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Overburden Emplacement Facility Management Plan

**McARTHUR RIVER MINE PHASE 3
DEVELOPMENT PROJECT**

January 2012

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Appendix E2 – OEF Management Plan

McArthur River Mine Phase 3 Development Project Overburden Emplacement Facility Management Plan January 2012

Appendix E2 – OEF Management Plan

Contents

1	Introduction	1
1.1	Overview of Phase 3 Development Project OEFs	1
2	Overburden Geochemical and Multi-Element Nature.....	3
2.1	Overview.....	3
2.2	Overburden Geochemistry	3
2.3	Metal Concentrations	5
2.4	OEF Objectives	6
3	North OEF	7
3.1	Geological Setting.....	7
3.2	Stability.....	8
3.2.1	Modelling Method and Parameters	8
3.2.2	NOEF Stability Analysis Results	10
3.2.3	NOEF Design and Operations for Stability.....	11
3.3	Other Design Parameters	12
3.4	PAF Management Concept	12
3.5	NAF Areas Concept.....	13
3.6	Cover Design and Integrity.....	15
3.6.1	Cover Design	15
3.6.2	Cover Integrity	15
3.6.3	NAF Areas Cover.....	16
3.6.4	PAF Cells Cover.....	16
3.7	Surface Water Management System	18
3.7.1	Definitions	19
3.7.2	OEF Water Management Concepts	19
3.7.3	PAF Dams	20
3.7.4	NAF Dams (Sediment Ponds)	20
3.7.5	Dirty Water Drains.....	22
3.7.6	Clean Water Drains.....	22
3.7.7	Contour Drains for Rehabilitation.....	22
3.7.8	Rock Chute Drop Structures for Rehabilitation	23
3.8	Staged Development and Rehabilitation Strategy	23

Appendix E2 – OEF Management Plan

4	East and South OEFs	31
4.1	Stability Analysis.....	31
4.2	Other Design Parameters	32
4.3	NAF Areas Concept.....	32
4.4	Cover Design and Integrity.....	32
4.5	Surface Water Management System	33
4.5.1	Erosion Protection Bund (EPB)	33
4.5.2	Dirty Water Drains and Sediment Ponds.....	33
4.5.3	Clean Water Drains.....	33
4.6	Staged Development and Rehabilitation Strategy	33
5	West OEF.....	38
5.1	WOEF Design Parameters.....	38
5.2	PAF Management Concept	38
5.3	Cover Design	39
5.4	Surface Water Management System	39
5.5	Staged Development and Rehabilitation Strategy	39
6	OEF Monitoring.....	40
6.1	Kinetic Leach Testing	40
6.2	Further Geochemical Assessment	40
6.3	Monitoring Program	40
6.4	Monitoring Frequency.....	41
7	OEF Rehabilitation and Mine Closure	44
7.1	Overview.....	44
7.2	Contour Banks.....	44
7.3	Revegetation.....	45
7.4	Erosion Control.....	45
7.5	Key rehabilitation materials.....	45
7.6	Material stockpiling and deployment.....	46
8	Environmental Risks - OEFs.....	47
9	References	50

1 Introduction

This Overburden Emplacement Facility (OEF) Management Plan provides a description of the placement, dimensions, capacity, construction methods and environmental management techniques of the OEFs that will be associated with the McArthur River Mine Phase 3 Development Project (the Project). This plan will be reviewed regularly to ensure that it is up to date with current practices and knowledge.

The OEFs for the Project are shown in Figure 1-1.

1.1 Overview of Phase 3 Development Project OEFs

The Life of Mine (LOM) overburden production estimates including the Project total 660 million tonnes (Mt), up from 130 Mt for the existing operation. Hence, the Project will contribute an extra 530 Mt of overburden material. The Project will necessitate the expansion of the existing North OEF (NOEF), with the addition of new OEFs to accommodate the additional material. The NOEF will increase in height from 55 m to 80 m, together with adding a new South (SOEF) and East OEF (EOEF) to the south and east of the open pit to a maximum height of 80 m.

The majority of overburden will still be sent to the NOEF. This location was originally selected for the current operations after consideration of floodwater levels, surrounding topography, cultural heritage, watercourse crossings, location of other infrastructure, and available capacity. These issues are still relevant for the Project.

OEFs provide the final storage for overburden material excavated from the open pit during the mining process. Some overburden has the potential to generate acid rock drainage (ARD) due to the presence of pyrite in the geological strata and their potential exposure to oxygen and water. Classification of overburden as Potentially Acid Forming (PAF) and Non-Acid Forming (NAF) (NAF also contains Acid Consuming (AC) material) is conducted to ensure that PAF material is handled with sufficient care to limit environmental harm.

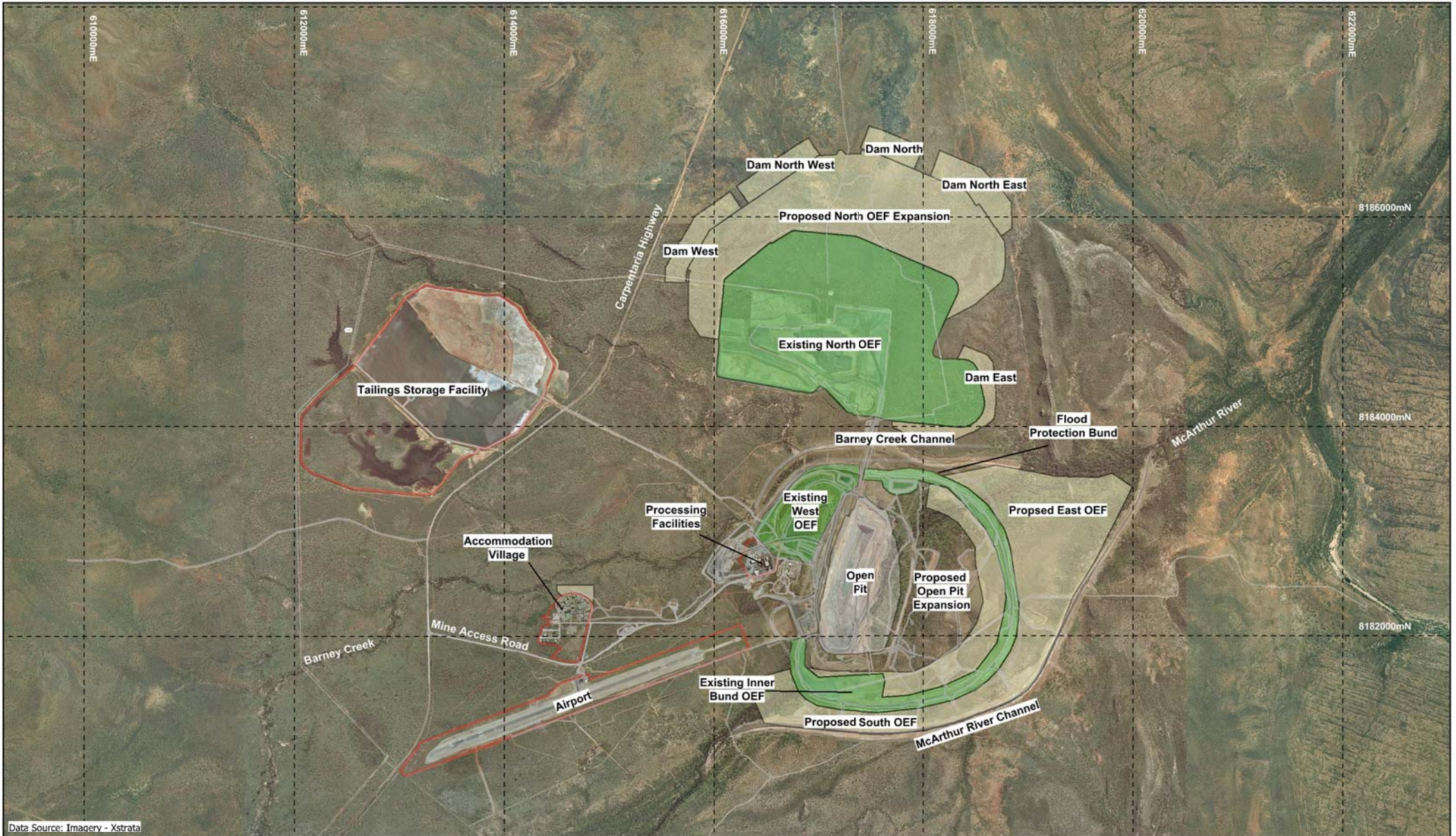
The NOEF has been constructed outside of the existing flood protection bund, which surrounds the current open pit. A detailed report on the NOEF concept, specifications, staging, and capacity is contained in the URS report *"Final Report – McArthur River Mine Overburden Emplacement Facility Design"*, dated 30 July 2008, which was submitted as Appendix 3 in the 2008 Mining Management Plan. A minor revision to the NOEF design was completed in 2011 (SDMMP, 2011) that changes some of the geometry of the NOEF, whilst still honouring the original design principles.

All PAF material associated with the Project will be stored in encapsulated cells within the NOEF, as is the current practice. NAF material will be used in all other OEFs (i.e. the new South and East OEFs) and for the construction and encapsulation of PAF cells in the NOEF. NAF rock also provides benign construction material for other uses within the Project area, such as haul road construction. The NOEF currently has an approved footprint of 375 ha and a maximum height of 55 m. This will be increased to a footprint of 860 ha and a maximum height of 80 m.

The South and East OEFs (SOEF and EOEF) will become part of the existing flood protection bund (Bund OEF) for the Project. It will be used for the storage of NAF material only due to the proximity to the McArthur River Channel. Currently, the footprint of the approved flood protection bund and Bund OEFs is 120 ha, which will be increased to 270 ha with a maximum height of 80 m with the addition of the East and South OEFs.

The existing West OEF (WOEF) is located within the flood protection bund to the west of the open pit. The northern part of the West OEF was completed during the 2010-2011 reporting period and now has office and workshop infrastructure located on top of it. The southern part of the West OEF will be extended over the current stores area once they are moved in 2012. This area will then be built up to form a new run of mine (ROM) pad, servicing a new primary crusher. NAF and PAF materials will be used for this construction, adhering to the design principles detailed in the annual MMP's.

The OEFs are designed to protect against environmental impacts. To do this, they must be physically stable in the long-term. The position, height and slope of the OEFs are important factors in their physical stability. The most important chemical property of the overburden is linked to the potential contact with air and water, which may produce leachate.



Data Source: Imagery - Xstrata



2 Overburden Geochemical and Multi-Element Nature

2.1 Overview

The MRM overburden has been classified into the following categories to define its potential environment impact: Potentially Acid Forming (PAF) waste, and Non-Acid Forming (NAF). PAF overburden has the potential, in the presence of air and water, to generate acid water, soluble metals and salts that could impact the environment.

NAF overburden is chemically stable with low potential for generation of environmentally significant products. NAF overburden also has the capacity to neutralise runoff and potential seepage from PAF material.

The storage strategies for each of these materials differ, as they each have different uses and potential environmental effects.

Acid generation from mine materials is caused by the exposure of naturally occurring sulphide minerals, most commonly pyrite (FeS_2) to atmospheric oxygen and water. Sulphur assay results are used to calculate the Maximum Potential Acid (MPA) that could be generated by a waste, either directly from pyritic sulphur content, or by assuming that all sulphur not present as sulphate occurs as pyrite. Pyrite oxidises to generate acid according to the following overall reaction:



While the above sulphide oxidation reaction generates acid, there is often a counterbalancing reaction from naturally occurring carbonate and silicate materials which can neutralise the acid generated. The interaction and overall mix of the acid generating and neutralising materials determines the amount and rate of any acid generation.

The net acid producing potential (NAPP) is used as an indicator of materials that may be of concern with respect to acid generation and represents the balance between the MPA and the acid neutralising capacity (ANC) of the material. By convention, the NAPP result is expressed in units of kg of H_2SO_4 (sulphuric acid) per tonne of overburden ($\text{kg H}_2\text{SO}_4/\text{t}$).

If the ANC significantly exceeds the MPA, then the material is NAPP negative and likely to be NAF. Conversely, if the MPA significantly exceeds the ANC, the material is NAPP positive and likely to be PAF. The net acid generation (NAG) test has also been used to indicate the acid forming nature of mine materials.

2.2 Overburden Geochemistry

Previous investigations into the geochemical characteristics of overburden have been reported in *"Geochemical Assessment of Overburden and Tailing Materials Including Conceptual Design of Overburden Emplacement Area"* (URS, 2005a). This covers overburden for the existing Phase 2 mine, and the proposed Project open pit.

A new geochemical investigation commenced in September 2011 to increase confidence in predicting the occurrence and behaviour of PAF material as part of the Project. This includes increased sample densities and verification of the open pit/final wall characteristics. Over 5,000 m of overburden was drilled in this program and results will be combined with existing geochemical data. Drilling campaigns will be on-going to collect more detailed information in advance of the planned mine extents, with approximately 3,000 m per year of drilling budgeted throughout the mine life until the end of bulk waste mining.

Based on previous studies, MRM materials contain reactive pyrite, but also contain a significant amount of ANC as well as non-reactive sulphides, such as galena (PbS) and sphalerite (ZnS) that do not generate acid. MRM conducted a geochemical assessment of overburden materials as part of an intensive exploration program carried out in 2002. The geochemical data were used to determine the geochemical characteristics of overburden likely to be excavated and to develop management strategies for overburden placement.

Appendix E2 – OEF Management Plan

URS (2005a) provides geochemical data obtained for 656 selected drill core samples (at approximately 5 m depth intervals). The samples were selected to represent the various potential overburden rock types likely to be generated, from 35 drill holes across the range of rock types expected in a large pit. The results, as summarised in Table 2-1, indicated that PAF materials are restricted to zones within the upper and lower pyritic shale rock types.

Table 2-1 – Summary of waste rock characterisation results (2005a)

Rock Type	No. of Samples	% Total Samples	% PAF	%NAF
Cooley Dolomite	83	7.5	0	100
Upper Dolomitic Shale	42	3.8	7.3	92.7
Upper Pyritic Shale	137	12.4	46.7	53.3
Lower Pyritic Shale (including Bituminous Shale)	527	47.7	22.2	77.8
Lower Dolomitic Shale	50	4.5	0	100
W-Fold Shale	236	21.4	0	100
Teena Dolomite	30	2.7	0	100

A cross section (Figure 2-1) through the final Phase 2 (current approved) and Phase 3 (proposed) open pits shows that considerable Cooley Dolomite, which is AC material, is present in the final wall and last stages of the Phase 3 mining. However, it is also evident that the lower parts of the open pit have higher proportions of PAF, which requires forward planning of the OEF construction and rehabilitation.

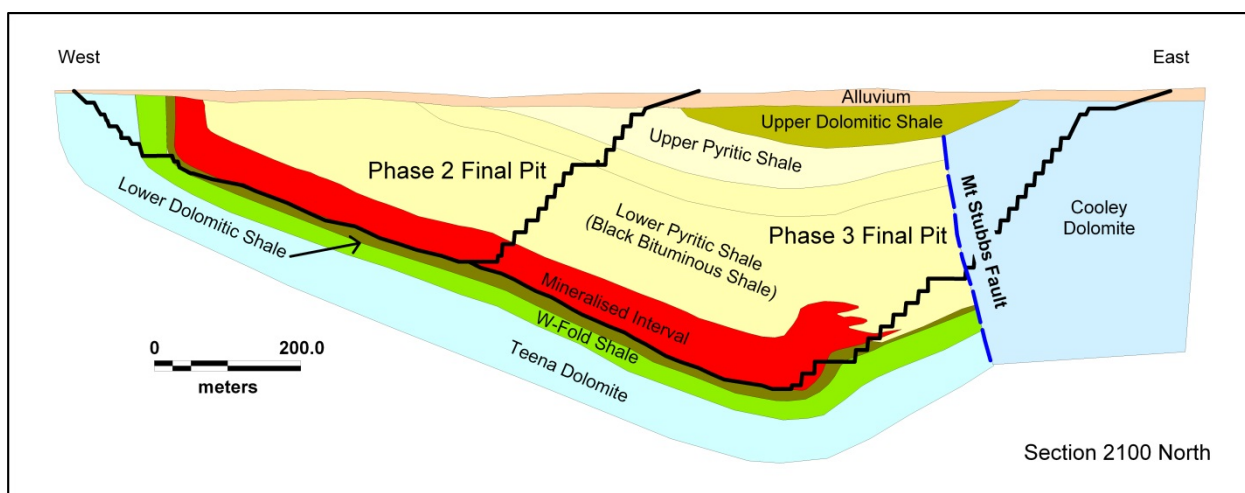


Figure 2-1 Cross section showing waste rock types and open pit limits

Appendix E2 – OEF Management Plan

The sulphur content of the pyritic shale can be high (up to 16.7%) and has the capacity to generate a significant quantity of acid drainage (up to 145 kg H₂SO₄/t as predicted in the NAG test). However, there is likely to be a period of time before acid conditions may become apparent in these materials (lag-period) due to high ANC content. Consequently, PAF shale materials are selectively handled and encapsulated as part of the NOEF management strategy.

The W-Fold Shale, Cooley Dolomite and Teena Dolomite rock types have a very low sulphur content and high ANC. These rock types are NAF and are also a potential source of highly AC material. The lower dolomitic shales occasionally have a relatively high sulphur content, however all samples have a moderate to high ANC and a low (strongly negative) NAPP value. The geochemical data suggests that most of the dolomitic shale materials also have significant acid consuming characteristics.

Geochemical data will continue to be used to determine the acid forming nature of overburden materials prior to mining using exploration drill core and/or active bench face samples. Acquired data will be used to block model overburden materials in advance of mining and to facilitate and verify the implementation of proactive overburden management strategies and procedures (i.e. selective handling, placement and clay encapsulation of PAF materials).

A procedure for the categorisation and management of overburden during mining operations has already been produced (MRM Document Reference: MIN-TEC-PRO-1000-0015-EOM Sampling).

Identifying the ore, overburden and the different types of rock is important for both the mining operation and environmental protection. Geologists verify each stage of mining using extensive studies, geochemical testing, maps, surveys and samples. The geologists physically walk the face to be mined and delineate the face with coloured paint and tape to differentiate between the ore and types of overburden. Each ore and rock type are removed separately by diggers, and placed into specified trucks. The trucks also identify whether they carry PAF, NAF or ore material. The type of rock determines where their load is deposited.

