 1.2 Flow Chart		
1.3 Field Check List		
Chapter 1.0 Preparing for a Field Trip, 1.4 Packing the Lab Truck		18/05/2011
1.5 Inventory for Lab Truck Mud Maps		
1.0 Preparing for a Field Trip, 1.5 Lab Truck Mud Map- Roof and Cabin		
Lab Truck Mud Map Laboratory Module		18/05/2011
Chapter 1.0 Preparing for a Field Trip, 1.6 Electrical Conductivity Standard Selection for the Field		18/05/2011
Chapter 1.0 Preparing for a Field Trip, 1.7 pH standard selection for the field		18/05/2011

Document Name	File Name	Date
Chapter 1.0 Preparing for a Field Trip, 1.8 Quality Control Check List		18/05/2011
Chapter 2.0 Calibration Standard Preparation, 2.1 pH Standard Preparation		18/05/2011
Chapter 2.0 Calibration Standard Preparation, 2.2 Zobells Standard Solution Preparation		18/05/2011
Chapter 2.0 Calibration Standard Preparation, 2.3 Electrical Conductivity Standards Preparation		18/05/2011
Chapter 3.0 Meter Calibration, 3.1 Dissolved Oxygen Field Meter Calibration (YSI DO200)		
Chapter 3.0 Meter Calibration, 3.2 pH Calibration-Bench (TPS Lab Chem-C)		18/05/2011
Chapter 3.0 Meter Calibration, 3.3 pH Calibration-Field (YSI pH100)		18/05/2011
Chapter 3.0 Meter Calibration, 3.4 Pipette Calibration		18/05/2011
3.4.1 Pipette Calibration Sheet		
Chapter 3.0 Meter Calibration, 3.5 Electrical Conductivity Calibrations-Bench Meters (TPS labCHEM)		18/05/2011
Chapter 3.0 Meter Calibration, 3.6 Electrical Conductivity Calibration- (Field meter YSI EC300)		18/05/2011
Chapter 3.0 Meter Calibration, 3.7 mV Calibration-Field Meter (YSI pH100)		18/05/2011
3.8 Field Calibration Sheet		
Chapter 3.0 Meter Calibrations, 3.9 Turbidity-Field Meter HI93703 Calibration Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.1 Quality Control Samples		18/05/2011
Chapter 4.0 Sampling Techniques, 4.2 Blank Sampling Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.3 Duplicate Sampling Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.4 Control Sampling Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.5 Sampling a Bore		18/05/2011
Chapter 4.0 Sampling Techniques, 4.6 Cyanide WAD and Total Sampling Procedures		18/05/2011
Chapter 4.0 Sampling Techniques, 4.7 Surface Water Sampling Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.8 Suspended Solids Procedure		18/05/2011
Chapter 4.0 Sampling Techniques, 4.9 Acidity Digital Titrator Test Method		19/01/2010
Chapter 4.0 Sampling Techniques, 4.11 Alkalinity Digital Titrator Test Method		18/05/2011
Chapter 4.0 Sampling Techniques, 4.11 Discharge or Flow Rate Procedure		18/05/2011
4.11.1 Discharge or Flow Rate Calculation Sheet		
4.11.2 Discharge or Flow Rate Record Field Sheet		
4.12 Ground Water and Surface Water Field Sampling Sheets		
Chapter 4.0 Sampling Techniques, 4.13 Turbidity-Field Meter HI93703 Operation Procedure		18/05/2011

Document Name	File Name	Date
Chapter 4.0 Sampling Techniques, 4.14 Dissolved Oxygen- Meter Operation Procedure (YSI DO200)		18/05/2011
Chapter 4.0 Sampling Techniques, 4.15 pH Operation-Field YSI pH100		18/05/2011
Chapter 4.0 Sampling Techniques, 4.16 Electrical Conductivity Operation-Field YSI EC300		18/05/2011
Chapter 4.0 Sampling Techniques, 4.17 mV Operation-Field YSI pH100		18/05/2011
Chapter 5.0 Filtering Procedures, 5.1 Inline Filtering Procedure		18/05/2011
Chapter 5.0 Filtering Procedures, 5.2 Syringe Filtering Procedure		18/05/2011
Chapter 5.0 Filtering Procedures, 5.3 Vacuum Filtering Procedure		18/05/2011
Chapter 5.0 Filtering Techniques, 5.4 Washing Filter Units in the Field		18/05/2011
Chapter 7.0 Working with Acids, 7.1 Acid Dispensing		18/05/2011
7.2 Acidification Notice		
Chapter 8.0 Data Management, 8.1 Entering Field data into SLOG		18/05/2011
Chapter 8.0 Data Management, 8.2 Importing Data into SLOG		18/05/2011
Chapter 8.0 Data Management, 8.3 SLOG Site Naming Protocol		18/05/2011
Chapter 9.0 Dispatching Samples for Laboratory Analysis, 9.1 Dispatching Samples to NTEL for Analysis		18/05/2011
Chapter 10.0 Duties on Returning from a Field Trip, 10.1 Retiring from a Field Trip- Flow Chart		18/05/2011
Chapter 10.0 Duties on Returning from a Field Trip, 10.2 Sample Bottle and Equipment Washing Procedure		18/05/2011
Chapter 10.0 Duties on Returning from a Field Trip, 10.3 Bottle Washing		18/05/2011
