# BROCKMAN RESOURCES LIMITED

## MARILLANA PROJECT
## MINING BYPRODUCTS MANAGEMENT

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# 1 INTRODUCTION

The proposed mine and processing plant at Marillana will have four main output streams: iron ore final product, mine waste, and fine and coarse rejects. While the former is transported off site by rail for sale, the remaining three streams need to be placed in permanent storage locations on site. This document describes the composition of these three streams, and the potential storage methodologies and locations.

# 2 ORE CHARACTERISATION

Three styles of mineralisation have been identified within the Project area. These are:

- **Channel Iron Mineralisation,** comprising abundant +2 mm pisoliths (or pelletoids) cemented by goethite, with occasional organic wood structures now totally replaced by goethite or hematite. These tend to be within pelletoids but may not be the dominant component. The pelletoid texture varies but frequently has a porous goethite nucleus and a cortex that is both goethite and hematite. Some examples usually under 2 mm may be hematite rich and probably contain some maghemite. Some of the wood structures where dominant as pelletoids are excessively porous.
  The matrix is dominantly a fine grained often porous goethite, through which are weakly disseminated fine titanium oxides. This matrix goethite can have a micro oolitic character. The matrix to the pelletoid has a porous ooid texture. The ferruginous examples are composed of either haematite nuclei to goethite cortices, or solely of goethite. Haematite is occasionally present as small fragments.

- **Unconsolidated Pisolite Detrital Mineralisation,** comprising 50% to 70% well sorted 1 - 3 mm sized spheroidal clasts (pisoliths) formed around either maghemite or hematite and mixed with silt to fine sand sized material. This zone usually lies above or proximal to the CID mineralisation and may have resulted from decomposition/reworking of the CID mineralisation

- **Hematite Detrital Mineralisation,** comprising subangular to subrounded clasts of predominantly hematite and BIF. More mature detritals have higher proportions of rounded clasts (mainly hematite) and immature detritals have more subangular clasts, with a higher BIF/chert component. The hematite detritals usually lie above the pisolite detritals, but can be intercalated with them on a 1 - 5 m layering. The contact with the pisolite detritals is almost invariably gradational.

The average grade of the detrital ore resource is 43.2% Fe, and of the CID 57.1% Fe. The target grade for saleable beneficiated detrital iron ore is 59% Fe, with low levels of Al and Si. To achieve this, it is a “simple” matter of separating the lower Fe clasts/pelletoids from the higher Fe clasts/pelletoids. The processing methodology selected to perform this task is the use of density (the higher the Fe content, the higher the density). The use of simple gravity techniques means that no chemical processing is required, and that the product streams differ only from the input stream by virtue of Fe content and grain size.

# 3 PRODUCT STREAM CHARACTERISATION

## 3.1 Mine Waste

Mine waste is material that originates from within the proposed mine pit that does not contain sufficient iron to be processed economically into a saleable final product, but must be moved from its original location in order to access ore lying underneath it. The process of moving the mine waste will be predominantly performed using large excavators and haul trucks. During the relocation process, the mine waste does not undergo any physical transformation, other than that of the excavation process itself.

A minor portion of the total mine waste, the topsoil, will be treated differently. More selective mining methodologies will be used to recover the topsoil (including the contained seed stock), and stockpiled separately, for future re-use within the rehabilitation process.

## 3.2 Fine Rejects

All ore presented to the processing plant is scrubbed to liberate the fine and coarse clasts/pelletoids from the clays. The scrubber discharge is screened to remove the fine particles (-1 mm) which are transferred to the spiral plant. Here the -45 µm material is separated by cycloning, and transferred to the fine rejects thickener.

The +45 µm, -1 mm material is passed over a series of spirals, to gravity separate the saleable iron ore from the lighter, less iron-rich waste. This latter stream is also transferred to the fine rejects thickener, where coagulants and flocculants are added to assist the dewatering process. The combined fine rejects are pumped to the Fine Rejects Storage (FRS) facilities, where more water is decanted and returned to the plant for re-use.