2.3 Metal Concentrations

Previous multi-element tests indicate that arsenic (As), cadmium (Cd), copper (Cu), manganese (Mn), lead (Pb), and zinc (Zn) are commonly present in most overburden rock types at elevated concentrations. The enrichment of these elements with respect to normal background concentrations is to be expected and reflects the natural geochemical enrichment that defines a mineral deposit.

These metals are bound-in with the overburden and are not readily available to mobilise into the environment. Metal solubility is strongly pH-dependent so that if overburden materials become acidic, leachate may contain elevated concentrations of dissolved metals.

A series of long-term kinetic leach column tests was undertaken to test if metals can leach out of the overburden (URS, 2005a). These tests indicated the following:

- seepage from PAF overburden materials can become acidic after a period of exposure to oxidising conditions. Seepage is likely to be brackish to saline and may contain elevated concentrations of soluble metals (generally Cd, Fe, Mn, Pb and Zn) and sulphate compared to relevant livestock drinking water quality criteria. It is for these reasons that all PAF material requires encapsulation by NAF materials
- seepage from NAF overburden is likely to be pH neutral and generate excess alkalinity. It is expected to be slightly brackish and contain relatively lower concentrations of soluble metals, although soluble Mn (and occasionally some other metal concentrations) and SO₄ may exceed livestock drinking water quality criteria
- the placement of NAF overburden surrounding PAF overburden is likely to significantly improve potential seepage quality from PAF overburden

Appendix E2 – OEF Management Plan

- PAF and NAF overburden materials retain a high proportion of their inherent ANC after 18 months of exposure to oxidising conditions. The inherent ANC should continue to provide significant acid buffering for these materials, although for PAF materials the ANC may be sufficient to moderate but not prevent acid conditions.

The tests showed that soluble metals in runoff/seepage from OEF materials will remain within ANZECC (2000)/NEPM (1999a) concentration guidelines criteria for livestock drinking water under neutral or alkaline pH conditions.

2.4 OEF Objectives

For OEFs used for the storage of NAF material only (East and South OEFs), the main objectives are to achieve stable landforms capable of rehabilitation, and to manage surface water runoff.

Encapsulated PAF storage necessitates additional OEF construction objectives including:

- limiting the potential for acid leachate generation from the PAF cells
- limiting water infiltration into the PAF cells
- controlling any leachate that is generated, particularly during the construction phase of the PAF cells.

The same final objectives for NAF OEFs also apply to the PAF cells, ensuring that the final landform is capable of suitable rehabilitation, undergoes minimal erosion, and conforms to the Sustainable Development Water Management Plan.

3 North OEF

A plan of the various components over the life of mine of the NOEF is shown in Figure 3-1

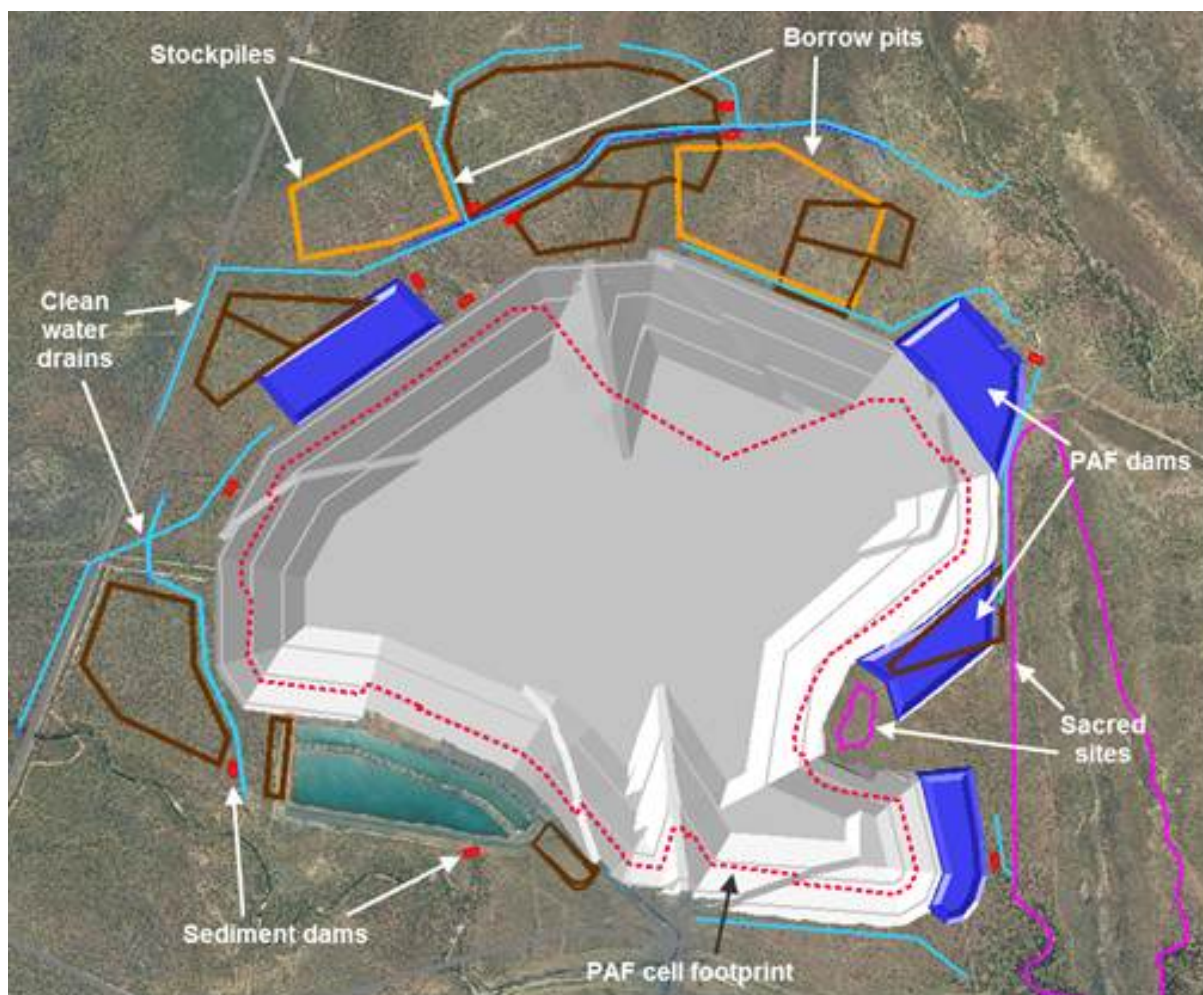


Figure 3-1 Plan of NOEF and associated infrastructure

The figure shows multiple ramps. Whilst the three in the south are for haul truck access from the pit, the rest are to facilitate rehabilitation, as stockpiled materials (topsoil, clay and NAF overburden) are rehandled from stockpiles around the perimeter of the OEF to the completed surfaces. Some clay borrow pits for end of life rehabilitation are shown in the north.

Also visible are water management structures (dams, drains and sediment traps) around the perimeter of the OEF. All of these features will be discussed in more detail throughout later sections.

The NOEF is planned to store PAF overburden in addition to NAF (inside the dotted red footprint), so the concept has been developed to achieve the objectives stated earlier. The features of the NOEF which enable it to satisfy these objectives are discussed in later sections.

3.1 Geological Setting

The terrain within the NOEF primarily comprises a near level to gently inclined alluvial backplain of the McArthur River with deep grey and brown cracking clay soils. That unit is bordered along the southern and eastern boundaries of the OEF by local intensively dissected and eroded marginal slopes to drainage which also comprise deep mostly brown cracking clay soils.

The cracking clay soils are generally deep (>2.0 m) with strongly structured surficial soil horizons which have cracking extending to a depth of about 0.8 m during the dry season. The deeper subsoils (>1.2 m) are calcareous and locally gypseous, with massive soil structure and very low permeability and hydraulic conductivity.

To the north and west of the NOEF, the terrain comprises gently undulating plain with shallow to medium deep red and yellow earth soils underlain by weathered dolomite or dolomitic siltstone and local low gravelly rises. Intervening broad near level to broadly depressional drainage flats also occur, which have moderate to deep silty to loamy surface duplex soils and mottled yellow earths with medium to heavy clay subsoils.

The clays underneath the NOEF footprint and in the surrounding areas contain the bulk of the required resources for capping and dam construction. An estimate of the quantities and an assessment of the properties of the alluvials under the NOEF have been made by Hatch (2011).

Quaternary Alluvium consisting of silt, sand, clays and gravel, occurs on the flood plains, levees, flood terraces and channel floors of the McArthur River where the East and South OEFs are planned.

3.2 Stability

The NOEF expansion includes a height increase over the original design by an additional 25 m (i.e. from 55 m to 80 m) associated with further lateral extension. Stability analysis was conducted on the Project design for the NOEF to verify that this higher facility would remain stable. The updated work was based on the geotechnical model and material properties from the original NOEF design (Xstrata Zinc, 2011). This included evaluating the long term performance of the NOEF under static and seismic conditions.

3.2.1 Modelling Method and Parameters

The stability analysis used the 2D Limit Equilibrium slope stability program *SLIDE* using the GLE/Morgenstein-Price method of analysis and the following assumptions:

- Mohr-Coulomb model
- homogenous material
- non increasing shear strength during construction
- drained material (no groundwater)
- circular slip surface with two cases considered – deep residual clay (i.e. no bedrock) and with bedrock at 4 m below residual clay.

The stability analyses were conducted on the critical cross-section (i.e. having the maximum driving forces) through the NOEF. These are shown in Figures 3-2 and 3-3.

Appendix E2 – OEF Management Plan

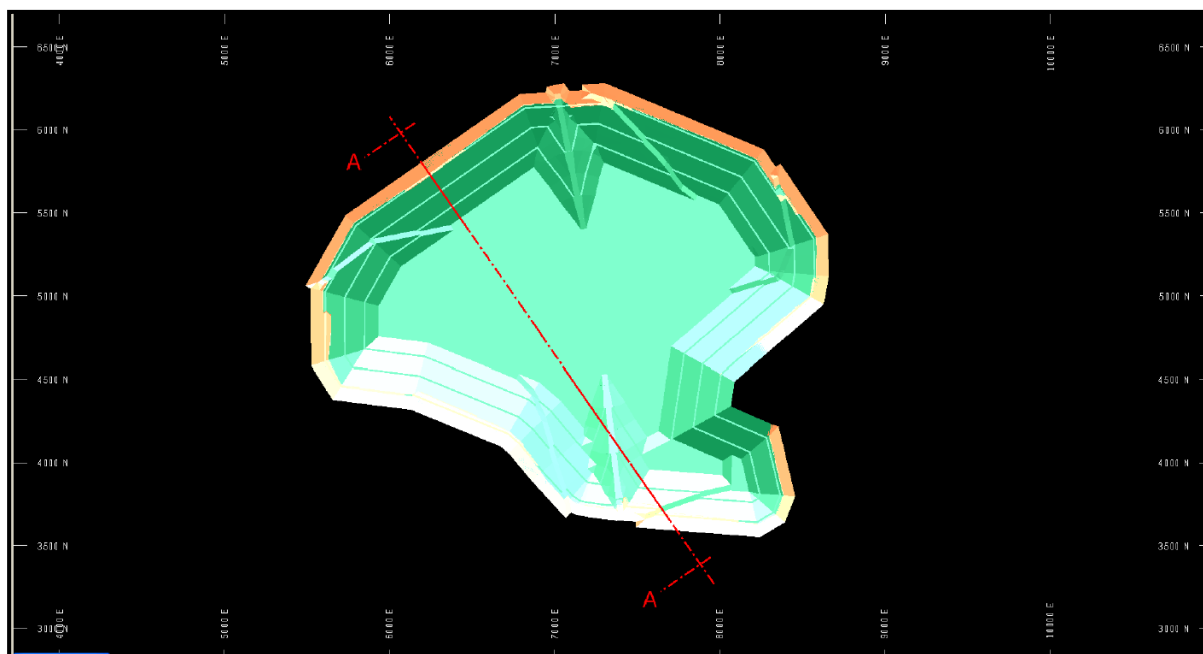


Figure 3-2 Cross Section Location of North OEF Geotechnical Stability Analysis

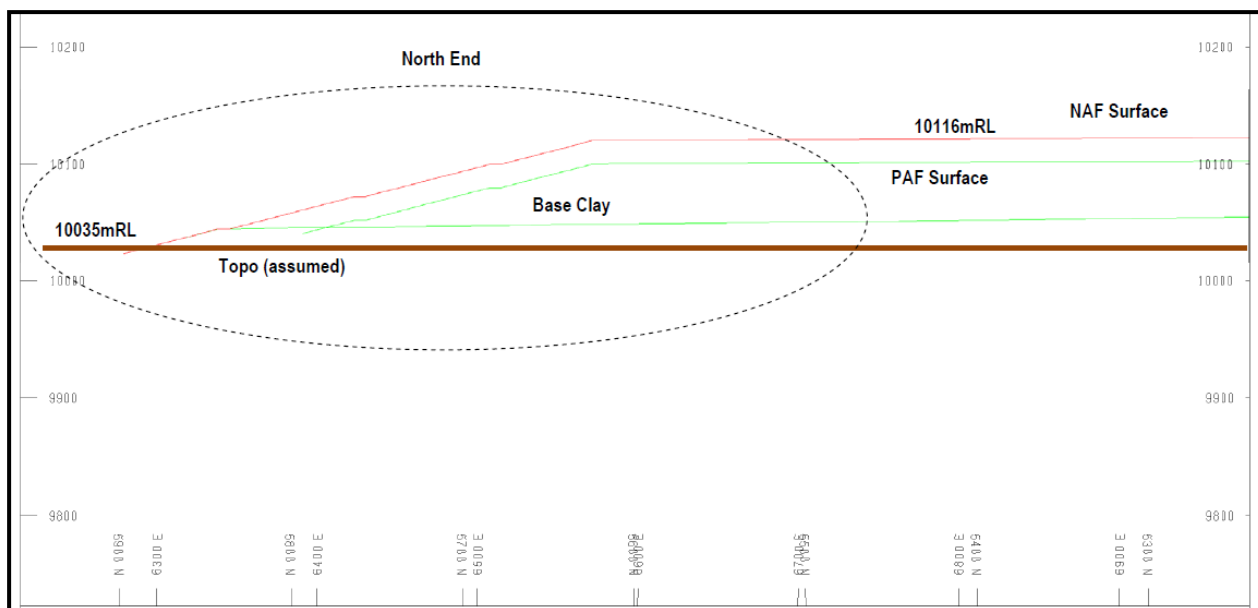


Figure 3-3 Cross Section of North OEF – Geotechnical Stability Analysis

Design of the existing Phase 2 NOEF was completed in 2008 with a final report prepared by URS (URS, 2008). The report indicated that the subsurface condition of the NOEF site consisted of topsoil overlying alluvium and residual clay underlain by the bedrock. The thickness of the topsoil ranged from 0.1 to 0.7 m. The alluvial clay was up to 4 m thick.

Very stiff residual clay was encountered below the alluvial clay. The bedrock was encountered at depths as shallow as 2.5 m. Groundwater was not encountered at the time of the site investigation. Test pits completed in 2011 by Hatch confirm that similar conditions exist for the area underlying the NOEF expansion for the Project.

Appendix E2 – OEF Management Plan

Thus, the input parameters used by URS in 2008 were considered valid for use in 2011. The key parameters are shown in Tables 3-1 and 3-2.

Table 3-1 Summary of Material Properties for Short Term Stability Analysis (Xstrata Zinc, 2011)

Type of Materials	Unit Weight kN/m ³	Cohesion (kPa)	Friction angle, (deg)
NAF/PAF	20	0	38
Alluvial Clay - undrained	18	50-150	0
Alluvial Clay - residual	18	0	27
Residual Clay - undrained	20	150	0

Table 3-2 Summary of Material Properties for Long Term Stability Analysis (URS 2008)

Type of Materials	Unit Weight kN/m ³	Cohesion (kPa)	Friction angle, (deg)	Remarks
NAF/PAF	20	0	38	Assumed
Alluvial Clay	18	0	27	Lab Result
Residual Clay	18	10	30	Lab Result

Various scenarios were analysed to verify the short, medium and long term stability condition of the NOEF. The Short Term scenario has the geometry of the OEF with angle of repose batters and undrained foundation conditions with the properties as shown in Table 3-1. The Medium Term scenario has the same angle of repose batters, but with drained foundations (Table 3-2). The Long Term scenario had batters flattened to 1:4, also with drained foundations. The scenarios were also checked in absence of the bedrock below the alluvials (i.e. very conservative approach) and in its presence (i.e. realistic).

3.2.2 NOEF Stability Analysis Results

A summary of the slope stability results is shown in Table 3-3.

The stability analysis demonstrated that the NOEF is considered stable over short, medium and long term periods provided that shallow bedrock occurs within the OEF footprint.

When bedrock is not present, the NOEF is still considered stable over the medium to long term, however, in the short term, during construction and prior to reaching its final height, local batters of the NOEF may be temporarily unstable (MRM, 2011).

Appendix E2 – OEF Management Plan

Table 3-3 Factor of Safety (FOS) against Slope Failure (NOEF)

Scenario	No bedrock	With Bedrock
Design Criteria*	1.3	
Short Term	<1.0	>1.3
Comments	Very conservative approach. Potential deep seated failure through residual clay.	Stable overall slope. Possible surficial failures at dump faces which are expected and can be managed.
Design Criteria*	1.2	
Medium Term	>1.2	>1.2
Comments	Stable overall slope. Possible surficial failures at dump faces which are expected and can be managed.	Stable overall slope. Possible surficial failures at dump faces which are expected and can be managed.
Design Criteria*	1.5	
Long Term	>1.5	>1.5
Comments	Stable overall slope	Stable overall slope

*From URS (2008). Factor of Safety quantifies the risk of failure of the slope, with a value below 1.0 indicating that the slope would be unstable.

3.2.3 NOEF Design and Operations for Stability

The design of the NOEF used the following parameters to meet the requirements of the stability analysis:

- The overall slope of the final OEF is approximately 1:4.3, comprised of the following slope components
 - nominal 13.6 m high lifts at an angle of repose of 35°, with 35 m wide berms; or
 - nominal 13.6 m high lifts with batters flattened off to 1:4 slope, with a 10 m berm on every second lift.

The combination of batter and berm parameters depends on the location of the slope and the rock used in its construction, as will be discussed in upcoming sections.