Chapter 11.0 Cleaning and Maintenance, 11.1 Lab Truck Cleaning Procedure		19/05/2011
Chapter 11.0 Cleaning and Maintenance, 11.2 Lab Truck Daily Checks, Operational and Maintenance Procedures		19/05/2011
Chapter 11.0 Cleaning and Maintenance, 11.3 Washroom Cleaning Procedure		19/05/2011
Chapter 11.0, 11.4 Daily Checks		19/05/2011
11.5 Emergency Eyewash and Shower Maintenance Record Sheet		
Gallay Lab 999 Micro Washing Instructions		
Chapter 12.0 Emergency Procedures, 12.1 Samples Security During Cyclone Watch or Warning		19/05/2011
Chapter 12.0 Emergency Procedures, 12.2 Winch Operation, Safety and Maintenance		19/05/2011
Chapter 13.0 Administration Procedures, 13.1 Environmental Monitoring Unit Overtime and TOIL Procedure		
Chapter 13.0 Administration Procedures, 13.1.1 Overtime and TOIL Administration Procedure		
Chapter 13.0 Administration Procedures, 13.1.2		

Document Name	File Name	Date
Lodging and Overtime and TOIL Claim		
13.2 Brother MFC-6490CW LAN Manual		
Chapter 6.0 Preservation Techniques, 6.1 Preservation Techniques for Heavy Metal, ICPMS, Cation, Ammonium, Nutrient, TDS and Anion Samples		19/05/2011
Chapter 8.0 Data Management, 8.2 Importing Data into SLOG- Trouble Shooting-Where Number 1 Row Contains 'CC' after the Element		19/05/2011
EMU Procedures Title Page		19/05/2011
Environmental Monitoring Unit Field Trip Packing List		
Sample Preservation and Storage		
Specs Bench EC pH		
Specs DO Meter		
Specs TurbidityHI 93703		
Specs YSI EC300		
Specs YSI pH100		
Methodology for the Sampling of Ground Waters		Mar-09
Methodology for the Sampling of Surface Waters		Mar-09
Environmental Monitoring Unit Field Report		27/04/2010
EMU MRM WQ data 2010		
EMU MRM WQ data 2010_QAQC		
McArthur River Mine (MRM) Monitoring Program Groundwater 2010		
McArthur River Mine (MRM) Surface Water Monitoring Program 2010		
201102 DoR Incident Management Process Flowchart		
Notification of a Serious Accident or Critical Incident (Environmental)		Feb-09
Correspondence from: Eileen Mcgovern, Melanie Bradley	MRM- Pictures of salts accumulating on rocks downstream provided by ECNT	1/12/2010
Correspondence from: Chris Francis	Western desert Recourses/MRM	29/11/2010
RE: Reports of Salt Deposits on the Banks of Surprise Creek		14/01/2011
Correspondence from: Andrew Scott, Peter Zeroni, Chris Francis	FW: Western Desert Resources & McArthur River Mining	19/01/2011
Field inspection report		13/12/2010

APPENDIX E REVIEW OF ENVIRONMENTAL COMMITMENTS – MMP 2009/2010

TABLE 19 LIST OF ENVIRONMENTAL COMMITMENTS FROM MMP 2009/2010

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
1	Sewage at the camp is treated through an intermittent extended aeration type sewage treatment plant. Water from the plant is irrigated on to an area away from the camp area after treatment has taken place.	1.3.1	Mentioned in: GEN-SD-PLN-6040-0003 Waste Management Plan I003 Rev 0	Did not observe onsite. Will follow up next audit.	Not verified
2	In 2010 the sewage treatment facilities will be upgraded to include additional aeration and settling tanks.	1.3.1	Mentioned in: GEN-SD-PLN-6040-0003 Waste Management Plan I003 Rev 0	Did not observe onsite. Will follow up next audit. Update works starting April May 2011	Not verified
7	MRM has a weed management plan detailing actions required for successful weed management on site, which is reviewed each year.	2.1.4	Weed Management Plan 2009, Weed Management Plan 2010/11.		Compliance
8	During 2008 and 2009 fish surveys were also conducted and a summary of this has been included in the Water Management Plan submitted in August 2009.	2.1.5	091108 Water Management Plan.		Compliance
9	Cattle have been excluded from the mining and processing areas by the construction of a 17 kilometer fence line.	2.2.1	New fence line docs- Plan, quotes, sacred site search, invoices, response to DOR audit	Fence in progress, to be finished in dry season of 2011	Incomplete
10	For normal operations, if any employee (or contractor) needs to undertake any ground disturbing activity, they must obtain approval from both MRM's Community Relations Department and Environmental Department, in order to ensure that no inadvertent damage is caused to any features of cultural heritage or environmental significance. This is conducted through the Permit to Clear system.	2.2.3	Change management form and clearing permit for new location of fence line . GEN-ENV-PRO-6040-0001 MRM clearing permit procedure, 2011 Clearing Permit Form, 2011		Compliance