Approximately 215 Mt of fine rejects are expected to be generated over the life of the mine, at an average rate of 11.1 Mt/y.

## 3.3 Coarse Rejects

Coarse material from the scrubbers (+8 mm) is crushed to (-8 mm) and combined with the +1 mm, -8 mm portion of the scrubber discharge, and transferred to the Jig plant. The jigs are used to gravity separate the saleable iron ore from the lighter, less iron-rich waste. This latter stream is de-watered, and conveyed to the Coarse Rejects stockpile.

Approximately 163 Mt of coarse rejects are expected to be generated over the life of the mine, at an average rate of 8.5 Mt/y.

# 4 STORAGE METHODOLOGY

## 4.1 Mine Waste

Mine waste is typically disposed of either to locations within the mining void or onto ex-pit surface dumps. The design of the surface dumps is constrained by the ability of the haul trucks to build the dumps, and by the long term plan for the dumps. Dumps that will be relocated prior to mine closure can be constructed with slope angles of 37°, while dumps that will be left in place after mine closure have maximum slope angles of 20°.

## 4.2 Fine Rejects

The fine rejects are pumped from the fine rejects thickener to the final storage location at a target density of 50% w/w. The coagulants and flocculants added at the thickener to assist in the dewatering process are benign, and the fine rejects themselves are geochemically inert (non-acid generating). Consequently, the FRS is not required to be lined, and water seepage back into the aquifer will assist in the final consolidation of the fine rejects.

### 4.2.1 Surface Storage of Fine Rejects

On start-up, fine rejects will need to be desposited into a FRS dam on the surface. Conceptual design of this dam has been conducted by Coffey Mining Pty Ltd (Coffey) as part of the prefeasibility study (PFS), and documented in "*Fines Rejects Storage Facility Design"* July 2009. The basic design is an earthern wall construction using mine waste, with a 20m wide crest and 3H : 1V outside batters. Underdrainage and decant facilities will be used to recover water back to the processing plant.

### 4.2.2 In-pit Storage of Fine Rejects

In-pit storage of fine rejects can be established once a suitable portion of the mine void can be isolated from the active and future mining areas. Mine waste can be used to construct internal walls within the pit, thereby creating a number of cells for fine rejects storage. A study is currently underway to define the design criteria for these in-pit FRSs.

Construction for in-pit FRS will include the installation of pipelines for fine rejects delivery and return water, pipeline bunding and associated sumps, and establishment of monitoring / recovery bores.

When the cells have reached capacity, they will be covered with mine waste as part of the final site closure strategy.