Normal MRM operating practices covering OEF operations, including the following list, are used to manage the risk of failures during operations:

- regular inspections of foundations and faces by supervisors and geotechnical engineers for bulging and slumping
- regular inspections of the tiphead by dozer operators
- sloped tipheads, drains and windrows to keep water away from tipheads and toes.

Appendix E2 – OEF Management Plan

On-going investigation and testing of foundation conditions will be required in advance of the active NOEF areas to verify the presence of bedrock and gain site specific material properties to enable appropriate designs and operating practices to be planned.

3.3 Other Design Parameters

The NOEF has been limited to a maximum height of approximately 80m to match the height of the surrounding natural landforms. Note that the true height varies dependent on ground elevation – the design criteria employed was to limit the highest point of the OEF to 116 RL, which is the top of the nearby Mt Stubbs hill.

Haul roads are required to gain access to the OEF during its construction and rehabilitation phases, as well as for post-mine monitoring and maintenance. The roads have been designed at 35 m wide with a maximum gradient of 1:10 (10%), to suit the largest truck envisaged over the life of the Project.

Whilst the lift heights have been nominated as 13.6 m, they will vary depending on the area being constructed. The base layer is designed to establish a slope that differs from the natural ground slope, so the thickness of the base layer could end up ranging from 1 m up to 25 m. However, the maximum lift height for tipping has been limited to 20 m, based on operational experience within Xstrata. Single tip lift heights over this could introduce unnecessary risk of local slope failure at the tiphead. Lower lift heights may be used to enhance stability and reduce differential settlement in certain circumstances, depending on materials used and compaction factors.

3.4 PAF Management Concept

The strategy for managing PAF overburden was established by URS (2008), with the same concept employed with the larger revised NOEF. This strategy is one of “multiple lines of defence” against the ingress of oxygen and water into the PAF materials, thereby minimising and managing leachate. This is achieved as follows:

- the base layer is proof rolled and poor materials removed and replaced. This ensures a stable base layer
- a NAF base is built up so that the lowest point of the PAF cell is above the 1:100 ARI level, to prevent the PAF cell being inundated. The NAF base is constructed as a series of planes with a slope of 1:100 toward dams on the perimeter of the OEF that can collect any water running off this surface
- a 0.6 m thick layer of low permeability clay is placed on top of the NAF base. This forms the bottom of a PAF cell, and directs runoff and/or seepage into the dams
- the PAF overburden is then tipped on this clay base to the upper and outer limits of the PAF cell. Again, the top of the cell is sloped at 1:100 toward the dams
- the PAF cell is then prepared for encapsulation by flattening the batters to a slope of 1:4, which is flat enough to enable safe traversing by compaction equipment. Another 0.6 m thick layer of clay is spread and compacted over the top and sides of the PAF to create a completely enclosed cell. The slope of the cell toward the PAF dams aims to shed water, thereby minimising infiltration
 - note that if an entire cell is not completed by the start of the annual wet season, what PAF is there is covered with clay to minimise ingress of water. Therefore, there are many small PAF cells within the one larger PAF footprint.
- a cap of NAF overburden is placed above and around the final surface of the PAF cell to provide a thicker barrier that water and oxygen would have to penetrate to get to the PAF material. Also, water percolating through the NAF would likely gain some AC potential.
 - the current design specifies a nominal 20 m true-thickness NAF cap above and around the PAF cell. The optimum thickness will be researched over time. At present, large volumes of NAF are stockpiled and rehandled late in the mine life to place this cap, increasing the

Appendix E2 – OEF Management Plan

disturbance footprint and erosion potential (through ex-dump stockpiles) and greenhouse gas emissions (through extra rehandle).

- finally, a cover is constructed over the outside of the OEF. In areas above the PAF cell footprint (and 50 m laterally beyond it), this will consist of another 0.6 m layer of low permeability compacted clay, followed by a growth layer and topsoil to enable evapotranspiration.

A cross section showing these features is included as Figure 3-4.

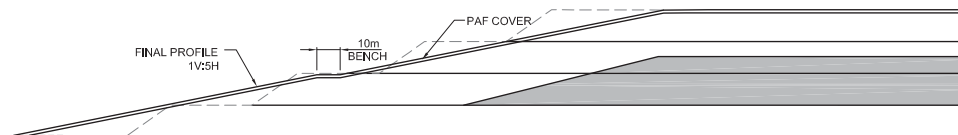
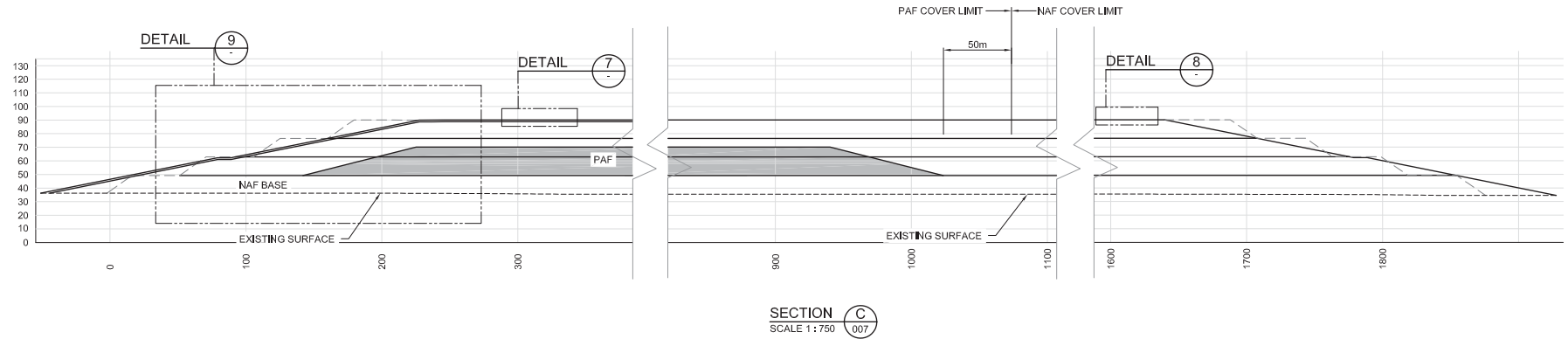
3.5 NAF Areas Concept

There may be areas of the NOEF that are able to be built out of NAF only, with no PAF in any of the lifts. This reduces the requirement to limit water and oxygen ingress to the inner core of these areas; hence some of the requirements of PAF areas can be left out.

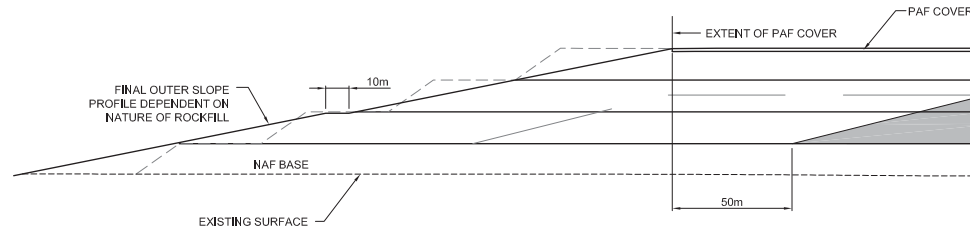
Stages where only NAF will be placed will be tipped in nominal 13.6 m lifts on a proof rolled base - stability of NAF only stages is still important. The batter slopes will depend upon the properties of the NAF used to construct the outer layers of these areas: hard, durable NAF may be left at close to the angle of repose, as the natural segregation of end-tipped rock results in a coarse outer layer that has higher natural erosion resistance; friable rock (either initially or after weathering) may need cutting back of the batters to a 1:4 slope to enable erosion protection and water management structures to be constructed.

The cover for NAF areas has the requirements to stabilise the surface rather than limit water and oxygen ingress, so the compacted clay layer is not required.

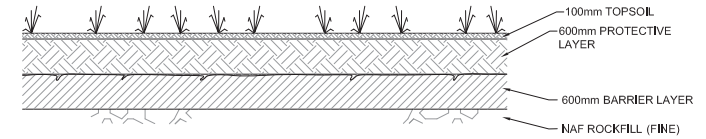
A1 THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET INCLUDING THE SPECIFICATIONS.



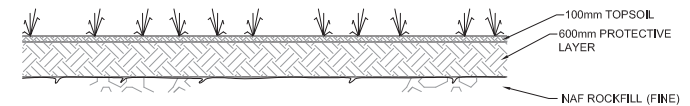
DETAIL 9 OPTION 1: COVER ON OUTER BATTER SLOPES
NTS



DETAIL 9 OPTION 2: NO COVER ON OUTER BATTER SLOPES
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DETAIL 7 PAF COVER
NTS



DETAIL 8 NAF COVER
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15 0 15 30 45 60 75
DIMENSIONS ARE IN METRES

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METSERVE
Mining & Energy Technical Services Pty Ltd

xstrata
ZINC

Data Source: URS 2005 EIS

McArthur River Mine Phase 3 Development Project

Current North OEF Cover Design

20/12/2011

Datum: GDA94
Projection: MGA53

FIGURE 3 - 4

3.6 Cover Design and Integrity

This section discusses the covers of the NOEF in more detail.

3.6.1 Cover Design

The design of the OEFs requires an outer layer of benign, inert overburden to provide the best long-term physical and geochemical stability. In order to provide a rehabilitated landform that satisfies the final land use criteria, the OEFs will require a cover to establish vegetation. However the nature and performance of this cover will be different for the NAF areas and above the PAF cell in the NOEF.

Where the OEF comprises only NAF materials, the cover is required to establish a vegetative cover. However, where the PAF cell is located, the cover is required to limit infiltration of water in the OEF such that infiltration to the PAF cell is minimised. Cover infiltration will be reduced by constructing a cover that will behave as a store-and-release cover, which is also referred to as an evapotranspiration (ET) cover. An ET cover is designed to temporarily store infiltrated rainfall, which is subsequently removed from the cover soils by evaporation directly from the soil surface and by plant transpiration where soil moisture is drawn into the plant roots and conveyed up into the leaves of the plants. Ideally, local vegetation (such as native cane grasses in the case of the MRM site) would be established on the cover. Typically, local vegetation planted on local soils has a better chance of long-term survival with less maintenance and is more likely to endure extreme weather events.

A conceptual cover design was completed by URS (2008) and this design has been used as the basis for the cover designs presented here. These designs will be revised and updated throughout the mine life, and will incorporate the result of field trials when land becomes available for rehabilitation.

3.6.2 Cover Integrity

The integrity of the proposed cover has been considered in the design of the cover layers, the surface water management system, and revegetation work. The main factors that could compromise the integrity of the cover system at the NOEF (and other OEFs) include:

- erosion (e.g. gully erosion) through poor performance of stormwater drainage works. This could arise through poor implementation of the cover design and it is expected that strict contractor supervision and survey control will be required during cover construction. It is expected that ongoing maintenance work will be required to the storm water drainage system during the vegetation establishment phase
- fire and extreme climatic events. Fire and extreme climatic events such as extended periods of drought could impact upon the integrity of the cover system and increase the likelihood of significant erosion or drying/cracking of the clay growth layer. Extreme climatic events may also restrict the establishment of vegetation across the surface of the cover. The thickness of the growth layer has been selected to ensure the integrity of the important low permeability clay layer would not be compromised under such conditions
- differential settlement of waste rock. The waste rock materials are likely to have a variable particle size ranging from boulders through to fines and it is expected that some settlement will occur after waste rock is placed. Once the OEF has been established for a period of time and the cover is constructed across the surface of the dump thereby controlling the infiltration of surface water, then the risk of differential settlement impacting on the cover integrity is considered to be low. The risk is also low due to covers only being constructed over the flat areas and 1:4 batters, not the angle of repose faces that may move
- slope stability. The 1V:4H perimeter slopes (overall) of the OEFs are considered to have an adequate factor of safety against slope failure, which is supported by geotechnical modelling

Appendix E2 – OEF Management Plan

- cover penetration by vegetation. Revegetation of the surface of the OEFs will include grass cover and shallow rooted shrub and tree species. Deep-rooted tree species could be introduced by wind or animal activity. However a vigorous cover of grasses should limit the ability of widespread colonization. It is expected that maintenance work will be required during the establishment of the vegetated cover to prevent weed growth. Weed inspection and spraying should be undertaken early in the wet season
- cover penetration by animal/insect activity. Insect and animal activity is inevitable in the long term. However, these impacts are expected to be localised in extent. The depth of the growth layer has been selected to minimise the potential impacts of animal activity
- cracking of clay materials. Cracking of compacted layer is possible under extreme dry periods, however, the depth of the growth layer has been selected to protect the clay from drying out in these extreme periods.

3.6.3 NAF Areas Cover

The NAF cover is intended to support vegetation as part of rehabilitating the OEFs to a suitable final land use. Therefore the cover is only required over the gently sloped final 'dome' of the OEF. The key assumption in this decision is that the outer batter slopes dumped at the angle of repose comprise of sound, hard, durable NAF rockfill.

The cover in the NAF areas will comprise a two layered system which is summarised as follows:

- the first layer to be placed will comprise a 'protection' layer which would comprise an uncompacted material suitable for root growth
- the second layer will be topsoil to provide a growth layer for vegetation.

Where friable NAF is placed on the outer batters, and hence flattened off to a 1:4 slope, the longer slope will present a larger exposed to erosion potential. Trials will need to be conducted on a range of materials and cover designs to develop a suitable combination that results in a stable landform in the long term.

3.6.4 PAF Cells Cover

The PAF cover is a risk reduction measure to improve the controls to limit water and air infiltration to the dedicated PAF cells. Therefore the PAF cover should extend a minimum of 50 m beyond the outer limits of the PAF cell footprint to limit the risk of infiltration.

The cover above the PAF cells has been developed from a conceptual four-layered system modelled for the Tailings Storage Facility (TSF) to a three-layered system by eliminating the capillary break layer, which is considered unnecessary for a cover placed over free-draining NAF material.

The PAF cover design is described below:

- the first layer (clay liner) to be placed would be the 'barrier layer' comprising a low permeability material that would be compacted in place to act as a barrier to infiltration into the waste rock materials
- the second layer would be the 'protection layer' which would comprise an uncompacted material suitable for root growth and to provide protection to the underlying barrier layer
- the final layer would be topsoil to provide a growth layer for vegetation.

These layers are described in more detail below.

- Barrier Layer - The barrier layer comprises of a 600 mm thick fine-grained material with high clay content. This material will be compacted in place to obtain a low permeability layer to act as a barrier to water infiltration and oxygen ingress into the NOEF. The clay materials that could be sourced from

Appendix E2 – OEF Management Plan

the NOEF footprint have a permeability of between 10^{-9} and 10^{-10} m/sec, if compacted to achieve a relative compaction of 98% of the Standard Proctor Maximum Dry Density. These tested permeability values are towards the upper range of recommended permeability limits for barrier materials

- Protection or Growth Layer - The protection layer will comprise a 600 mm thick rocky material suitable for the growth of vegetation. Depending on the availability of suitable material at the time, it could be augmented by the clay material identified for use as a barrier layer. The objectives of the protection layer are:
 - to protect the underlying barrier layer from degradation during extreme drying events
 - to minimise the potential degradation of the barrier layer due to penetration of roots, cracking due to drying or differential settlement, animal activity including native and stock animals
 - limit the potential impacts of surface erosion due to wind and surface water runoff, which may reduce the effective thickness of this layer in the long term
 - to provide temporary moisture storage for vegetation necessary to perpetuate the evapotranspiration process
- To provide a growth medium for plant roots.
- Topsoil - Topsoil is defined by MRM as the "upper soil layer enriched with nutrients and seeds, and is typically only 100 mm thick." The mine area has been mapped to describe general soil types and this mapping indicates that the soils vary according to terrain; ranging from lithosols on hill and ridge tops, to grey and brown cracking clays in gullies and depressions. Topsoil will be stripped and stockpiled for subsequent rehabilitation activities. It is proposed that further testing and analysis of topsoil materials be completed immediately prior to rehabilitation works to assess the need for additional treatment, such as the addition of gypsum and fertiliser, to promote vegetative growth across the rehabilitated surfaces.

Since the PAF cells will be encapsulated in compacted clay that will be graded to promote drainage of infiltration, the surface cover of the OEF is an additional line of defence to reduce the risk of infiltration reaching the PAF cell. It is recognised that the design of cover systems to limit infiltration have to consider a range of factors that may compromise the integrity of the cover. However the key design objective is a risk management strategy rather than a need to eliminate seepage through the cover. Therefore numerical modelling was undertaken to assess the leakage through various ET cover options for the OEF.

The ET cover leakage rates were evaluated using Visual HELP which employs a quasi two-dimensional water-balance modelling package. The water-balance method evaluates:

- water moving into the capping materials (e.g., infiltrating rainfall)
- changes in the amount of water stored in the waste material
- water moving out of the NOEF (e.g., evaporation from the OEF cap, collection layer drainage flows, or emissions through the barrier systems).

The average rainfall for the site area is approximately 780 mm (predominantly as summer rainfall), while mean annual pan evaporation is about 2,450 mm. This climatic setting results in minor recharge through the soil profile. The results of the modelling show that average annual infiltration rates for the selected cover design are approximately 70 mm per annum and that increasing the depth of the cover does not significantly reduce the infiltration performance. Therefore the additional costs of a greater cover thickness are considered to not be warranted.

Appendix E2 – OEF Management Plan

The fate of infiltration into the NOEF is difficult to quantify. However other factors that need to be considered when assessing the risk of infiltration to the NOEF and increasing the risk of infiltration to the PAF cells include:

- the NAF lifts above the PAF may be covered with clayey soils or compacted to act as wearing layers to reduce damage from machinery. These layers are designed to slope (1% grade) toward the perimeter of the OEF to convey waters away
- coarser grained NAF will promote lateral unsaturated flow
- the PAF cell is encapsulated by a 600 mm thick clay barrier to further limit water infiltration. Given these additional factors it is considered that insignificant amounts of water will penetrate the PAF.

Results from the HELP modelling indicate that an ET cover with the following profile would reduce the flux of potentially impacted moisture out of the OEF:

- 100 mm of vegetated topsoil cover
- 600 mm protection layer cover
- 600 mm of compacted clay (intact clay with a saturated hydraulic conductivity between 2×10^{-8} and 5×10^{-8} m/sec).

Preliminary results from the SEEP/W modelling suggest that cover infiltration can be diverted laterally towards the margins of the NOEF. This suggests that the flux of moisture into the PAF material can be reduced to an acceptable level.