13	Every year Mc Arthur River mine revises its Sustainable Development (SD) Strategy, Policy and Annual SD Plan.	3.1	GEN-SD-PLN-6040-0001 MRM SD ANNUAL PLAN 2011. ADM-HSE-PLN-6040-0001 HSE Department Annual SD Plan.		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
15	The following objectives and targets have been put into the 2010 SD Annual Plan: Review and overhaul closure commitments and costings within the annual Mining Management Plan submitted to the Department of Resources and to ensure compliance to all commitments made	3.3.2	ADM-HSE-PLN-6040-0001 HSE Department Annual SD Plan.		Compliance
16	Submit prior to the Mining Management a Water Management Plan for the site as per legislative requirements to the Department of Resources	3.3.2	Water Management Plan 2010/2011 Correspondence between the DoR and MRM.		Compliance
17	Achieve a 5% reduction of fresh water consumption reduction per tonne of product produced over 2008 by the end of 2010.	3.3.2		Did not observe. Will follow up next audit.	Not verified
18	Where available, further rehabilitation activities will be conducted in 2010 in areas of the McArthur River Channel and Barney Creek.	3.3.2	CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, tree planting registers, invoices		Compliance
19	In addition to the rehabilitation of the diversion works, seeding will also occur where available on available topsoil stockpiles, decommissioned workshop areas and roads, go lines and other disturbed areas to prevent erosion and promote soil health.	3.3.2	Tailings Dam cell 1 direct seeding photographs, file notes.	Not many other areas ready for rehab (pers. Comm. Gary Taylor 2011).	Compliance
20	Rehabilitation trials will recommence on the Bring Bong dredge spoil and opportunistic planting will occur.	3.3.2	Photographs, file note, proposals from CDU. Observed during site inspection	No rehab trials commenced due to no CDU PhD student starting. Opportunistic planting did occur in early 2011	Incomplete
21	To continue reporting under the Greenhouse House Challenge, NGERS and NPI and investigate activities that will reduce emissions and waste outputs.	3.3.2		Did not observe. Will follow up next audit.	Not verified
22	Review the Waste Management Plan and set targets based on recycling activities and disposal option.	3.3.2	GEN-SD-PLN-6040-0003 Waste Management Plan I003 Rev 0	Targets are set for recycling, oils and batteries, but targets are only given in volumes/weight. Percentages of the total waste recycled should be given.	Compliance, but improvement needed.

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
23	MRM will undergo as part of its operational approval a third party full compliance audit on its commitments made in the Mining Management Plan, Environmental Impact Assessment and Water Management Plan. This will be conducted by Environmental Earth Sciences the Independent Monitor.	3.3.2	NA	This commitment does not capture the scope of the Independent Monitor's audit. The Independent Monitor's scope of works is set out in the IMACs and section 1.3 of this report.	Compliance – However, commitment should be revised.
24	MRM will continue to produce an Annual Sustainability Report for the community.	3.3.2	This document was not part of the Independent Monitor's document request this year.	Will follow up next audit.	Not verified
25	All employees within the Environment team have their own responsibilities which are outlined in their job descriptions.	4.2.2	Staff competency documents provided.		Compliance
26	Environmental impacts and aspects on site are identified through annual risk reviews.	4.2.4	Risk assessments reported in MMP 2010/2011-	New risk mgmt system implemented. Will follow up next audit.	Compliance
27	Any environmental incidents that do occur are reported in Site Safe and actions are assigned to staff with appropriate time frames in which to complete.	4.2.4	Incident Report forms were reviewed.	Site Safe was not reviewed. The IM noted that some incidents reported to the DoR were not supported by MRM internal forms.	Not verified.