## 4.3 Coarse Rejects

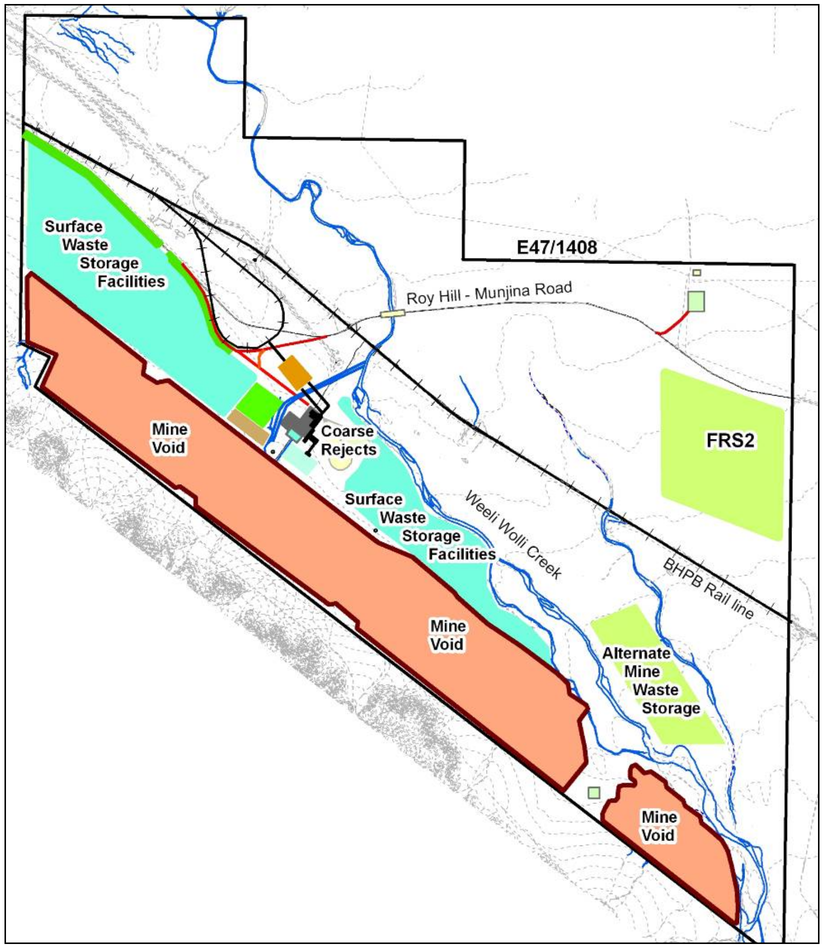
As the coarse rejects are dewatered in the processing plant, they can be conveyed to any location, and stacked using mobile stacker conveyors. These conveyors can stack in front of themselves, and then ramp up on the stacked material. Hence they will slowly construct a conical-shaped stockpile, of a height controlled by the angle of inclination the conveyors can construct, and the available area for stockpiling.

When space is available in-pit, the conveyors will be extended to the pit, so that further disposal is into the mining void.

# 5 STORAGE LOCATION SELECTION

At the commencement of the PFS, a number of locations were identified for the potential storage of the different mining byproduct material types. These were investigated, and a short list developed for incorporation into the final PFS site layout and into the cost estimation process. Figure 1 shows the potential waste storage locations investigated.

**Figure 1 Layout of potential storage locations**




### 5.1 Mine Waste

With the selection mine waste disposal methodology being that of truck and excavator, there are no physical limitations to where mine waste can be placed, other than those of the natural environment and cost.

#### 5.1.1 Mine Waste Adjacent to the Mining Pit

On mine start-up, it is inevitable that mine waste will need to be stockpiled on the surface. Some of this material will be able to be used as part of other mine infrastructure developments, such as pads for the processing plant and for embankments for the fine rejects storage facility.

In the interests of minimising trucking haul distances, it was envisaged that two waste dumps would be required, one each to the east and west of the processing plant site, to service the two ends of the orebody.

The surface hydrology study[1] has identified that, in a 1 in 100 year annual recurrence interval (ARI) flood event, the Weeli Wolli Creek would over-top its banks, and flood the proposed processing plant site.

[1] *Marillana Surface Water Assessment* 2nd July 2009, Aquaterra

Flood bunding will be installed prior to the construction of the Waste Dumps to ensure that flood protection for the mine and for the processing plant is achieved for the commencement of mining. The toe of the flood bunding will be located a minimum of 50 m from the Weeli Wolli creek bank to provide a 30 m non disturbance zone to protect existing riparian vegetation and a 20 m access corridor. Flood modelling indicates that velocities are steady with distance from the creek bank and hence the use of a larger set back would not reduce flood velocities adjacent to the bund.

The bunding height will vary across the site dependent on local topography. Typically to provide protection against 1 in 100 year flooding with appropriate freeboard, bund height will be 3-4 m high. The bund would require construction and compaction to an engineering specification, whilst the slopes will be dependent on the material used and the achievable compaction, indicative slopes are 1 Vertical : 3 Horizontal. Flood modelling indicates that the 1 in 100 year flood velocity against the bunds average 0.7 m/s. Based on this velocity, an appropriately constructed bund is expected to remain stable and scour protection is not required.