Furthermore, physical and chemical test work on other rock types throughout the operation may be undertaken to identify potential alternative suitable rock to give more flexibility in the scheduling of placing the outer layers.

3.7 Surface Water Management System

The rehabilitated NOEF will require a robust surface water management system to collect surface water and potential seepage for diversion in a controlled manner. The surface water drainage system must manage all runoff across the area and be sustainable in the long-term.

Key objectives for the design of the surface water management system include:

- limit sediment load to the surrounding waterways
- adequate engineered storage dams to collect potential seepage/drainage from the PAF cells in the NOEF
- drains adequately designed to contain flows for high intensity rainfall events, and to limit potential for erosion within the drains
- prevent clean and contact water from mixing.

Surface water management features include sediment traps, bunds and v-ditches for containment of runoff, and dams for containment of sediment and potential seepage from PAF cells.

Runoff from the NOEF must be controlled throughout the life of operation and after mine closure until it has been demonstrated to be adequately rehabilitated.

Appendix E2 – OEF Management Plan

3.7.1 Definitions

For surface water management purposes, the surface runoff generated at the Project is divided into three types based on water quality (WRM, 2011):

- 'Clean' – surface runoff from areas of the Project where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas
- 'Dirty' – surface runoff water and potential seepage from the Project areas that are disturbed by mining operations such as NAF OEFs, workshop areas and roads. This runoff may contain silt and sediment, but is unlikely to contain contaminant concentrations in excess of ANZECC (2000) guidelines for a 95% level of protection in freshwater ecosystems for key water quality parameters (adjusted for water hardness). However, this runoff must be of suitable quality if discharge into natural watercourses is required
- 'Contaminated' – surface runoff water and potential seepage from areas affected by mining operations and potentially containing chemicals of various types generated by mining operations. Areas where hazardous waste can potentially be generated include where ore is stockpiled, areas where PAF waste rock is encapsulated on NAF waste rock in an OEF, the open pit and underground mine voids, and process areas. Runoff from these areas must be managed to avoid discharge of potentially contaminated water into the natural watercourses. There are restrictions on the use and release of this water.

3.7.2 OEF Water Management Concepts

During and after rainfall events water has the potential to flow along the following paths:

- runoff from the NOEF surface:
 - runoff from the NOEF surface will occur and therefore should be of an acceptable quality to be released into the environment, subject to appropriate sediment control via a settlement pond, prior to establishment of vegetation.
- infiltration within the NOEF:
 - water infiltrating the NOEF will encounter the wearing surface layers placed at the top of each lift. The wearing surface will comprise a lower permeability material that is expected to divert a significant portion of any infiltration along the wearing surface to the outer batters of the NOEF
 - some infiltration through the wearing surface may occur, which could seep through subsequent layers of the NOEF and potentially come in contact with the PAF cells
 - infiltration that comes into contact with the NOEF PAF cells could saturate and ultimately penetrate the clay surrounding the PAF cell. The quality of any seepage from the PAF cell is also difficult to predict given that the surrounding NAF materials surrounding the PAF cell have acid consuming/buffering potential that would neutralise acidic leachate. However, the seepage management strategy proposed has assumed that this seepage, if generated, will be acidic and unsuitable for discharge to the environment.

Further detailed studies including site monitoring, lysimeters, geochemical testwork and mathematical modelling will be continued as more accurate information about the actual permeability characteristics of the constructed NOEF layers, wearing surfaces, and the clay encapsulating the PAF cells.

The features of the water management system used to enable these concepts are discussed below, and can be seen schematically in Figures 3-7 to 3-11.

Appendix E2 – OEF Management Plan

3.7.3 PAF Dams

PAF storages (PAF dams) will be required to capture runoff and potential seepage from the PAF portions of the NOEF during the operation and rehabilitation establishment phases. Any runoff from the PAF areas will be collected and retained within the closed mine water management system.

The PAF dams will be constructed with a compacted clay core and base, followed by rock armouring of the walls to protect them from erosion, based on the satisfactory performance of the existing dams at the NOEF. Runoff from the surface of the NOEF would flow along the compacted clay layer on top of the NAF base, and into the dam (through culverts if haul roads are built between the NOEF and dam crest). Sprinklers and/or sprays will be installed to maximise evaporation losses.

The PAF dams have been sized for a 5% probability of exceedance, and take into account the contributing area reporting to each dam. Overall, the total storage capacity of new dams required for the Project would be in the order of 3,160 ML. There should be no requirement to move water between dams, though systems may be established in some dams to enable this functionality, as well as to transfer water to the CRP (for mill supply) or to TSF Cell 4 for evaporation. In extreme events, the dam may overflow into receiving waters via engineered spillways under the strict guidance of prescribed discharge licences.

For the Project, the sediment dam for the NAF stages would be built below ground level. Then, if PAF is to be placed in the landform, the walls will be raised and lined with clay. The crest level of PAF dams would be above the 100 year ARI flood level.

3.7.4 NAF Dams (Sediment Ponds)

Metals in the NAF materials to be used to construct the NOEF NAF areas will be bound in with the overburden and are not readily available to mobilise into the environment. Metal solubility is strongly pH-dependent so that if overburden materials become acidic, leachate may contain elevated concentrations of dissolved metals. These conditions will not exist in NAF areas of the NOEF, therefore metals will not mobilise or leach into the surface or groundwater systems.

Runoff from any NAF-only stages of the NOEF and any rehabilitated OEF surface is likely to contain sediment load that may be directed through sediment traps prior to discharging into receiving waters. Sediment dams are sized to hold the runoff from small events for a period of up to five days to allow any sediment to settle, before the clear water (subject to meeting discharge standards) is then pumped out to the receiving environment. These dams will need regular de-silting to ensure capacity is maintained. If the water is required to be released prior to satisfactory settling, flocculants may be required.

Sediment ponds will be sized and configured during the detailed design phase of the OEFs and the TSF in accordance with the Best Practice Erosion and Sediment Control guidelines (IECA, 2008). Sediment ponds will be designed as 'Type F' sediment basins (see IECA, 2008).

Figure 3-5 shows a typical cross-section of a 'Type F' sediment pond to be used in the site.

Appendix E2 – OEF Management Plan

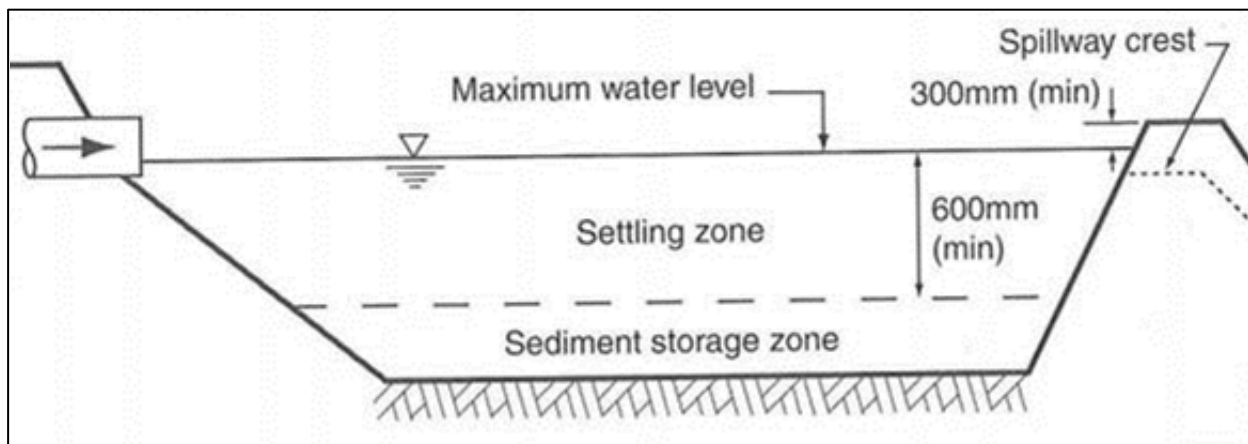


Figure 3-5 Schematic for NAF sediment ponds

The following is of note:

- the sediment ponds will have two zones: a settling zone to treat the sediment laden water; and a sediment storage zone for the collection of sediment that drops out of the water
- the settling zone of the sediment ponds will be sized to capture the required 63% AEP (1 year ARI) 5-day rainfall event from the contributing catchment area. The size of the sediment storage zone of the sediment pond will be 50% of the settling zone. Note that the adopted sediment pond volumes mean that the capacity of the sediment ponds will be exceeded regularly and water will spill to the receiving waters at least once in most years
- where possible, sediment ponds will be located in old drainage channels such as old or abandoned creek channels that have been isolated due to mining activities to minimise the amount of excavation required for the storage and allow water to overflow/be pumped into a natural downstream channel after treatment
- the sediment ponds will be designed for a 5-day cycle where by the sediment laden water fills the sediment pond, is treated and then pumped out to the receiving environment within a maximum of five days. The water will be then pumped down to the sediment storage zone in preparation for the next runoff event
- de-silting of the sediment pond should be undertaken as required when the sediment storage zone is close to full
- long-term sediment ponds that will be active for longer than 2 wet seasons, will be constructed with spillways designed to convey the 1% AEP (100 year ARI) discharge plus a 300 mm freeboard to the crest of the dam wall
- short-term sediment ponds that will be active for 2 wet seasons or shorter, will be constructed with spillways designed to convey the 10% AEP (10 year ARI) discharge plus a 300 mm freeboard to the crest of the dam wall
- adequate erosion protection will be required at and downstream of the spillway of the sediment pond.

3.7.5 Dirty Water Drains

A network of drains would be installed around the perimeter of the NOEF to collect and transfer any dirty water coming of the NOEF areas to the NAF sediment ponds. In dry weather, the low flows in these drains would likely be seepage, and so would be pumped out of small sumps into the PAF dams. In wet weather, the flows would overtop the sumps and flow through the sediment pond system.

The design of these structures will be dependent on their intended life. Structures that will be active for longer than 2 wet seasons will be constructed to contain the 100 year ARI design discharge, whilst shorter lived drains would be designed for 10 year ARI events.

These drains would be trapezoidal in cross section, cut into the natural ground with a matching bank constructed from the excavated spoil to keep water from overflowing the channel (Figure 3-6). They will have grass cover where possible. Rock check dams and sediment traps may be required to reduce and manage erosion.

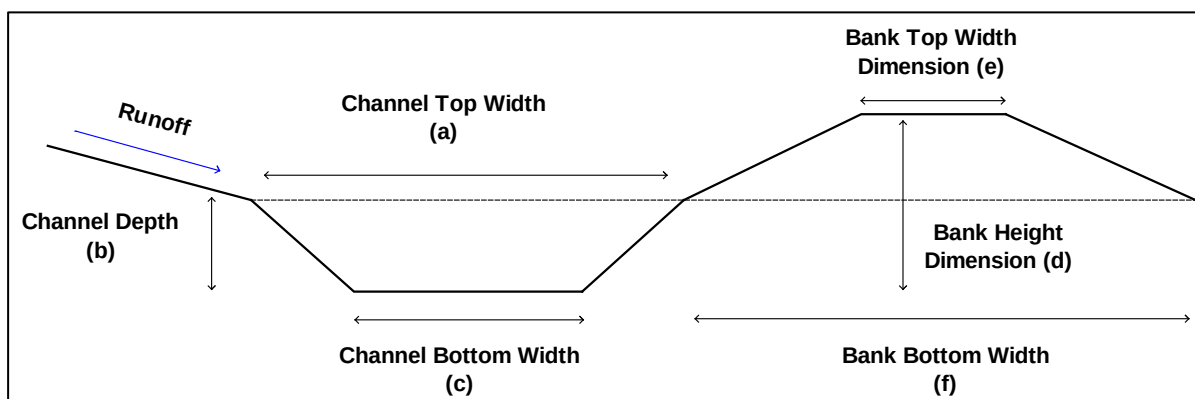


Figure 3-6 Schematic cross section of drains

3.7.6 Clean Water Drains

Over 11 km of clean water drains are planned over various times of the NOEF life to divert clean runoff away and around NOEF operational areas. These will be sized to pass the required flows of 100 year ARI events. These drains will also be designed as per Figure 3-6.

3.7.7 Contour Drains for Rehabilitation

Regularly spaced contour drains will be provided on the ultimate NOEF cover as the primary form of defence against sheet flow causing rilling and gully erosion of the surface and outer slopes of the NOEF. Key features of the contour drains should include:

- contour drains should be formed by constructing small embankments rather than cutting into the ground surface to ensure that adequate cap depth will remain beneath the drains
- the longitudinal gradient of the drains will be dependent upon the overall surface profile and the nature of the surface materials but generally should be no flatter than 1V:200H to limit siltation and no steeper than 1V:50H to limit scour. The longitudinal gradient of the contour drains also needs to be compatible with the likely methods and equipment used for construction (e.g. flatter drains are not suited to construction with a dozer). The base of the V-shaped contours drains will eventually silt up and form a parabolic shape cross-section and this siltation should not be removed unless excessive depth of siltation substantially reduces the flow capacity of the contour drain. It is desirable to retain minor depths of silt deposits (say up to 150 mm) in the drains as this greatly assists in maintaining moisture in the soil profile and maximising the success of vegetation growth along the contour drains

Appendix E2 – OEF Management Plan

- the drains should have a V-shape with relatively flat side slopes, designed for the drain flow depth and expected flow velocities
- the spacing of the contour drains should be selected to limit the velocity of the sheet flow across the surface of the NOEF and must consider an un-vegetated surface for short-term events during establishment and a vegetated surface for the long-term. Typical spacings of drains could vary from 30 m to 50 m on outer slopes of the OEF to up to 200 m across flatter areas of the NOEF surface
- the maximum length of contour drains will be determined based on limiting catchment areas, flow contribution and velocities within the drain. Temporary rock check dams placed at regular intervals along the contour drains during the establishment phase can increase the length of drain, minimising the number of rock drop structures required. Maximum slope lengths of 150 m to 250 m could be required, which indicates that rock chute drop structures could be required at intervals of between 300 m and 500 m across the NOEF, depending upon the slope profiles.

Typical details for the proposed contour drains will be provided prior to construction of the NOEF cover.

3.7.8 Rock Chute Drop Structures for Rehabilitation

Rock chute drop structures are required to convey flows from the contour drains on the NOEF cover to the toe of the NOEF. The dimensions of the rock chute drop structures depend on peak flows, slope of the chute, height of the chute, and grading (size) of the rock.

Each rock chute drop structure must increase in size down the slope of the NOEF as additional contour drains contribute more flow to the structure. The rock chute drop structures therefore have narrow width near the top of the NOEF and larger width at the toe of the dump.

Key features of the rock chute drop structures include:

- the required dimensions of the rock chute drop structures related to the number of contributing contour drains
- the flow down the rock chute drop structures has high velocity and energy, and outlet aprons are required to dissipate flow energy at the toe of the rock chute drop structures
- the rock chute drop structures must be constructed of durable rock, as these structures are required to ensure sustainability of the permanent rehabilitation works.

Details of the proposed rock chute drop structures will be provided in future Mining Management Plans prior to construction of the NOEF cover.

3.8 Staged Development and Rehabilitation Strategy

The NOEF will be constructed in stages (Figure 3-7 to 3-11). The benefits of staged construction include:

- the area disturbed at any one time is reduced
- the volume of surface water runoff that needs to be managed is reduced
- the NOEF will attain its full height progressively which will enable rehabilitation to be undertaken
- it will enable rehabilitation trials to be undertaken earlier.

The material schedule will determine how many stages are active at any one time: the amount of NAF mined varies over time, so NOEF planning must ensure that enough PAF cells are set-up ahead of time before periods of lower NAF mining occur. Views of the five-year snapshots in Chapter 4 - Project Description give an indication of the staging concepts for the NOEF:

- a central corridor is left open for access to the back areas of the NOEF

Appendix E2 – OEF Management Plan

- the NOEF is constructed from the closest stages first, working back to the more distant stages
- The footprint has to become quite large before the top of the NOEF can be reached. Thus, the only early areas available for rehabilitation are the faces
- The final five year snapshot, which is partially reproduced in Figure 3-12, shows how one NAF only stage of the NOEF is actually rehandled in the late stages of the mine life to be used for capping of PAF. The late years of the ex-pit mine schedule have insufficient NAF to cap the PAF, thus stockpiled material must be used. Use of a NAF only stage as a stockpile enables the total disturbed area to be reduced.

As mine plans change over time (due to factors such as changing prices, technology, and geological knowledge), the facility designs must have the flexibility to adapt to a range of scenarios. The annual mine plans must constantly be adjusted to optimise the timing of stages and the use of stockpiles to enable all objectives to be achieved.

Indications of areas of the NOEF rehabilitated over time are shown in Figure 5-1 to Figure 5-3 in Chapter 5 – Rehabilitation and Decommissioning.

Rehabilitation and closure of OEFs will be discussed in more detail in Section 7 of this document.