28	MRM has implemented the following environmental training programs: Development of specific environmental responsibilities for Managers to include in Job Descriptions; Provision of environmental information through the site induction process	4.2.5	Job descriptions provided		Compliance
29	McArthur River Mine has an Emergency Response Plan which is reviewed annually by the Safety and Training Adviser but has input by various other positions around site for specific Emergencies that are environmentally based.	4.2.8	MRM Emergency Response Plan GEN-GEN-PLN-6040-0001		Compliance
30	The monitoring conducted at MRM is specified primarily in the Water Management Plan, Mining Management Plan and in the Environmental Monitoring Plan.	4.2.9	WMP 2010/2011 MMP 2010/2011 Environmental Monitoring Manual		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
31	The objective of the depositional dust monitoring program is to monitor potential contaminated particulate matter (dust particles) arising from MRM activities.	4.2.9.1	MMP 2010/2011	This is stated as the aim of the program. MRM should go further to indicate the intention of managing and reducing dust emission, rather than just monitoring it.	Compliance – revision of commitment should be considered.
32	An improvement to the dust monitoring program in 2010 is to occur with the inclusion of Minivol™ dust samplers which will allow more accurate measurement of air quality which can be compared to the relevant air quality standard; National Environment Protection (Ambient Air Quality) Measure (NEPM/AS2800).	4.2.9.1	Bing Bong dust sampling audit, 2010.	The Minivol samplers have been used for the Bing Bong dust sampling audit, however it is unknown whether a formal monitoring program is being considered. No monitoring of other mine site areas has been completed. The investigation did not compare concentrations to relevant air quality standards.	Incomplete
33	A soil monitoring program is in place at MRM and is conducted annually at the Mine Site and Bing Bong Port Facility.	4.2.9.2	Soil monitoring data provided MMP2010/2011		Compliance
34	Structural surveillance of the TSF and associated infrastructure is conducted regularly, in accordance with site procedure MET-GEN-GDL-2800-0001.	4.2.9.3	Infrastructure reports provided		Compliance
35	Tailings are analyzed on a monthly basis for their oxidation characteristics.	4.2.9.3	Monthly tailings geochemistry results (Excel spreadsheets). Environment department Sample Submission Forms to ALS and ALS COAs compiled monthly for 2010	Geochemical testing of the 'final tails' provides evaluation of the potential acid generating capacity of the tailings and changes in the geochemistry of the tailings over time. The analysis of tailings allows for increased accuracy in relation to emissions report through the National Pollution Inventory (NPI). Monitoring of the product also underpins management of waste material and mitigation measures for potential environmental incidents. Tailings are analysed on a monthly basis for their oxidation characteristics. These analyses include ANC (Acid Neutralising Capacity), NAPP (Net Acid Producing Potential), MPA (Maximum Potential Acidity) and NAG (Net Acid Generation). Interpretation of trends in tailings geochemistry should be incorporated in annual reporting	Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
36	Monitoring will be undertaken to measure the effectiveness of revegetation works as well as the extent of natural regeneration and the characteristics of the evolving ecosystem.	4.2.9.4	2009 Barney Creek Riparian Veg Monitoring Report, Veg monitoring report Mar 2011		Compliance
37	Monitoring will be undertaken to measure the effectiveness of revegetation works within the rechannelled sections Barney Creek and McArthur River.	4.2.9.6	Repeat of 36? 2009 Barney Creek Riparian Veg Monitoring Report, Veg monitoring report Mar 2011		Compliance
38	Revegetation of the McArthur River re-channel is scheduled to commence in the 2009/2010 wet season (tubestock and direct seeding).	4.2.9.6	CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, tree planting registers, invoices	Mainly dry season planting now and tubestock rather than direct seeding	Compliance
39	MRM is committed to conducting a riparian bird monitoring program to assess the impacts of the McArthur River diversion on riparian birds and to measure the rehabilitation success of the Barney Creek and McArthur River re-channeling works.	4.2.9.7	Riparian Bird report Oct 2009, May 2010		Compliance
40	The approval from the Commonwealth Government for the expansion project requires a monitoring program to assess the status of listed migratory birds and other birds on the lower McArthur River/Port McArthur.	4.2.9.9	Migratory Shorebird and other bird Monitoring Reports Feb 2010 and April 2010	April survey highlighted the importance of the Port McArthur area for migratory birds	Compliance
41	Mosquito monitoring was introduced in 2009 in response to comments made by Environmental Earth Sciences, the elected independent auditors and as an original commitment for the open pit project.	4.2.9.8	Mosquito Monitoring Program 2009/10 report, field data sheets		Compliance
42	As recommended by the Medical Entomology Department, NT Government, sampling will occur once monthly during the period from June to October (5 trapping episodes per year) and fortnightly from November to May (14 trapping episodes per year).	4.2.9.8	Field Data sheets		Compliance