### 5.1.2 Mine Waste In-Pit

As moving material by truck and excavator is a relatively expensive methodology for bulk material movement, it is preferred that mine waste be retained within the mining void where possible. The Marillana mine void will be up to 50 m deep, and as such it would be advantageous if the trucks could be kept within the pit itself, rather than having to climb out of the pit. This would be advantageous not only for noise and dust levels, but would also reduce truck cycle times, and reduce fuel consumption.

### 5.1.3 Mine Waste Across Weeli Wolli Creek

With limited space between Weeli Wolli Creek and the eastern end of the mine pit, a waste storage location on the northern side of Weeli Wolli Creek was considered, as shown in Figure 1 as Alternate Mine Waste Storage. A dump site here would require environmental approvals not only for the dump site here, but also for the creek crossing. As this site lies within the 1 in 10 Year ARI flood impact area, it would need to be constructed so as to minimise erosion during such events.

### 5.1.4 Summary

From a purely-economic perspective, the preferred mine waste storage location is within the mine void, followed by adjacent to the mine pit.

A conceptual mine plan developed in the PFS shows that 110 Mbcm will need to be stored ex-pit, and 528 Mbcm in-pit. More detailed mine planning could have the potential to further reduce mining cost by reducing the ex-pit storage requirement.

Storage across Weeli Wolli Creek should only be considered as a last resort. Not only does it involve the longest haul distances, but it invokes a number of environmental issues, such as the Weeli Wolli Creek crossing and flood protection, both short term and long term. Consequently, this option has been eliminated from consideration.

## 5.2 Fine Rejects

### 5.2.1 Fine Rejects Storage Site 1 (FRS1) - Adjacent to the mining pit

As no mining void is available on start-up, the initial FRS facility would be located close to the processing plant and mine pit (material for the embankment would be from mine waste). The most likely location will be to the northwest of the processing plant site, where there is sufficient room to construct a single facility that would last till in-pit storage is available. For the purposes of the PFS, an area was included on the site layout, though this was purely for planning purposes. The facility will lie within the area on Figure 1 shown north-west of the plant site and labelled *Surface Waste Storage Facilities.* Detailed analysis and mine scheduling is required to determine the optimum location for this facility.

### 5.2.2 Fine Rejects In-Pit

As noted in Section 4.2.2 above, fine rejects can be placed into in-pit storage cells, once sufficient space has been opened up.

The mine pit at Marillana is some 50 m deep, and over 1,000 m wide. Walls for the in-pit storage cells can be constructed from mine waste relocated from elsewhere in the mine pit. The biggest constraint in developing such cells is simply opening up a sufficiently large area to permit the construction of the in-pit cells without impacting on ongoing mining operations or placing operators at risk.

It is noted that the design criteria for the walls of the in-pit cells will be different to those of the surface FRS facilities, as

- The cells are only temporarily free-standing. Eventually both sides of the walls will be filled with either fine rejects or mine waste, and the contents of the cells will also be covered with mine waste, as the pits are slowly backfilled totally
- They need to be constructed such that they do not adversely impact on existing and post-mining regional subterranean water flows

### 5.2.3 Fine Rejects Storage Site 2 (FRS2)

The Fine Rejects Storage Facility design conducted by Coffey evaluated the situation of how to handle fine rejects if in-pit storage was not available when FRS1 reached capacity. A location was identified for this facility, as indicated on Figure 1 as FRS2.

FRS2 is a four cell paddock type fine rejects storage facility with 3 m high starter embankments constructed of clayey borrow material obtained from within the FRS footprint. The embankments will be raised using fine rejects and upstream construction methods. This approach is not common with iron ore fine rejects, so the suitability of the fine rejects for upstream construction would need to further examined by a program of laboratory testwork. The downstream batters of the raises would be capped with a 0.5 m thick layer of mine waste rock to mitigate fine rejects erosion. Progressive placement of downstream capping with each embankment raise is recommended.

The facility footprint was sized so that the rate of fine rejects vertical rise was approximately equal to or less than 2 metres per year. This rate of rise has been shown to optimise the drying and consolidation time for fine rejects and allow for upstream construction.