Appendix E2 – OEF Management Plan

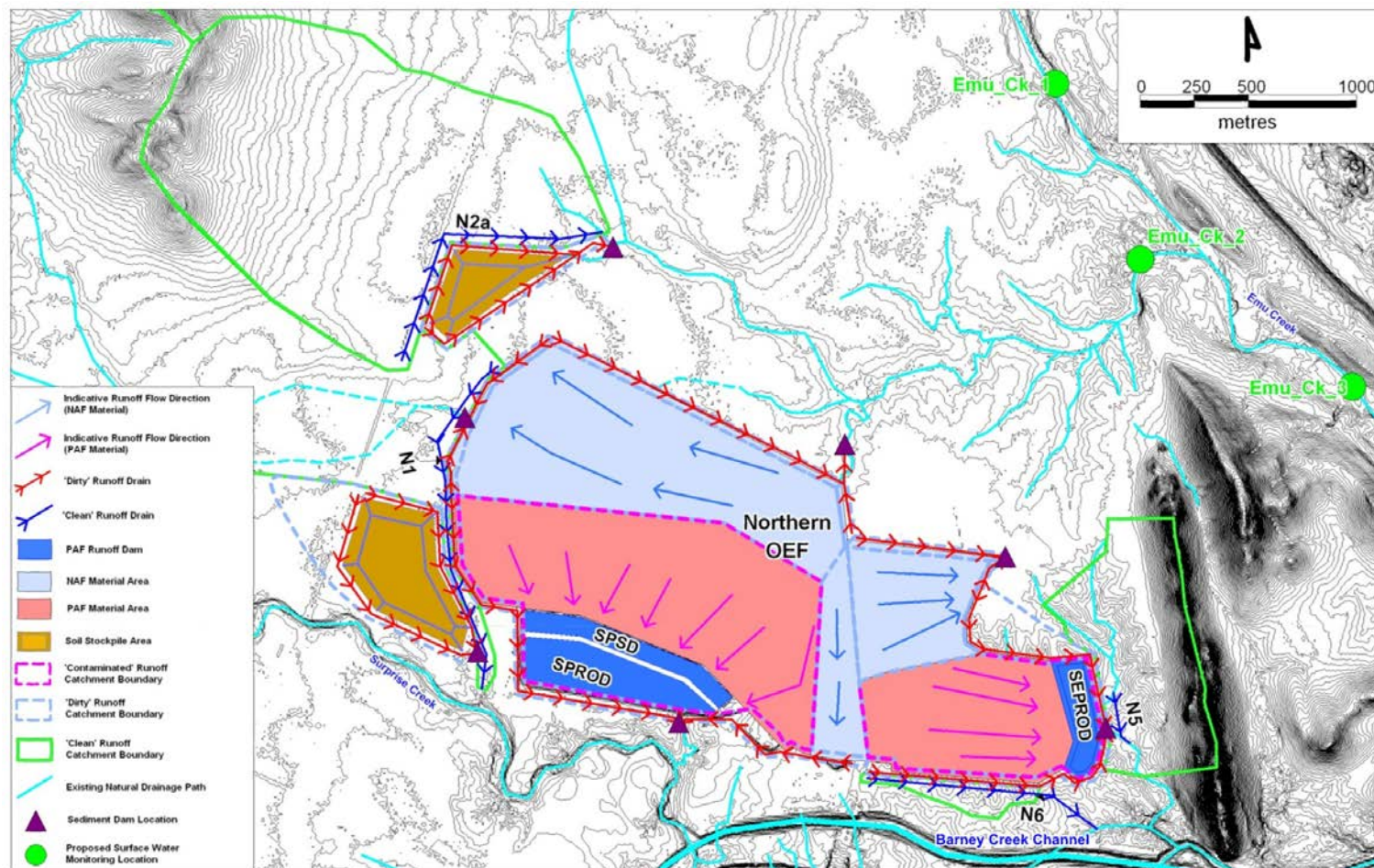


Figure 3-7 NOEF water management concepts for 2015

Appendix E2 – OEF Management Plan

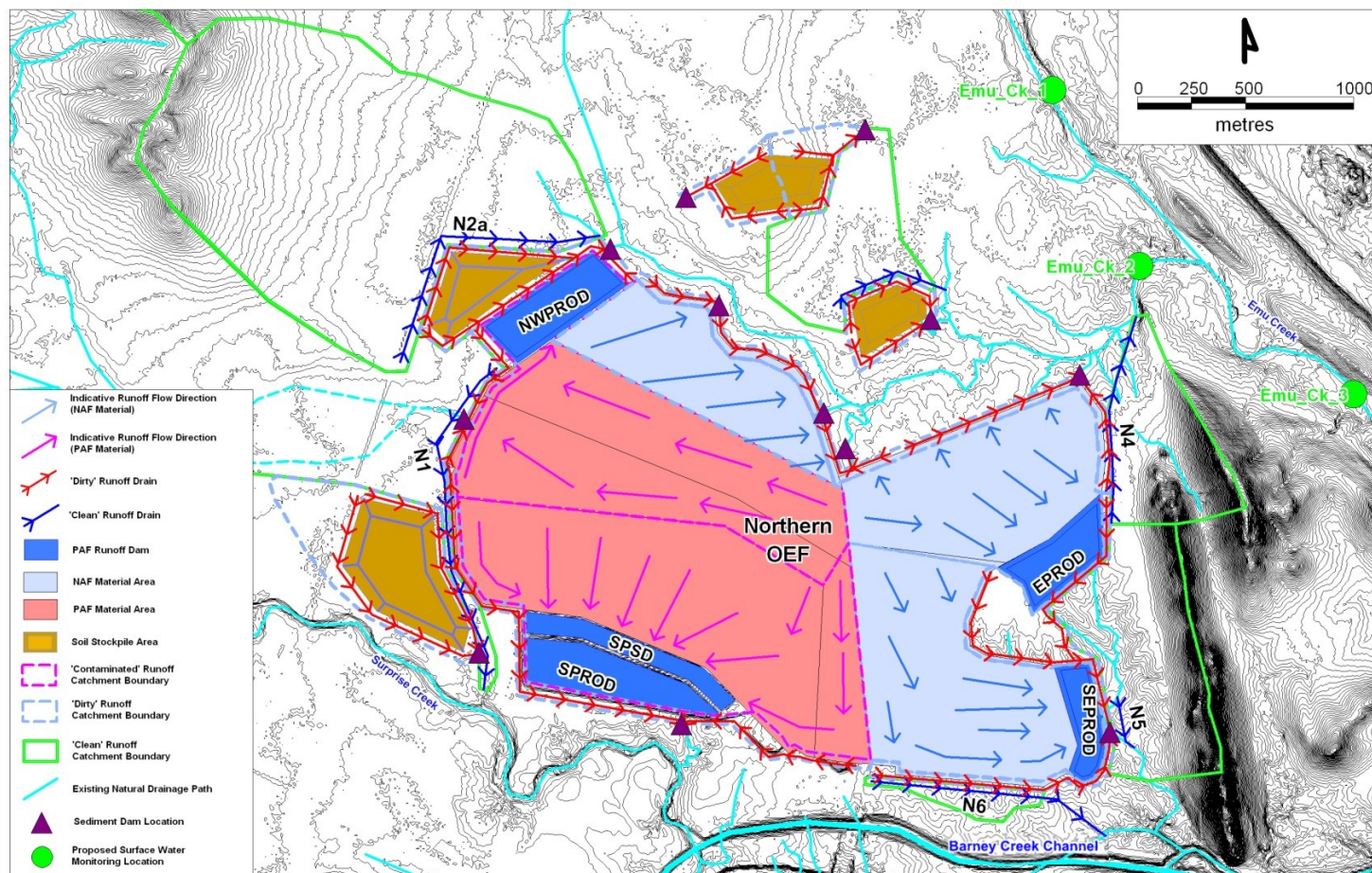


Figure 3-8 NOEF water management concepts for 2020

Appendix E2 – OEF Management Plan

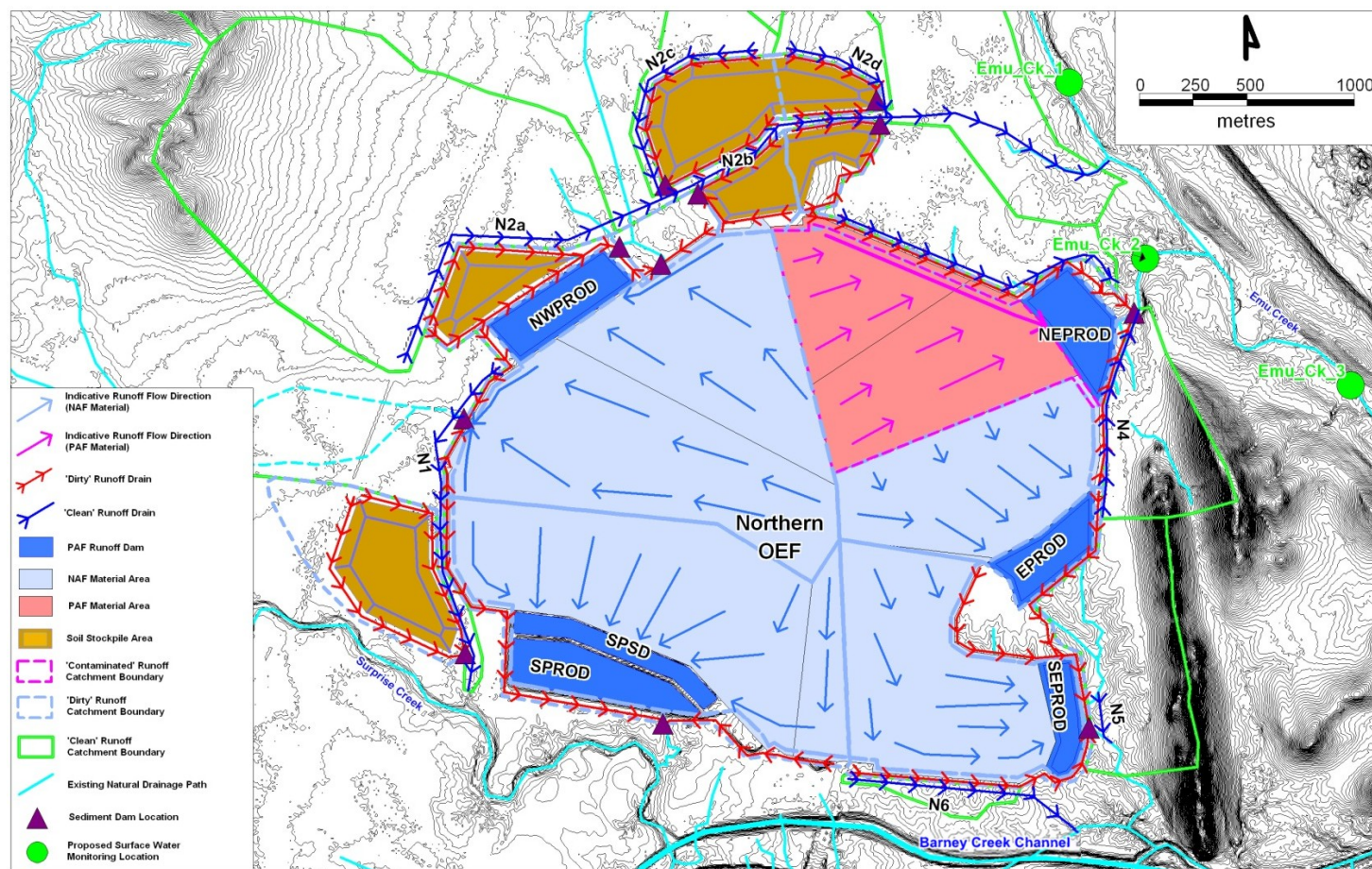


Figure 3-9 NOEF water management concepts for 2025

Appendix E2 – OEF Management Plan

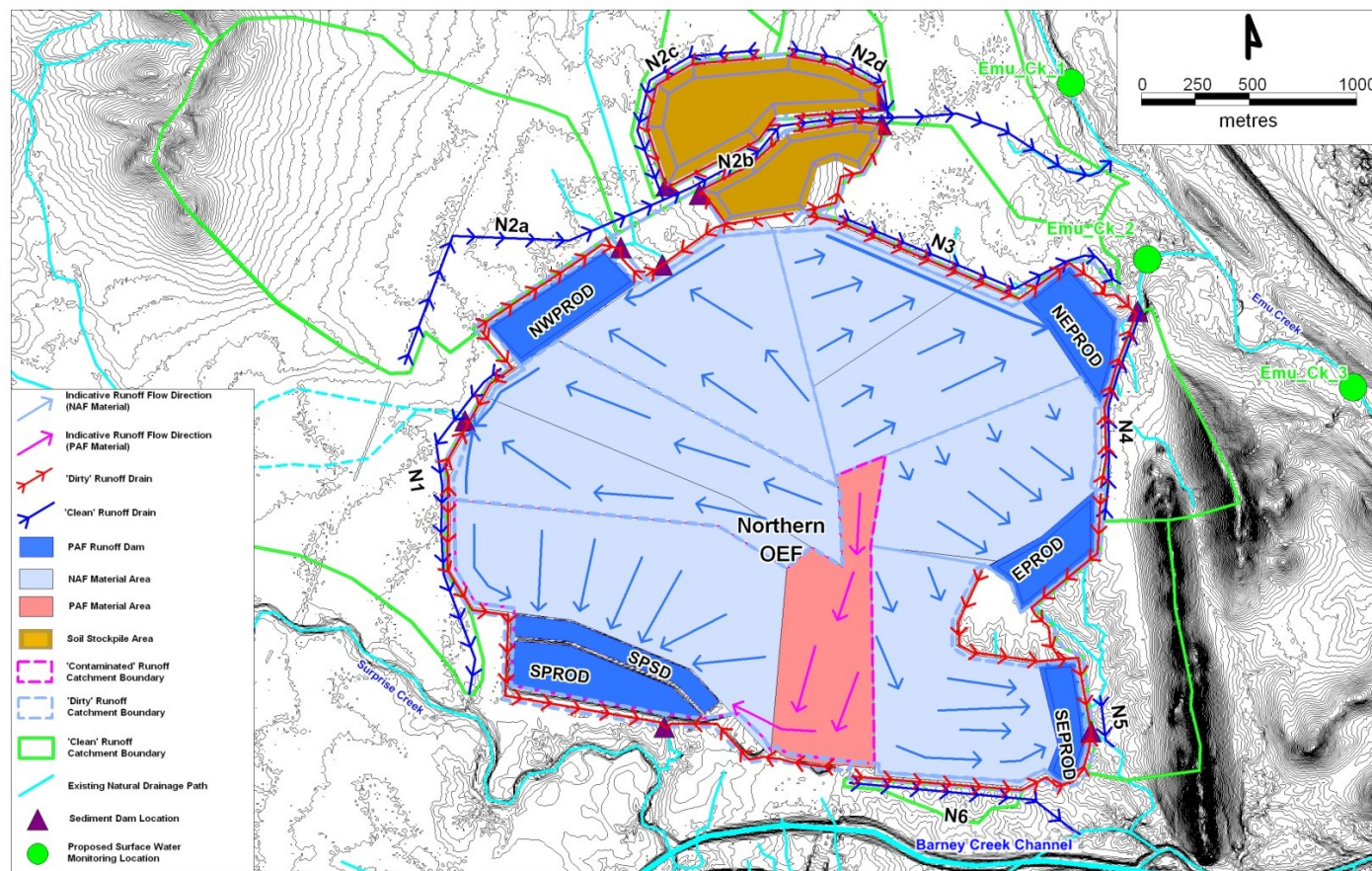


Figure 3-10 NOEF water management concepts for 2030

Appendix E2 – OEF Management Plan

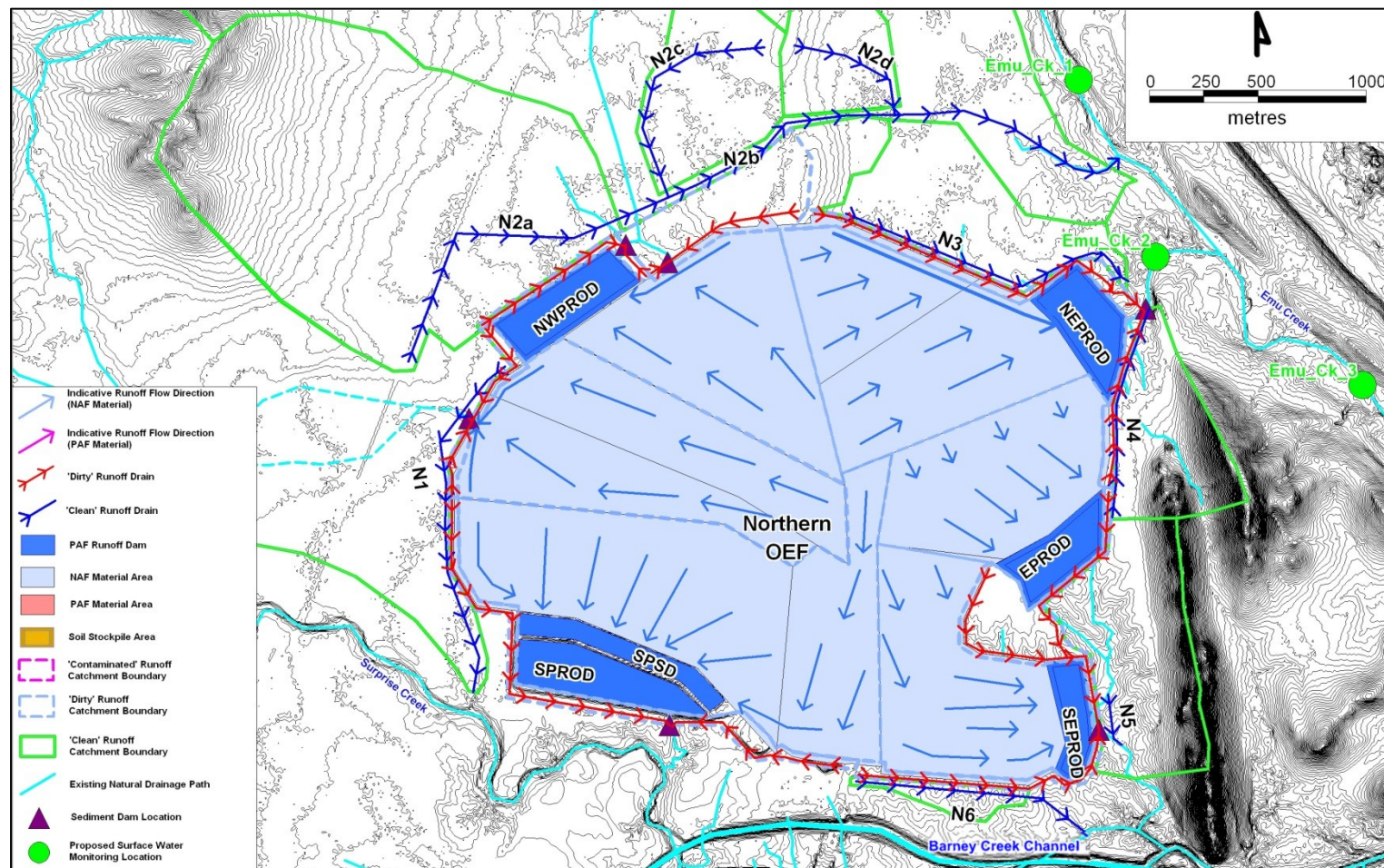


Figure 3-11 NOEF water management concepts for end of mine life

Appendix E2 – OEF Management Plan

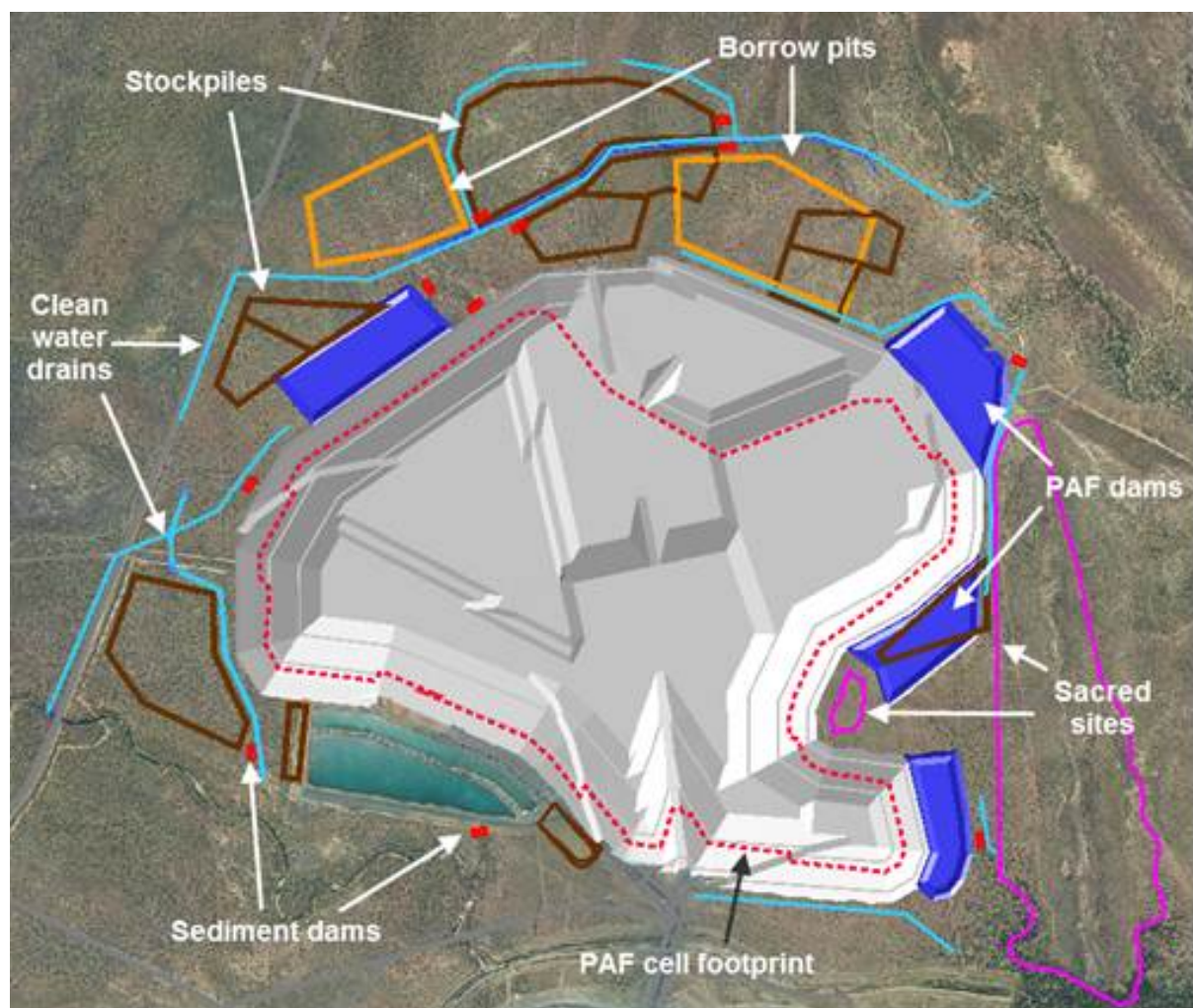


Figure 3-12 Elements of the NOEF as per the current mine plan

4 East and South OEFs

A view of the East and South OEFs is shown in Figure 4-1. These utilise the area between the openpit crest and the Barney and McArthur Channels, with offsets to allow for crest instability and rehabilitation requirements. The OEFs have a setback of at least 75 m from the crest of the channels, and this buffer is over 125 m in many areas. The OEFs have several access ramps, to enable hauling from the southern, central and northern ends of the open pit.

As the width of the SOEF is restricted, it was decided not to maximise the capacity of the OEF in this area, but instead to set aside a larger surface area at the current mine levee wall height for stockpiling of rehabilitation materials for use on the EOEF.

A feature of the EOEF is a step in the top lift, which extends to a height of 80 m above ground level. This is required to ensure that the rockpile (and equipment operating on it) is safely below the Obstacle Limitation Surface (OLS) of the McArthur River airstrip. The OLS ensures safe operation of the aerodrome is possible in all weather conditions.

As a risk mitigation measure, these OEFs will not be used to store PAF overburden.

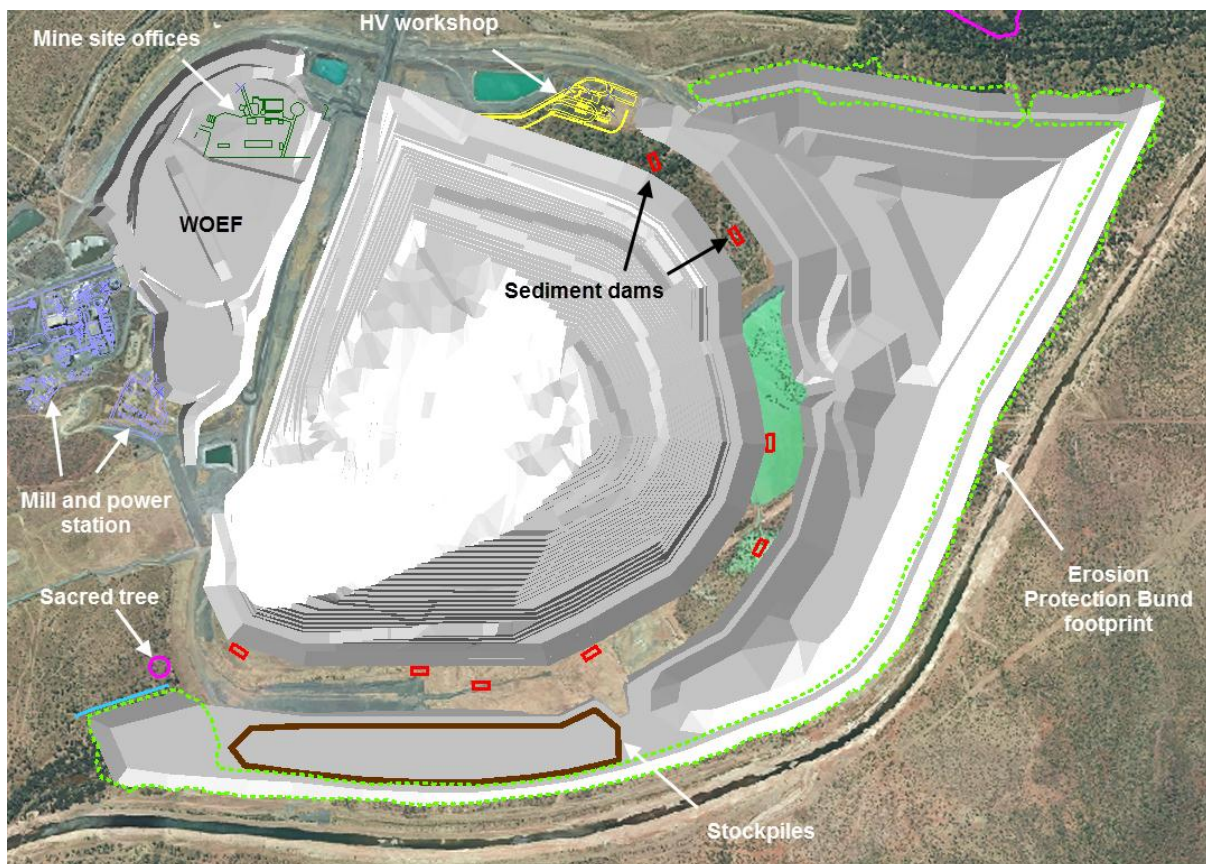


Figure 4-1 Plan of the features of the East and South OEFs

4.1 Stability Analysis

Limited test pit excavations were obtained from the footprint of the proposed EOEF (Hatch, 2011) due to permit, access and disturbance conditions. However, it was found that conditions were more variable than at the NOEF. There were more sands present mixed in with silt and clay layers. This may result in better drainage properties below the OEFs.

Appendix E2 – OEF Management Plan

It has been assumed that the design parameters used for the NOEF would be suitable for the EOEF. This sets the overall slope to a maximum of 1:4. Further foundation investigations will be required to increase confidence in the design parameters before the OEFs are developed. Investigation of drainage parameters of the soils will be important.

The SOEF is not considered to have any stability problems as it is at the same height as the current mine levee wall.

Due to exposure of the toe of the OEFs to floodwaters of the channels, special precautions will be taken to protect them from erosion and scouring which may lead to local instability. The construction of an Erosion Protection Bund (EPB) as an integral component of the OEFs will be elaborated in later sections.

4.2 Other Design Parameters

The EOEF has been limited to a maximum height of approximately 80 m to match the height of the surrounding natural landforms, and to remain under the airstrip OLS. The narrower base and triangular footprint leads to an OEF that is similarly shaped to a natural hill when compared to the much larger NOEF.

Haul roads are required to gain access to the OEFs during its construction and rehabilitation phases, as well as for post-mine monitoring and maintenance. The roads have been designed at 35 m wide with a maximum gradient of 1:10 (10%), to suit the largest truck envisaged over the life of the Project.

The lift heights vary depending on the lift being constructed. Due to the set height of the mine levee wall (at 44 RL), the base layer is from 12 m to 18 m high. The other lifts have been designed to a nominal height of 15 m. Lower lift heights may be used to enhance stability and reduce differential settlement in certain circumstances, depending on materials used and compaction factors.

The EPB is a trapezoidal shaped bund wall that will be constructed out of select NAF fill. The rock wall must be permeable to enable any high levels of water to drain away from the toe of the OEFs. The crest width is a nominal 20 m wide, assuming that mining operations haul trucks will be used to construct the wall - this may be reduced if smaller equipment is utilised. The outer face will be constructed to a 1:4 slope with a coarse rock erosion protection armour layer. The inner batter will be constructed to an angle of 1:2. The crest elevation has been set to the 100 year ARI event level, which changes along the length of the wall, but is typically around 39 m AHD to 41 m AHD. This makes the wall from 5 m to 13 m high, depending on local topography.

4.3 NAF Areas Concept

The concept for the SOEF and EOEF is identical to that for NAF areas of the NOEF. The OEF lifts will be tipped on a proof rolled base, with zones of poor foundation conditions excavated out and replaced. The batter slopes will depend upon the properties of the NAF used to construct the outer layers of these areas: hard, durable NAF may be left at close to the angle of repose, as the natural segregation of end-tipped rock results in a coarse outer layer that has higher natural erosion resistance; friable rock (either initially or after weathering) may need cutting back of the batters to a 1:4 slope to enable erosion protection and water management structures to be constructed. Note that the outer face of the EPB will always be constructed to a 1:4 batter angle.