43	Analysis is conducted by the Medical Entomology Department within the NT Government, and involves identifying the species present in samples collected.	4.2.9.8	Results sheets sent from Entomology to MRM, 2009/10 report		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
44	Controlled burns are undertaken approximately every three years in each area; however these areas are visually inspected to determine annual burning requirements.	4.2.9.9	MMP 2009/10		Compliance
45	Controlled burns are managed through a 'Permit to Burn' system.	4.2.9.9		Personal communications	Compliance
46	All contaminated waste is disposed of within a designated area of the tailings storage facility (TSF).	4.2.9.10.2		Observed on site.	Compliance
47	Putrescible waste is disposed of in a series of trenches located in the south-eastern corner of the water management dam at the TSF. This waste is periodically burnt.	4.2.9.10.3		Observed on site in 2010	Compliance.
48	MRM has a policy of waste minimization and recycling where cost effective or cost neutral.	4.2.9.10.5	Waste Management Plan	Policy does exists and the IM will examine the operation of the policy next audit.	Compliance
49	MRM has a Weed Management Plan in place and this strategy is carried out with the assistance of NRETA.	4.2.9.11	Weed Management Plan 2009, Weed Management Plan 2010/11		Compliance
50	Work conducted at the Tailings Dam since the Independent Monitor has included the installation of further pumps on recovery bores and an additional sump.	4.2.10.2	Observed in Field	High water levels at time of inspection	Compliant
51	Recovery rates from these locations are recorded on a weekly basis as part of the Surface Water monitoring and all rates have been reported on within the Water Management Plan.	4.2.10.2	Scanned copies of Recovery Bore monitoring data sheets. TSF Monthly Reports.	Details on the performance of the seepage recovery system have not been reported in the WMP, and should be in future.	Compliant
52	A trial area of Total Ground Control was implemented on the remaining portion of cell one as a dust mitigation strategy and the remainder solution will be utilised next operational year in between further capping activities.	4.2.10.2		Observed during site inspection. Capping of Cell 1 complete for dust suppression purposes only.	Compliant
53	URS completed an electromagnetic Survey of the TSF in early December and the results of this report will be utilised to plan and implement further strategies in trouble spots identified.	4.2.10.2	URS EM Survey report.	EM survey completed, but should be used in conjunction with continuing improved understanding of the hydrogeology and monitoring of the TSF, and not as a stand-alone measure.	Compliant

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
54	All drainage works requested from the Independent Monitor were undertaken before dredging commenced at Bing Bong and included a perimeter drain and re-contouring of the last several cells to ensure adequate drainage and silt attenuation.	4.2.10.2		Observed during site inspection in 2010 and 2011 However, drain needs to be cleaned out/maintained.	Compliant
55	Soil samples were taken in proximity to the Dredge spoil in order to identify their saline content so comparisons can be made to control locations and future sampling.	4.2.10.2	Soil salinity results from 2010 were reviewed.		Compliant
56	Initial vegetation scar mapping has been conducted with the use of aerial photographs based on annual ones taken by AAH Hatch.	4.2.10.2	None	Orthophoto of Bing Bong area have been viewed but no interpretation has been carried out in 2009/10	Incomplete
57	Other smaller items that were also identified by the Independent Monitor have been entered into Site Safe with appropriate time frames given to them for completion.	4.2.10.2		Independent Monitor will verify next audit.	Not verified
58	Over the next operational year the main areas of rehabilitation will include: Progressive rehabilitation of the Northern OEF; Stage one of rehabilitation, over the remainder of cell one at the Tailings Storage facility; Rehabilitation of the Mc Arthur River Channel; and Maintenance rehabilitation of the Barney Creek Channel	6.2	CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, tree planting registers, invoices, Tailings Dam cell 1 direct seeding photographs, file notes	OEF not ready for rehab (Gary Taylor pers.com 2011), This is not documented in MMP	Compliance
59	In order to facilitate faster growth rates and better survival rates over the dry season MRM are employing the use of a water sled with irrigation as a new initiative.	6.5.1.2	CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, Sled flow meter readings, photographs of sled	Proving effective	Compliance
60	The Mc Arthur channel and Barney Creek works will be protected by rock lining. Rock chutes have been designed in several areas along both channels limiting the amount of clearing where possible.	6.5.1.2	None	Rock lining had previously been completed, as had all the various chutes. Hence it is unclear what works are being referred to here. (It is noted that some additional rock lining was undertaken to address 2009/2010 wet season flow impacts.)	Compliance – Commitment should be revised to be more specific.