As this facility lies within the 1 in 10 year ARI flood event area, it would have to be designed so as to minimise erosion during flood events.

Pumping costs to FRS2 would be significantly higher than to in-pit storage locations. Consequently, this options has been eliminated from consideration.

### 5.3 Coarse Rejects

As the coarse rejects leave the processing plant on a conveyor and are simply dry-stacked, they can be stockpiled anywhere providing the site is accessible by conveyor.

## 6 PROPOSED MINING BYPRODUCT DISPOSAL METHODOLOGY

### 6.1 Mine Waste

Mine waste extracted prior to the commencement of ore processing will be used to construct site infrastructure, such as FRS1, the plant pad, and flood protection bunds along the southern side of Weeli Wolli Creek.

Over the life of the mine, a total of 110 Mbcm of mine waste, out of a total of 561 Mbcm (or 20%), is expected to have to be stored on the surface, due to insufficient volume being available in-pit. The bulk of this will occur during the first five years, while the mining void is being developed.

The exact location of individual waste stockpile locations have yet to be determined, though it is anticipated that they will lie within the envelope shown in Figure 1 as Surface Waste Storage Facilities. Calculations conducted during the PFS have indicated that there is sufficient volume within this envelope to construct both mine waste and fine rejects storage facilities of the required volume without exceeding mine closure design parameters.

### 6.2 Fine Rejects

An initial Fines Reject Storage facility (FRS1) will be constructed, within the envelope shown on Figure 1 as Surface Waste Storage Facilities, prior to operations commencing, and will store approximately 7 years of fine rejects. After this time, mine scheduling indicates that sufficient capacity will exist within the mine void to commence the construct and filling of in-pit FRS cells.

The current mine production schedule estimates that some 78 Mt of fine rejects will need to be stored in FRS1 over the first 7 years. The remaining 137 Mt (64%) is scheduled to be returned to the mine void.

### 6.3 Coarse Rejects

It is proposed that coarse rejects will be dry-stacked adjacent to the processing plant on start-up. When sufficient open void in the mine pit is available, the coarse rejects conveyor will be extended to the mine void, and all coarse rejects thereafter stacked into the mine void.

Coarse rejects will also be used during the life of the mine for road construction purposes.

The current mine production schedule estimates that some 43 Mt of coarse rejects will need to be stored in the surface coarse rejects stockpile over the first 5 years. The remaining 120 Mt (74%) is expected to be returned to the mine void.

## 7 CONCLUSIONS AND RECOMMENDATIONS

- The majority of the stockpiling of mining byproducts on the surface will occur during the first 5-7 years, while the mining void is being developed
    - ➢ During the next phase of the project, detailed scheduling should be conducted, in conjunction with a detailed pit layout, to determine
        - The design constraints on developing in-pit fine rejects storage facilities
        - The operational constraints of in-pit fine rejects storage facilities
        - The earliest practical time that in-pit fine rejects storage facilities could be developed
- The calculations for the area required for ex-pit storage facilities indicates that these can be contained between the mining void and Weeli Wolli Creek/BHPBIO rail line. A provisional site layout has been developed to confirm this. For ongoing planning purposes, a generic envelope has been placed on the site layout (Figure 1) for surface waste storage facilities.
    - ➢ During the next phase of the project, a detailed site layout should be developed, taking into consideration
        - The actual volumes of mine waste and fine and coarse rejects that are scheduled to be stored ex-pit
        - The sources of this material
        - The final site closure plan
        - The impact of these storage facilities on Hamersley Range surface run-off, and the associated diversion channels
        - Protection of the environment along Weeli Wolli Creek
        - Protection of the site from flooding during 1 in 10 year and greater ARI flood events
        - Other mine infrastructure requirements (haul roads, conveyors, topsoil stockpiles)
- The current schedule estimates that 36% of the fine rejects, 26% of the coarse rejects, and 20% of the mine waste will need to be stored ex-pit
    - ➢ During the next phase of the project, a detailed analysis of the mine schedule should be conducted to determine the minimum volume of material that needs to be stored ex-pit.