The cover for NAF areas has the requirements to stabilise the surface rather than limit water and oxygen ingress, so the compacted clay layer is not required.

4.4 Cover Design and Integrity

The cover design is identical to that of the NOEF, which is discussed in Section 3.6.3. A 0.6 m growth layer will be placed over the NAF surface to enable root establishment, with a 100 mm layer of topsoil placed on top to support vegetation growth.

Appendix E2 – OEF Management Plan

4.5 Surface Water Management System

The components of the water management system for the SOEF and EOEF areas are discussed here. The staged development of the structures is shown in Figures 4-2 to 4-4.

4.5.1 Erosion Protection Bund (EPB)

The EPB will be constructed in advance of the bulk tipped NAF overburden, during the dry season. This will protect the loose rock from being washed away in flood events affecting the nearby Barney and McArthur Channels. The toe of the EPB will be at least 75 m from the crest of the channels.

The EPB will protect drains and sediment ponds constructed inside the EPB from damage during the wet season. However, the wall will be permeable to prevent possibly dangerous build-up of water pressure during flood periods, so it will not prevent water movement across the boundary.

4.5.2 Dirty Water Drains and Sediment Ponds

The proposed dirty runoff drains will direct runoff from the South and East OEFs towards sediment ponds. Runoff and seepage from the South and East OEF area is anticipated to be dirty and of a quality that can be released to the receiving waters after treatment in a sediment pond. If runoff and/or seepage from South and East OEF areas are found to be contaminated, active management measures and/or additional storage volume would be required to fully contain the contaminated water on-site.

It is expected that dirty runoff drains and sediment ponds located within the open pit flood protection levee will be operational (once constructed) for the full duration of the Phase 3 operations. Overflows from sediment ponds within the flood protection levee will be directed into the old McArthur River until it is filled as part of the EOEF, at which time the overflow will be directed into the open pit dewatering system.

Dirty runoff drains constructed on the outer perimeter of the dump (which is exposed to McArthur River and Barney Creek floodwaters) will be located on the inside toe of the proposed EPB. Runoff from the contributing areas will be directed to temporary sediment ponds located at the inside toe of the EPB.

Overflows from the sediment ponds will either seep through the EPB or flow through a spillway (overflow) pipe through the EPB. The final design of the sediment pond spillways will depend on the permeability of the EPB. One-way flap gates may be required on the end of the sediment pond pipe spillway to prevent McArthur River water from back-flowing into the sediment pond during periods of high flow.

The proposed drainage system would be protected from the McArthur River and Barney Creek flooding by the EPB. However, the proposed drainage system would be inundated by McArthur River floodwater seeping through the EPB on average every 2 to 5 years. Note that the dirty runoff management controls located along the EPB will be progressively covered over by NAF material as the OEFs progress towards the EPB. Rehabilitating the OEF close behind the advancing face will be important in managing erosion once the ground level sediment controls are buried.

Dirty runoff drains and sediment ponds will be designed as per the NOEF structures discussed in Section 3.

4.5.3 Clean Water Drains

A new clean runoff drain approximately 0.3 km long will be constructed around the western end of the SOEF to collect and divert clean runoff into an abandoned portion of the original McArthur River. The catchment area, adopted design standard and configuration of this clean runoff drain are given in Section 3.

4.6 Staged Development and Rehabilitation Strategy

The SOEF and EOEF staging is shown in Figures 4-2 to 4-4. The strategy for the development of these OEFs is outlined below:

Appendix E2 – OEF Management Plan

- The EPB will always be advanced in front of the bulk OEF tipping to ensure that water management and erosion controls are in place. Vegetation clearing and topsoil stripping will only occur in the dry season. Cleared and stripped areas not protected by the EPB must have rock tipped over them before the annual wet season
- The SOEF will be developed first, as this can be constructed to finished level very quickly, providing a large open area for storage of rehabilitation materials that will be stripped out from the EOEF footprint (topsoil and alluvials)
 - The western end of the SOEF that fills in the old remnant McArthur River channel will be delayed until suitable habitat is established for fauna living in this area, subject to satisfactory control of ground and surface water in this area.
- The EOEF will then develop from the south out to the point of the triangle, but avoiding the old McArthur River channel in the north until the new channel has achieved agreed rehabilitation targets enabling this to occur
- Much of the base layer of the EOEF will have to be constructed to enable a large enough area for upper lifts to be placed
- The external faces of the OEFs closest to the channels will be rehabilitated as soon as practicable after construction to minimise erosion.

Rehabilitation and closure of OEFs is discussed in more detail in Section 7.