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
61	Regular monitoring and feedback will be important during revegetation. Monitoring will measure the effectiveness of revegetation works as well as the extent of natural regeneration and the characteristics of the evolving ecosystem.	6.5.1.3	CDU vegetation monitoring report		Compliance
62	The OEF will contain potentially acid forming (PAF) material and non acid forming (NAF) material, with the PAF material encapsulated in a dedicated cell in the western area of the OEF.	6.5.4		This commitment is captured in the design, and the design is being followed. There is some question on whether the NAF is correctly characterised to avoid acid, metal and sulfate generation. There has also been some leachate discharge away from the PAF leachate collection pond.	Not Verified maybe partly compliant
63	The TSF area has been fenced to exclude stock, and permanent fire breaks will be constructed around the perimeter.	6.5.5	New fence line docs- Plan, quotes, invoices, response to DOR audit	Fence to be completed/ recommenced in dry season of 2011	Incomplete
64	Prior to capping the tailings, the post-mining tailings surface topography will be reformed to minimize erosion.	6.5.5	No – only clay placement	Cover placed at 0.5m thick no reshaping, however cover considered a temporary measure but some erosion occurring	Non Compliant
65	Rehabilitation on Cell one of the TSF commenced in September 2008. CDE Capital was awarded the contract to place the first layer of material over the deposited tailings.	6.7		Observed on site. However, we note that this is the first stage of rehabilitation and only acts as a dust suppressant.	Compliant.
67	Rehabilitation in 2009 on cell two was limited with only the application of Total Ground Control for dust suppression.	6.7		Observed on site. However, this is not a 2010 'commitment'. It is a statement of previous works	Compliant
68	Additional works including a raise in portions of cell one were also conducted along with spillway modifications.	6.7	Tailings Dam 2010 Cell 2 Spillway (MRM not dated)	Only work noted was in cell 2 not cell 1	Compliant
69	Barney Creek rehabilitation was completed in the first quarter of 2008 and requires no further work except for annual maintenance and monitoring for full rehabilitation.	6.8	MMP 2009/10 and 2010/11, photographs, riparian bird reports	Targeted tubestock planting to continue.	Compliance
70	A total of 23,084 seedlings were planted during December 2007 and January 2008. Table 6.2 lists the breakdown of species numbers.	6.8	Tree planting register Q1 2011		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
71	Topsoil is typically stored in piles less than 5m high.	7.2.2	No photographs or documentation of current topsoil stockpiles available. Pers. Comm. W Gary Taylor 2011 gave location of stockpiles	Independent Monitor will verify next audit.	Not verified
72	The ore spotter and/or excavator operators notify the truck drivers what material they are carrying. The trucks display the appropriate card in their windscreen to match the material they are carrying. This practice provides a check against hauling wrong materials to the wrong destination.	7.2.6		Independent Monitor will verify next audit.	Not verified on site.