Appendix E2 – OEF Management Plan

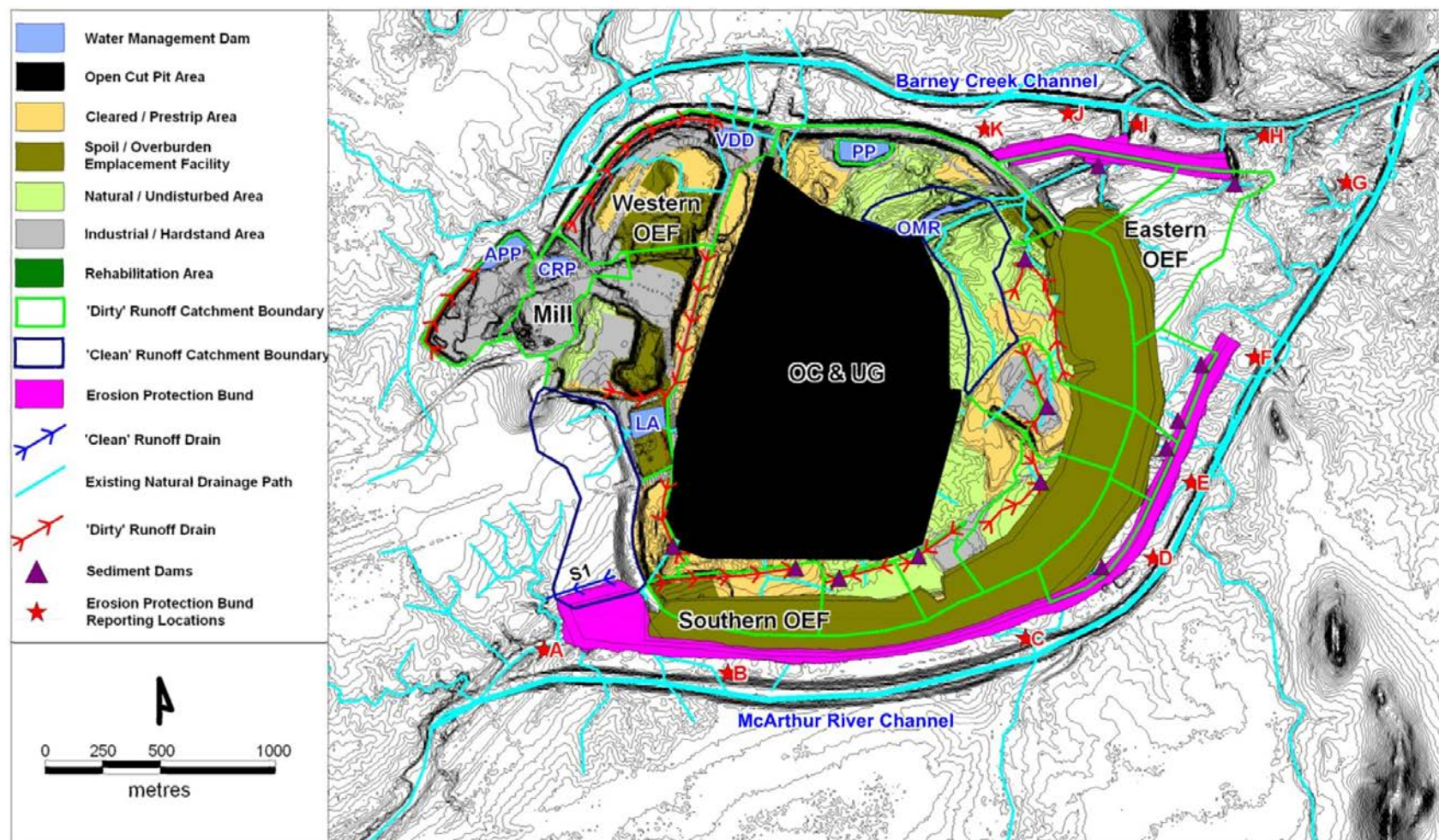


Figure 4-2 Water management concept of the SOEF and EOE in 2015

Appendix E2 – OEF Management Plan

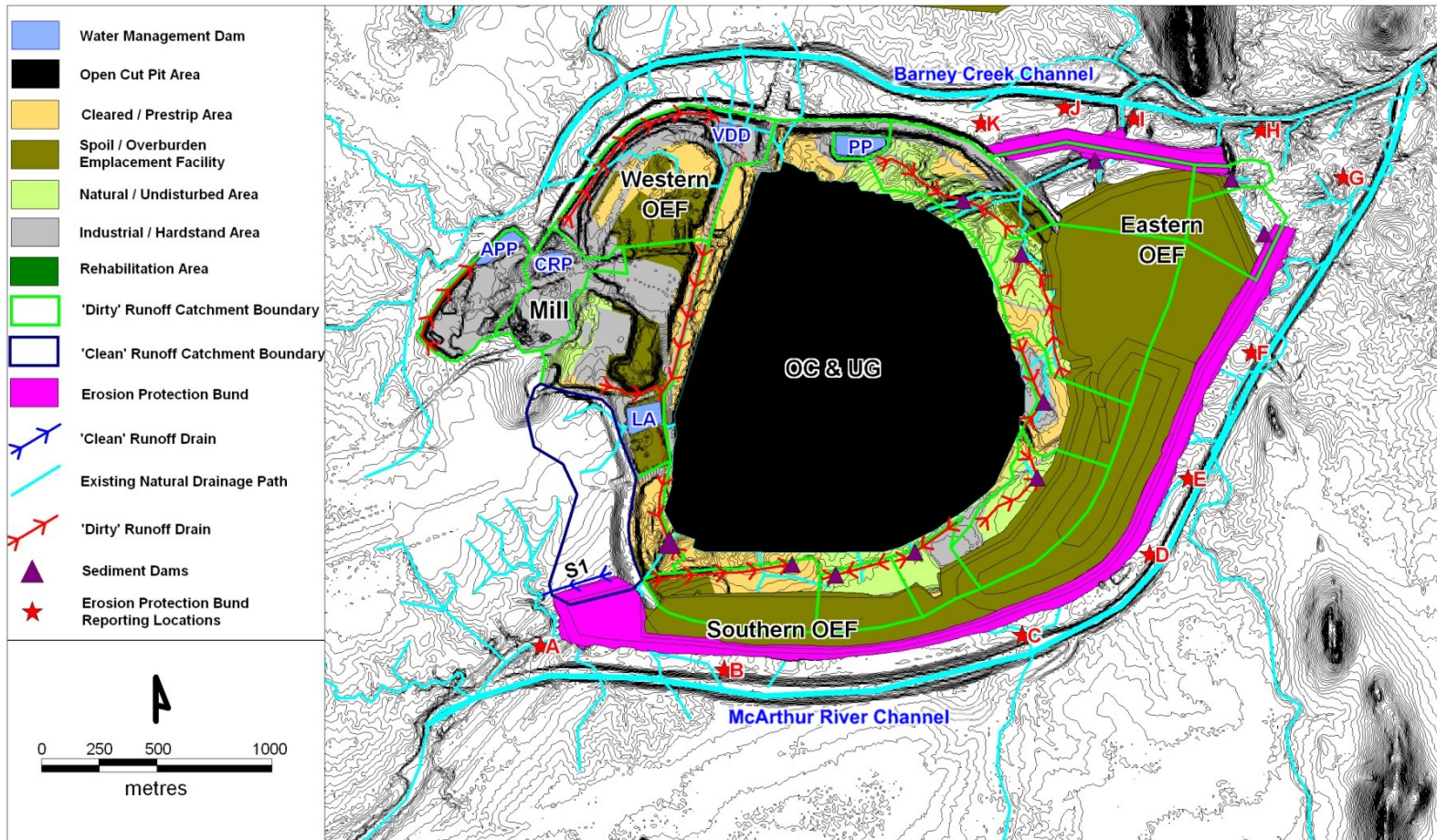


Figure 4-3 Water management concept of the SOEF and EOE in 2020

Appendix E2 – OEF Management Plan

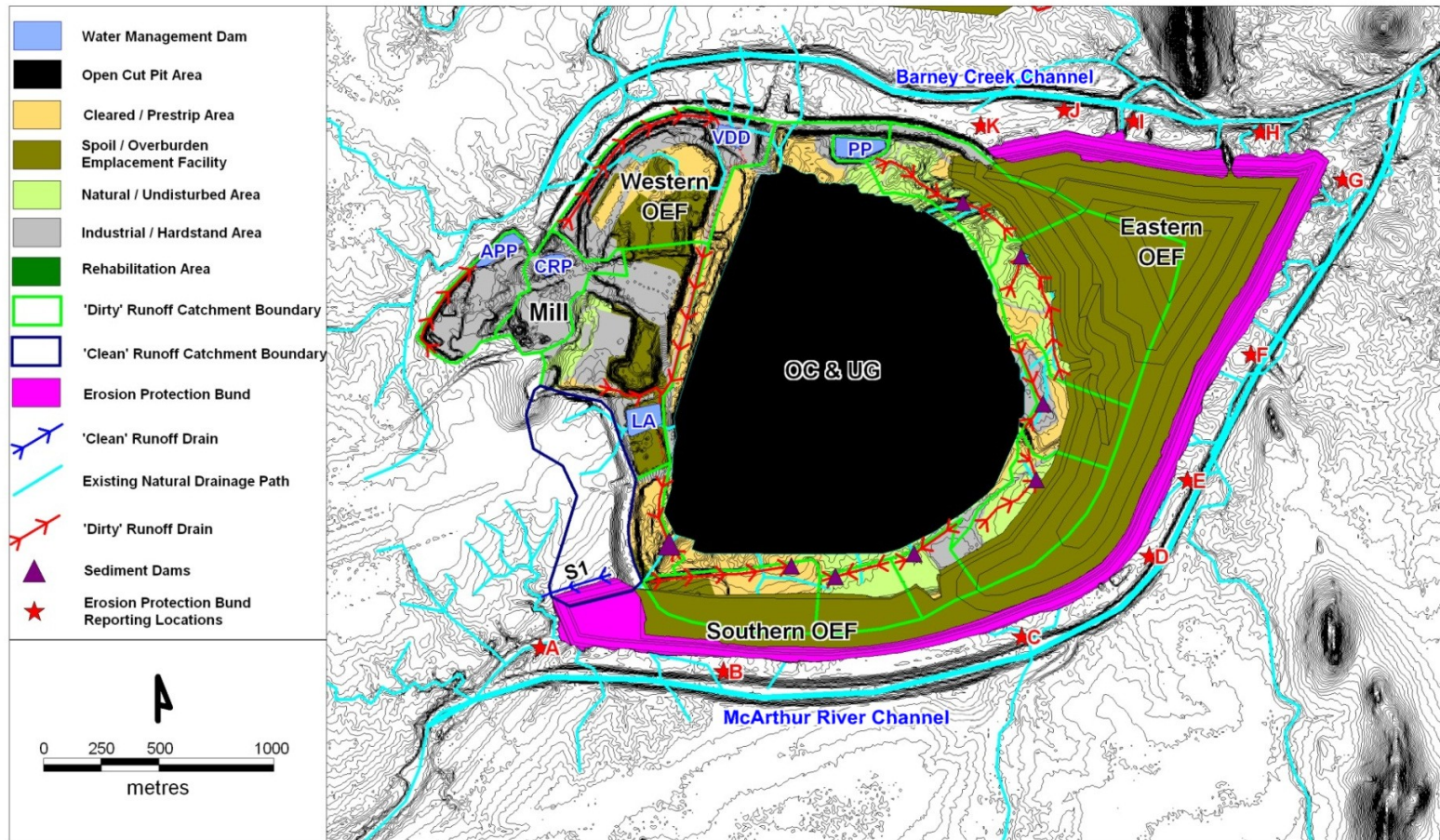


Figure 4-4 Water management concept of the SOEF and EOE in 2025

5 West OEF

The West OEF can also be seen in Figure 4-1, with the Mine Offices located on them. This OEF is located wholly within the mine levee wall. The WOEF was completed in 2011 to the original design; however the requirement to upgrade the ore crushing facilities has resulted in further works to be designed for construction in 2012 and 2013. This has made it desirable to move the existing stores building and yard, which makes an additional area of 2.5 ha available.

Approximately 4.5 Mt of overburden will be able to be stored in the WOEF, both in the area now occupied by the stores yard, and in building a portion of the OEF the height of the crusher.

Detailed designs for the WOEF, including the interaction with the proposed crusher system, will be undertaken in 2012.

5.1 WOEF Design Parameters

The design parameters that were established for the original WOEF will be used for the expansion of the WOEF, as the performance of the OEF to date has been satisfactory. The key parameters are:

- nominal 10 m lifts with batters left at the angle of repose
- 10 m berm every 20 m
- 35 m wide haul ramp (changed from 30 m) at 10% gradient
- maximum elevation of the main part of the WOEF is 66.5 RL to remain under the airstrip OLS, though the southern areas are also affected by sloping clearance surfaces of the OLS.

Design parameters for the extraordinary works associated with the crusher and conveying infrastructure will be developed as part of detailed design studies in 2012. It could be expected that reinforced retaining walls will be installed in the vicinity of the crusher, which would require select fill placement, compaction and drainage.

5.2 PAF Management Concept

As the West OEF is inside the mine levee wall, and drains back to the open pit, it can be used to store PAF overburden. The rules governing design of the PAF cells in the WOEF are shown in Figure 5-1:

- the base of the PAF must be above the 38 RL level, which was the 1:100 ARI flood level before the levee was installed
- the PAF cell will be encapsulated completely by at least 1 m of clay
- the PAF cell must be located at least 25 m horizontally and 3 m vertically from the final WOEF surface. This is to lower the risk of PAF exposure in the event of local instability.

The open pit is effectively the PAF dam where any leachate would report to.

Appendix E2 – OEF Management Plan

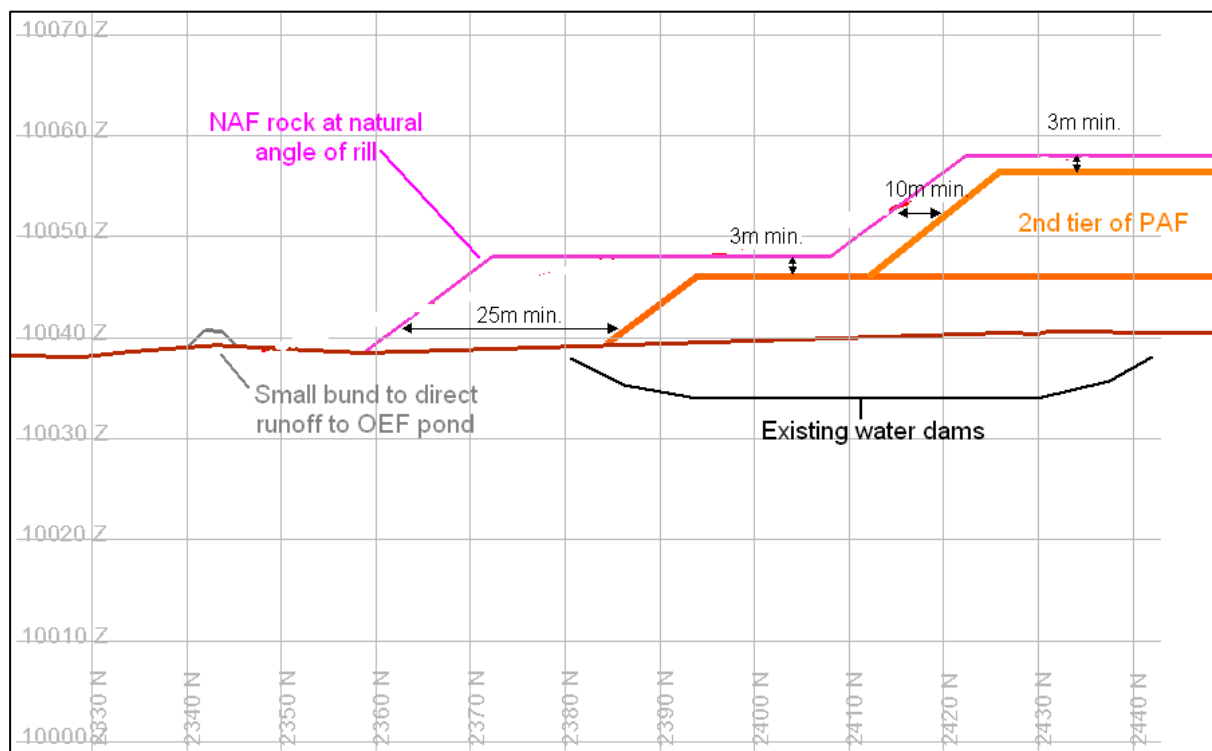


Figure 5-1 Schematic cross section of WOE showing PAF cell offsets (2006 MMP)

5.3 Cover Design

The West OEF will use the same cover as specified for PAF areas of the NOEF. A 0.6 m growth layer will be placed over the NAF surface to enable root establishment, with a 100 mm layer of topsoil placed on top to support vegetation growth.

5.4 Surface Water Management System

The northern end of the WOE was re-contoured through 2010 and 2011 to shed surface water to the northwest, where it would flow into drains toward Van Duncan's Dam (denoted as 'VDD' in Figure 4-1). The southern end, where the ROM pad and crusher will be operational, will have drainage designed as part of detailed designs to be completed in 2012. The drainage would be away from the infrastructure and toward the east and south areas of the WOE. Runoff would then report as it currently does to the drains at the toe of the WOE, which reports to Lake Archer (LA).

5.5 Staged Development and Rehabilitation Strategy

As the WOE is being used as a base for major infrastructure, it will not be rehabilitated until the end of the mine life. Despite having a NAF cap above the PAF cells, it is anticipated that the use of the top of the WOE as an industrial area and ROM pad will result in the top 1 m of NAF becoming potentially contaminated. Therefore, the closure plan for the WOE has allowed for 1 m of NAF to be excavated and placed in the bottom of the final open pit void, with a fresh 1 m layer of NAF replaced. The final cover would then be constructed over this, along with contouring and drainage structures to ensure the WOE remains stable in the long term.

6 OEF Monitoring

6.1 Kinetic Leach Testing

Kinetic leach tests are ongoing both on-site and in laboratory conditions. Samples are taken from both the tailings and overburden – the two largest waste streams on-site. The final events of the current program were completed in October 2011, and a report will be produced incorporating and comparing the 2010-2011 and the 2009-2010 wet season samples. It is intended that Kinetic leach tests will continue and will form a part of the annual monitoring program for the Project.

Previous static and kinetic leach column testing of NAF materials from the NOEF indicates that these materials are pH neutral and, based on previous kinetic leach column results (which commenced in October 2005) will remain pH neutral and generate excess alkalinity.

PAF material will be progressively clay encapsulated and surrounded by NAF material. Therefore, potential leachate from the OEF will be overwhelmingly dominated by the geochemistry of the NAF material and is unlikely to be acidic. Kinetic leach column testing to date indicates that when PAF material is combined with NAF material, the pH remains neutral. If the leachate from the NOEF was to become acidic, then soluble metals concentrations in the leachate could increase. However, as stated, the likelihood of the OEF generating acidic leachate is extremely low.

In any event, in line with the 'multiple lines of defence' approach, any potential leachate from PAF material that is generated will flow to the PAF pond and be reused in the processing plant. It will not be discharged to the environment (URS, 2005c). After mine closure, any potential leachate that may occur would evaporate from the PAF pond as this dam will be sized to accommodate a 1 in 100 year flood event. More information is available in Appendix E4 – Mine Closure Plan.

6.2 Further Geochemical Assessment

A new drilling program commenced in September 2011 to conduct a detailed geochemical analysis of the Project overburden material to increase confidence in predicting the occurrence of PAF during mining and to improve the efficiency with which the material can be separated from NAF material. Previous geochemical work covered the extent of the Phase 3 open pit, and the new drilling program will verify this data.

This investigation will include sulphur content and speciation to distinguish acid-forming sulphides from other material containing sulphur. Other tests will include Acid Neutralising Capacity (ANC), Net Acid Generation (NAG), paste pH and EC, Acid Buffering Characteristic Curves (ABCC), Kinetic Net Acid Generation (KNAG), carbon speciation, and elemental analysis of solid material and water extracts.

Over 5,000 m will be drilled and sampled by both a combination of regular sample intervals and specific targeting of known PAF strata. This information will add to the existing overburden geochemistry data base. This work will continue throughout the mine life to increase data density ahead of mining.

6.3 Monitoring Program

The existing OEF monitoring program will be reviewed and expanded to include specific parameters designed to provide feedback on the overall performance of the OEFs and the effectiveness of environmental management controls. Acquired data will be assessed regularly and presented in a series of regular reports.

It is envisaged that in the early stages of the establishment period, a monitoring report would be produced at the end of the wet season and the end of the dry season, with annual reports being prepared in the Mining Management Plan.

The main monitoring parameters for the program can include:

Appendix E2 – OEF Management Plan

- vegetation establishment and sustainability
- geotechnical stability
- erosion monitoring
- storm water drainage monitoring
- water quality
- groundwater /seepage monitoring
- cover performance.

Background soil samples in the vicinity of the proposed OEF footprints will be tested for metals to determine the significance of any enriched metals with respect to final rehabilitation. Rehabilitation of the OEF surface will be progressively undertaken and field trials will be conducted to determine any significant effects on rehabilitation success from any elevated metal concentrations in potential outer cover materials.