73	The geochemical data is logged in the drilling database, enabling NAF and PAF to be modelled in the geological block model.	7.2.7		Geological block model was not available for review.	Not Verified
74	Monthly samples are taken to ensure the correct classification and dumping location of the material. Mine surveyors provide a map and coordinates for each sample location and the material is sent away for analysis.	7.2.7		Only have monthly waste rock sampling to Feb 2010, nothing later Therefore it is not possible to clarify if this was being followed for the whole of 2010.	Not Verified. Likely to be compliant
75	The mining fleet is maintained on site. Emeco have workshop facilities located near the ROM pad, where the rubber tyred and smaller tracked machines are maintained. The workshop has a wash down pad, workshop pads, self-bunded lube storage, parts store, and an office.	7.2.10		Observed during 2011 site inspection.	Compliance
76	The pit stages also aim to preserve the original McArthur River (and its riparian corridor) for as long as possible, before mining through it in discrete stages.	7.3.1	MMP 2009/1, 2009 As Built Report	Actual amounts of vegetation cleared to date is difficult to find.	Not verified – But likely compliance
77	PAF cells will be placed in the core of the OEF, at least 25 m in from the outer edges of the OEF, and encapsulated in a clay layer of at least 1 m thickness.	7.4.1		This is happening and was observed on site	Compliance
78	NAF rock will be placed outside the completed PAF cell.	7.4.1		The Independent Monitor questions whether NAF is correctly characterised	Not Verified. Likely partial compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
79	The top of the clay layer encapsulating the PAF cells will be covered by a minimum of 3 m of NAF material.	7.4.1	Site inspection	Partially complete but some areas of clay exposed	Incomplete
80	The PAF dams consist of two portions, a sediment trap dam first, where any runoff and/or leachate will flow into; and a main dam. Runoff from the OEF spills into the sediment dam first.	7.4.3.4	Incident report of leachate not reporting to PAF pond 21/6/2010	PAF dam observed on site. Independent monitor will investigate this and request associated documentation and reporting regarding this issue next audit.	Incomplete
81	The PAF dams are constructed with a compacted clay core, followed by rock armouring to protect them from erosion.	7.4.3.4	no documentation on design sighted	Not inspected during site inspection, Independent Monitor will verify next audit.	Not verified
82	Topsoil (typically 100mm to 150mm thick) is stripped from areas ahead of mining, dumping, or construction.	7.7.2		Independent Monitor will verify next audit.	Not verified
83	In some cases fresh topsoil will be applied straight on the Mine levee wall as per the section of wall at the end of the airstrip, which was completed in the last quarter of 2009.	7.7.2		As seen in Independent Monitor site inspection in May 2011. Documentation difficult to find or absent	Compliance
87	A series of groundwater bores is proposed to monitor the effectiveness of the dewatering holes.	7.7.4	2010/2011SDWMP, 2010/2011 MMP.,	Independent Monitor will check on completion of these works (and above) as part of 2010-2011 report.	Compliant.
89	Any water coming out of the holes will be allowed to flow by gravity through pipes to sumps in the pit, or through broken rock into the underground workings. Water from pit sumps will be pumped into one of the mines dirty water dams.	7.7.5	2010/2011SDWMP, 2010/2011 MMP.	Independent Monitor will check on completion of these works (and above) as part of 2010-2011 report.	Compliant.
90	In conjunction with the dewatering holes, another program of cable bolting is planned to enhance the stability of the west wall.	7.7.5	2010/2011SDWMP, 2010/2011 MMP.	Independent Monitor will check on completion of these works (and above) as part of 2010-2011 report.	Compliant.
91	The last reporting period saw the construction of a water dam (Pete's Pond), surface water bunds and diversions, and a re-contouring of the area to the south of the pit to keep clean and dirty water separate inside the bunded area.	7.7.6	2010/2011SDWMP, 2010/2011 MMP.	Independent Monitor will check on completion of these works (and above) as part of 2010-2011 report.	Compliant.

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
92	Works in this MMP period will include: Final armouring and lining of Pete's Pond; Trimming and armouring of the bund; Clay lining and trimming of the re-contoured area; Re-contouring of the top of the West OEF; Re-contouring of the area between the West OEF and the pit; Completion of the plug across the old McArthur river channel inside the bund; Completion of a dam adjacent to the screening plant pad; Establishment of pump pads; and Installation of the associated pipes	7.7.6		Not verified this Audit.	Not verified
93	A mobile screening plant is used to segregate run-of-mine waste rock from the pit into the useful size groupings.	7.7.8		No comment as did not access pit during the inspection	Not verified
96	Activities completed in the last operational year that were approved in the last MMP include: Completion and commissioning of the tailings line upgrade.	7.12.2	Not inspected during site inspection, no documentation on design sighted	Pipeline not bunded on embankment ramps	Incomplete until bunding complete
100	Periphery deposition of tailings in Cell 2 continued with two programs of tailings line extension.	7.12.2	Observed during site inspection		Compliance
101	Operation of water recovery bores from the Surprise creek corridor back to the Cell 2.	7.12.2	Observed during site inspection	Not operating at time of inspection, only operate in dry season	Partially compliant