As the construction of the NOEF progresses, lysimeters will be installed at appropriate locations to monitor water infiltration. The lysimeter installation program commenced in 2011 at existing operations and will be described in future Sustainable Development Mining Management Plans.

6.4 Monitoring Frequency

The current monitoring program relating to the OEFs is shown below in Table 6-1 and mainly focuses on surface water and ground water. It will be reviewed and updated regularly throughout the life of mine. The monitoring program will be assessed and new monitoring points to match the Project footprint will be added if required. This process will be managed via annual Mining Management Plans.

The aims and objectives of the surface water monitoring program at MRM during the Project will remain the same as under current operations. Therefore, the current surface water monitoring network will remain basically unchanged, expect for some minor changes to improve and expand the current surface water monitoring program to account for the changes in site layout proposed as part of the Project.

As mentioned in Chapter 10 – Water Resources, three new surface water quality monitoring stations are proposed to monitor the impact of the North OEF runoff on Emu Creek receiving waters. These stations will monitor the background (upstream) water quality in Emu Creek, the quality of surface runoff entering Emu Creek from the NOEF area and the impact of the NOEF on Emu Creek receiving water quality.

It is also proposed to expand the artificial surface water monitoring network to include the monitoring of the six new storages proposed for the site, of which four new storages in the NOEF area, namely South-East PAF Runoff Dam (SEPROD), East PAF Runoff Dam (EPROD), North-East PAF Runoff Dam (NEPROD) and North-West PAF Runoff Dam (NWPROD) will be included.

Appendix E2 – OEF Management Plan

Table 6-1 OEF Monitoring Program

MONITORING PROGRAM	SITE CODE	LOCATION	PARAMETERS
Soil			
Mine site	S1 – S24	Sites correspond to dust sites D1-D24	<u>Annually</u> - Paste pH and EC - Particle size distribution - Major cations (Ca, Mg, Na, K) - As, Cd, Cu, Fe, Mn, Pb, Zn (2mm fraction)
Natural Surface Water			
Surprise Creek	SW1	Upstream of TSF	<u>Weekly (when flowing)</u> - Record cease to flow - pH, Temp, DO, EC, ORP, and turbidity (field meter) - TDS, TSS - Filtered metals (As, Cd, Cu, Pb, Zn) - Filtered major cations (Ca, K, Mg, Na) - Soluble Cl^- and SO_4^{2-} - Alkalinity - Anion and cation balance - SW 11 & SW21 (Additional as per WDL 174 = Al, Mg, Fe, Hg.)
	SW2	Downstream of TSF where Carpentaria Hwy crosses creek	
	SW23	Upstream Surprise Creek- upstream of SW1 (new)	
	SW24	Upstream of Surprise Ck-Barney Ck junction; adjacent to the Northern OEF (new)	
Barney Creek	SW3	Creek crossing on the mine site back road	
	SW4	Upstream of mine site – where Carpentaria Hwy crosses creek	
	SW22	Between mine site and Carpentaria Hwy (new)	
	SW25	Drainage line into Barney Ck channel (taken upstream of junction), adjacent to the Northern OEF (new)	
Barney Creek Channel	SW18	Barney Ck channel immediately downstream of junction with Surprise Creek	
	SW19	Barney Ck channel where pit-OEF haul road crosses the channel	
	SW20	Barney Ck channel downstream of SW19 at PWB access road	
McArthur River	SW6	Downstream of mine site and Barney Creek junction	
	SW7	Upstream of mine site	
	SW8	McArthur River Crossing - Borroloola	
	SW10	Immediately upstream of upstream gauging station	
	SW11	Downstream McArthur River, sampled adjacent to the downstream gauging station (new)	
	SW12	Downstream McArthur River channel and upstream of Glyde River junction	
	SW21	Upstream McArthur River upstream of SW10	
McArthur River channel	SW13	McArthur River channel (west/upstream end)	<u>Bi-Annually</u> - Multi-element ICP-MS scan (Inc. Hg) - chlorophyll 'a' - Alkalinity - ACB
	SW14	McArthur River channel mid-way between SW13 and SW15; near to 1 st borrow pit	
	SW15	McArthur River channel immediately downstream of junction with Bull Creek	
	SW16	McArthur River channel mid-way between SW15 and SW17; where current Glyde River access road crosses the channel	
	SW17	McArthur River channel (east/downstream end)	

Appendix E2 – OEF Management Plan

Table 6-1 OEF Monitoring Program (cont)

MONITORING PROGRAM	SITE CODE	LOCATION	PARAMETERS
Groundwater			
Northern OEF	GW64S, GW65S, GW64D, GW65D	Located on perimeter of Northern OEF	<u>Every 2nd Month</u> • Standing water level • pH, Temp, EC and ORP (field meter) • TDS/TSS • Filtered metals (As, Cd, Cu, Pb, Zn) • filtered major cations (Ca, Mg, Na, K) • Soluble Cl⁻ and SO₄²⁻ • Hardness <u>Quarterly</u> • Total metals (As, Cd, Cu, Pb, Zn) • Total major cations (Ca, Mg, Na, K) <u>Bi-Annually</u> • Multi-element ICP-MS scan (Inc. Hg) • TPH- sites: GW3A, GW5A, GW15, GW16, GW15 7 GW14
Sites destroyed	GW1A, 2, 5, 8A, 13, 17, 24, 25		
Mine Site Sediment			
Northern OEF PAF sediment dams	Northern PAF sediment dam Southern PAF sediment dam	PAF sediment dams at the Northern OEF	<u>Bi-annually</u> • Paste pH, EC • Particle size distribution • Major cations (Ca, Mg, Na, K) • As, Cd, Cu, Pb, Zn (total and 63µm fraction for one year then review)

7 OEF Rehabilitation and Mine Closure

7.1 Overview

Conceptual rehabilitation options/strategies have been developed for the OEFs and MRM will prepare detailed rehabilitation plans throughout the mine life. The plan will be designed to ensure that the rehabilitated OEFs will be a stable self-sustaining landform with no downstream contamination from sediment or metals.

It would not be appropriate to prepare and 'lock-in' a detailed rehabilitation strategy at this stage of the Project. Current best practice across Australia and internationally (particularly in tropical climates) is to develop detailed rehabilitation plans with sound data and knowledge of performance characteristics of the relevant materials determined from site-specific rehabilitation trials. Detailed rehabilitation design for the OEFs will be developed when conceptual strategies and supporting studies have been confirmed with pilot rehabilitation trials.

A detailed rehabilitation strategy will be developed throughout the mine life and during the construction of the OEFs, including a series of trials of various landform profiles, outer batter material types, revegetation strategies and surface water management systems. Trials will occur when areas of land become available for rehabilitation, when the area is no longer involved in the active mining process. The following discussion is provided to outline a general rehabilitation concept that will form the basis of future rehabilitation strategies and trials.

The results of the monitoring undertaken during the mine life will be used to design the closure strategy for the OEFs. The monitoring program will be maintained for as long as is necessary to determine that there is no potential seepage from the NOEF detrimentally affecting groundwater quality or surface waters off-site. More information is available in Appendix E4 – Mine Closure Plan.

7.2 Contour Banks

The concept of constructing bunds (or contours banks) to manage surface runoff at regular slope intervals has been proven in erosion control works extensively for agricultural land use and for mine rehabilitation where bunds have been properly designed and constructed. The potential for bunds to fill with sediment and eventually overtop or fail is critically linked to success of rehabilitation revegetation cover. As such the risk cannot be modelled until monitoring data are obtained from pilot rehabilitation trials to evaluate optimum rehabilitation design relative to site specific conditions. From these pilot trials and assessments, the bunds or alternative surface water 'drainage' strategies consistent with best practice will be designed to achieve erosion stability objectives.

When rehabilitation works are implemented, including the construction of surface water management systems and planting of vegetation, a monitoring and maintenance plan will be implemented. A key feature of this plan will be to demonstrate that vegetation has successfully been established over the OEF surfaces and that regular maintenance is undertaken to ensure that the designed surface water management system is functional. This would include desilting of drains, if required. As time elapses and the vegetation establishes and increases in density, the maintenance requirements for the drainage system diminish until a sustainable system is in place. Annual monitoring reports will be prepared to demonstrate that this has been achieved.

Acid (at pH sufficient to impact on quality of receiving waters) will not leach from the NOEF after rehabilitation because the OEF design - rehabilitation trials and performance monitoring are all intended to avoid production of acid leachate. The PAF ponds will not be decommissioned until this objective is confirmed by water quality monitoring. The detailed rehabilitation design will be developed using results from rehabilitation trials to ensure that this objective is achieved.

7.3 Revegetation

The top of all OEFs and the intermediate berms across the outer batter slopes will be rehabilitated progressively as sections of the OEF are fully completed. As discussed above, the final rehabilitation treatments will be selected based on the results of a series of field trials but conceptually will include:

- final profiling of the surface to achieve the desired gradients
- placement of a 0.1 m nominal thickness of topsoil across the profiled surface (to be reviewed throughout the mine life)
- contour ripping, seeding and fertilising to establish a grass cover.

Vegetation establishment on the crest and outer berms will improve the overall aesthetics of the OEFs and will also minimise post rehabilitation maintenance costs by encouraging 'self-healing' of minor erosion. A post-rehabilitation monitoring program will be implemented and should any significant erosion areas be identified, repairs would be carried out as required.

Testing and analysis of potential topsoil (or equivalent) materials will be completed as part of the design for the OEF rehabilitation in order to assess the need for additional treatment, such as the addition of gypsum, fertiliser and mulch, to promote vegetative growth across the rehabilitated surfaces.

The following will promote favourable conditions for the establishment of vegetation across the surface of the cover:

- topsoil type material must be suitably moisture conditioned (e.g. not long after the wet season, or sprayed) prior to placement to minimise loss of material to dust during placement and to ensure that the topsoil has an acceptable structure for sowing seed. The preparation of a loose and friable seedbed is essential for good vegetation establishment from seed. If it is very dry when cultivated, the soil will shatter and lose its structure, leading to surface sealing. If it is very wet, the soil may become compacted
- all topsoiled areas should be contour ripped and/or tined (after topsoil spreading) to a depth of at least 300 mm to create a 'key' between the topsoil and the subsoil. This operation will leave the soil surface in a roughened condition and should be undertaken immediately prior to sowing. Ripping should be undertaken on the contour to minimise erosion and maximise the moisture regime for vegetation establishment and the tines should be lifted for approximately 2 m every 200 m to reduce the potential for channel erosion
- the rehabilitation earthworks will be completed during the dry months to allow seed sowing to be undertaken during the period October to November prior to the wet season. There is a limited window of opportunity for sowing of seed (i.e. just before the wet season) and ideally, all sowing should be complete by mid-December.

7.4 Erosion Control

The topsoiled surface of the cover will be susceptible to erosion from wind and rain immediately after construction and during the vegetation establishment period. Erosion protection will be required to minimise erosion and the loss of seed and fertiliser from the surface of the cover. A range of options are available to provide erosion protection including a number of proprietary surface mat products, straw mulching or hydro-mulching.

7.5 Key rehabilitation materials

A program of clay investigations was undertaken in 2011 to enable estimates of the quantity, quality and location of clay resources around site for use in capping and rehabilitation. A summary of the results is shown in Table 7-1 below (Hatch, 2011). It is estimated that clay requirements for OEF capping (including contingency) is around 14 Mm³ over the life of mine, including Phase 3. It can be seen that there is sufficient clay in the open pit and OEF areas to complete rehabilitation as planned.

Appendix E2 – OEF Management Plan

Table 7-1 Clay Resource Summary

Feature	Estimated Clay Quantity (Million m ³)
TSF Borrow Area	3.17
Inside Cell 4 Footprint	0.24
Open pit Borrow Area	1.05
Eastern OEF Borrow Area	0.56
Northern OEF Borrow Area	14.22
Total	19.24 Mm ³

Life of mine statistics for topsoil in the open pit and OEF areas are summarised in Table 7-2

Table 7-2 Topsoil resources in the mining areas

Item	Estimated Quantity (Million m ³)
Current stockpiles	0.23
Additional stripping	2.10
Total Topsoil Resources	2.33
Required topsoil	2.32
Excess topsoil	0.01

7.6 Material stockpiling and deployment

An update on overburden geochemistry using the results of infill drilling conducted in 2011 is due in 2012. Schedules conducted as part of the Phase 3 studies have estimated the stockpiles of various rehabilitation materials required for successful closure of the mine. Over the life of mine, the following quantities of materials are expected to be stockpiled and rehandled at various times to enable progressive capping of the OEFs (refer to Table 7-3).

Extensive stockpiling is required to balance the mismatch between the availability of materials and rehabilitation requirements. This is evident in the NAF stockpile requirement. The last years of the mine life has a relatively high proportion of PAF mined in comparison to NAF, however the top 20 m of the NOEF must be NAF material only. This means that stockpiles of NAF and clay must be set aside for use in constructing the final OEF cap.

These works are scheduled to take from 2037 to 2039. Investigations into in-pit dumps for PAF material could significantly reduce this capping requirement; however, extensive geotechnical investigations will be required before the viability of this is known with the required level of confidence.

Table 7-3 – Estimate of life of mine stockpiles of rehabilitation materials at the OEFs

Material	Estimated Quantity (Million m ³)
Clay	7.5
NAF overburden	10
Topsoil	2.3

8 Environmental Risks - OEFs

The assessment of all risks posed by the storage, transport and disposal of overburden is a key component in the process of improving overburden management at MRM. All waste management practices are assessed annually on their potential environmental risk.

While assessing risk of waste management practices, all control strategies are taken into account. These control strategies reduce either the likelihood or the potential consequence of the risk. Control strategies may include implementation of procedures, adherence to guidelines, standards, legislation, routine maintenance, monitoring, and long-term mine planning.

The environmental risks associated with the OEF's that would require managing include the following:

- the North, South and East OEFs may be affected by occasional flooding
- permeability of cover, walls or base
- inadequate categorisation of geochemical characteristics of waste materials
- potentially contaminated runoff
- instability.

The current OEF management strategies to be implemented for each OEF to manage these risks are summarised below. These will be continually reviewed and adapted over the life of the Project.

Table 8-1 OEF Risk Management Strategy

Risk	Management Strategies
North OEF	
Location on the floodplain	• The OEF is located back from the floodplain where modelling has shown that flow velocities would not affect the NOEF. • PAF is only stored in cells above the 1:100 year flood level.
Permeability of the OEF cover, walls, and base	• The OEF design offers multiple lines of environmental protection. • An engineered cover layer over the top of the NOEF. • PAF materials are encapsulated in a clay cell that will prevent oxidation of PAF materials and minimise the risk of formation and mobilisation of acid leachate and metals contaminants. • Clay layer underneath the PAF cell that drains into the PAF dams, which will capture and store any runoff and/or leachate. • NAF materials will not generate contaminated runoff.
Inadequate categorisation of waste materials	• Extensive geochemical investigations in excess of industry standards have been undertaken for mine planning to categorise waste materials and will be ongoing throughout the life of mine. • Waste categorisation will continue during mining operations to categorise and manage NAF and PAF materials as per MIN-TEC-PRO-1000-0015-EOM sampling procedure. • Waste categorisation will consider the potential for acidic leachate, and non-acidic leachate contaminant risks. • Monitoring of runoff quality from sample points around the NOEF.

Appendix E2 – OEF Management Plan

Table 8-1 OEF Risk Management Strategy (cont)

Risk	Management Strategies
Potentially contaminated surface water runoff	- The West side will drain into sediment dams. - The East side will have major sediment traps at the head of the drainage lines to trap sediments.
Instability	- The NOEF is designed to an overall 1V:4H slope which modelling shows is stable. - There is provision to cut batters back to 1V:4H if the overburden is not durable or unstable. - Flat surfaces of the NOEF has been designed with a slope of 1:100 to prevent water from pooling near the edge of the NOEF, which could cause instability. - PAF cells are placed well inside the core of the NOEF.
Bund OEF's (including new East and South OEFs)	
Location on the floodplain	- NAF materials will not generate contaminated runoff. - The offsets of the OEF from the McArthur and Barney channels have been selected to enable rehabilitation of the channels and to limit changes in flood heights and flow velocities to manageable levels.
Permeability of the OEF cover, walls, and base	- No PAF materials are to be stored in these OEF's. - NAF materials will not generate contaminated runoff.
Inadequate categorisation of waste materials	- Extensive geochemical investigations in excess of industry standards have been undertaken for mine planning to categorise waste materials. - Waste categorisation will continue during mining operations to categorise and manage NAF and PAF materials as per MIN-TEC-PRO-1000-0015-EOM sampling Procedure. - Waste categorisation will consider the potential for acidic leachate, and non-acidic leachate contaminant risks.
Contaminated surface water runoff	- Runoff from the OEFs will flow through sediment traps if required and will be placed at the head of drainage lines to drop out any sediment. - NAF materials will not generate contaminated runoff.
Instability	- The OEF's will be designed to parameters similar to that of the NOEF. - Further sub-surface testing is planned for the proposed footprint for incorporation into geotechnical modelling. - The surface will be sloped to shed water off the perimeter.
West OEF (existing)	
Location on the floodplain	The OEF is located within the mine levee wall which is designed to withstand a 1-in-500 year flood event and hence is unlikely to be exposed to flood waters.
Permeability of the OEF cover, walls, and base	- PAF materials are located in clay lined cells within the core of the OEF - Any leachate reports to the open pit void. - NAF materials will not generate contaminated runoff.

Appendix E2 – OEF Management Plan

Table 8-1 OEF Risk Management Strategy (cont)

Risk	Management Strategies
Inadequate categorisation of waste materials	• Extensive geochemical investigations in excess of industry standards have been undertaken for mine planning to categorise waste materials. • Waste categorisation will continue during mining operations to categorise and manage NAF and PAF materials as per MIN-TEC-PRO-1000-0015-EOM sampling Procedure. • Waste categorisation will consider the potential for acidic leachate, and non-acidic leachate contaminant risks. • The West OEF drains back to the open pit.
Contaminated surface water runoff	• Runoff from the West OEF will be collected in the various runoff ponds which are located within the flood protection bund. Water in the OEF runoff ponds will be retained within the closed mine water management system and will not be discharged. • The West OEF drains back to the open pit.
Instability	• The West OEF has berms and batters to reduce the overall slope to a safe limit. • The surface will be sloped to shed water off the perimeter.

9 References

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