103	The concentrate filter cake is transported from the filter building to the mine site concentrate storage shed via a covered conveying system.	7.12.6		Did not observe. Will follow up next audit.	Not verified
104	Concentrate is transported from the mine site to Bing Bong by road-trains with covered, side-tipping trailers.	7.12.6	Observed during site inspection		Compliance
105	Tailings will be placed using a spigotted discharge system around the cell perimeter, which will minimise the risk of seepage from the TSF.	7.12.7	Observed during site inspection		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
106	The tailings will be deposited sub-aerially in thin layers to maximise the density of the tailings beach against the embankment, providing a low permeability beach of tailings between the decant water pond and the perimeter embankment.	7.12.7	Observed during site inspection		Compliance
107	Complete the coverage of cell 1 with clay to 500mm during the 2010 dry season.	7.12.8	Observed during site inspection		Compliance
108	Trials on the application of dust control chemicals was successful in the last operational period. These chemicals will be applied after the wet season when the tailings surface is drivable.	7.12.9		It is unclear whether this commitment is referring to Cells 1 or 2. Will follow up next audit.	Not verified
109	In the last quarter of 2009 the perimeter embankment wall on the eastern side of Cell 1 was raised to the same elevation as the perimeter wall on Cell 2. The overflow spillway on Cell 2 was raised by 1m to increase the freeboard capacity ahead of the 2009/2010 wet season.	7.12.10	Observed during site inspection		Compliance
110	The cargo hold of the Aburri is washed down at the completion of unloading operations. The gutters along each side of the Aburri allows for the decks to be hosed off, with the water collected in a sump near the stern ramp. Water used during the wash-down process is collected on-board and pumped to the Site Run-off Pond.	7.12.11		Did not observe. Will follow up next audit.	Not verified
111	During 2009, additional work to the gantry loader on the wharf was upgraded to ensure less spillage occurs while loading along with minimising dust generation.	7.12.11		The IM did not observe these specific updates, but did observe a loading procedure and was satisfied that no material was likely to escape.	Compliance
112	Dredging commenced in early November 2009 and to date approximately 63 thousand cubic metres has been removed from the swing basin and placed into cells A & B on the dredge spoil.	7.12.13	Dredge material Observed placed in ponds after dredging in 2010 site inspection.		Compliance
113	As per the dredge Management Plan accepted, monitoring has included in situ turbidity readings at the dredge, turbidity readings at each weir between ponds and at the outlet where water enters the marine environment.	7.12.13	Turbidity results within ponds and at outlet		Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
114	Soil testing has also commenced at the outlet to ensure no Acid sulfate contamination occurs as a result of the dredging campaign.	7.12.13	Acid Sulfate Soil analysis data provided		Compliance
115	Before any dredging took place extensive earthworks and drainage was implemented at the dredge spoil as a result of findings from the Independent Monitor. A perimeter drain was constructed, weirs were reinstated, road maintenance was conducted and additional monitoring of soils was undertaken in areas situated around the spoil.	7.12.13	Observed in 2010 and 2011		Compliance
116	During 2009 additional sprinklers were added to the evaporation system in order to evaporate a greater amount of water produced early in the year.	7.12.14	Sprinklers have been observed during site inspection		Compliance
117	Pond levels are managed daily and readings are sent to the HSE and Administration Manager in order to determine if further controls are required during high periods of rainfall.	7.12.14	Conversations with MRM indicated that runoff water at BB during the wet seasons was managed appropriately.		Compliance
118	Asphalt maintenance in various locations was also carried out around some areas of the BBROP and around the main gantry location in order to create a better seal and hence minimise any ground contamination due to water infiltration.	7.12.14	The Independent Monitor did not observe specific areas, but asphalt across the Bing Bong site appeared to be in good condition		Not verified - Likely compliance
119	A preliminary Mine Closure Plan has been developed for the Mc Arthur River Mine Site which will be reviewed every 5 years and thus will be completed again in 2013.	8.1.1	Preliminary Mine Closure Plan – March 2008		Compliance
120	Over the last reportable period the following areas were rehabilitated: Portions of the Mine levee wall; Bunding at the base of the ROM pad; and Small sections of the McArthur River channel	8.3.1	MR diversion as in CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, tree planting registers, invoices	Mine Levee wall and base of ROM as seen in Independent Monitor site inspection May 2011	Compliance

Commitment Number (MMP Appendix 2)	Commitment	section of MMP 09/10	Relevant documents reviewed	Additional Comments	Compliance rating
121	Over the next reportable period the following area will be rehabilitated: Mc Arthur River Channel with the use of direct seed and tube stock Targeted planting along Barney Creek as per consultant reports	8.3.1	CDU veg monitoring report Mar 2011, MMP 2010/11, photographs of diversions, tree planting registers, invoices	One side of the MR diversion was planted with 40,000 tubestock, the other side to be planted in 2011 dry season	Compliance confirmed in 2011