11 Flooding and Regulated Structure

11.1 Introduction

Matters raised in submissions to the EIS relating to Chapter 11 – Flooding and Regulated Structures were predominantly focussed on:

- Flooding of the sediment ponds at the originally proposed MIA;
- Flooding of the haul roads;
- Design the haul road crossings;
- Access to the originally proposed MIA during flood periods; and
- The use of bridge structures in waterway crossings.

Appendix A includes the full details of all submissions received for the Project.

The sections herein respond to the aforementioned submissions. In summary:

- The originally proposed MIA, BLF and RoRo are no longer required as the approved SRBP infrastructure will be utilised for the Bauxite Hills Project and there is no inundation to the SRBP MIA or sediment ponds during the 100 year Average Recurrence Interval (ARI) event and minimal ponding against the sediment pond embankment during the Probable Maximum Flood (PMF) event (estimated to be a 10,000,000 year ARI event);
- The north south haul road is no longer required as the existing SRBP main haul road will be utilised, which has a minimum 100 year ARI flood immunity which not allows access to the SRBP MIA during the 100 year ARI event;
- The BH1 haul roads has been relocated up-gradient and now has a minimum 100 year ARI flood immunity, except for at waterway crossings where a floodway arrangement is adopted to reduce filling within the waterway and associated environmental and flooding impacts;
- The haul road crossings have been conceptualised in Section 11.3; and
- No bridge structures are required along the new BH1 haul road alignment.

11.2 Flood Assessment of the MIA and Conveyor

As detailed in Section 1.1 of the Supplementary Report the originally proposed MIA, BLF and RoRo are no longer required as the approved SRBP infrastructure will be utilized. Whilst not relevant to the Bauxite Hills Project, the following provides a summary of the flood potential at the SRBP MIA.

Flood inundation mapping in Figure 11-1 and Figure 11-2 of the SRBP MIA and BLF shows the peak flood depths predicted for the 100 year ARI and PMF events, respectively. The maps indicate no flooding to the SRBP MIA during the PMF event, and once constructed even the sediment ponds are not inundated as the pond embankment forms a flood barrier to the fringe of the PMF affected zone. Flood depths may reach up to 0.5 m against the sediment pond embankment during the PMF event. Riprap or gabion mattress scour protection are not considered necessary given the rare nature of the event (approximately a 1 in 10,000,000 year ARI) and due to the very low velocities (<0.2 m/s) in this region. The sediment ponds are not impacted by the 100 year ARI event.
BH1 MLA boundary
BH6 West MLA boundary
BH6 East MLA boundary
SKARDON RIVER

Legend
Flood Depth (m)
0
0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 1.75
1.75 - 2.00
2.00 - 2.25
2.25 - 2.50

100 Year Peak Flood Depth Map
Figure 11-1

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DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
MEC Mining;
QLD Government Open Source Data;
Australian Hydrological Geospatial Fabric

DESIGNER
CDM Smith

CLIENT
METRO MINING LIMITED

SCALE: 1:50,000
GCS GDA 1994 MGA Zone 54

Drawing: 100 Year Peak Flood Depth Map
Figure 11-1

DRG Ref: BES150115-Flood Mapping PMP Yr Depth

MD
DRAWN
16/12/16
CHECKED
16/12/16
APPROVED
16/12/16

Notes:
- Added Haul Road Changes
- Updated Haul Roads and Infrastructure

OTHER DETAILS
- Scale @ A3: 1:50,000
- Project Details: BES150115-Flood Mapping PMP Yr Depth

GCS GDA 1994 MGA Zone 54

Figure 11-1
100 Year Peak Flood Depth Map
11.3 Haul Road Flooding and Culvert Crossing Design

As detailed in Section 4.2 of the Supplementary Report, the Bauxite Hills Project will use the existing SRBP north-south haul road to access the MIA. As such the proposed alternate north-south haul road is no longer required.

The BH1 haul road has been relocated to avoid HES wetlands. The new alignment for the BH1 haul roads significantly reduces the waterway crossings that will be required.

While the flooding related impacts have been significantly reduced, Metro Mining commits to undertaking detailed design of the haul road crossings in compliance with:

- Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways; and

Given the extent to which the relocation of the haul road reduces the potential for environmental impacts, Metro Mining is seeking to have the final design of the culvert crossings for BH1 assessed as part of the EA conditions for the Project.

In all cases the following specific conditions will be applied:

- Works will commence and finish within the dry season, and if used during construction, any instream sediment and instream silt control measures associated with the works will be removed within this period;
  - This measure eliminates the requirement to construct waterway barriers such as coffer dams to divert water around the construction area.
  - Stabilisation of the banks will be done post construction to allow revegetation and reduce scour potential.
- Crossings will have a minimum (combined) culvert aperture width of 2.4 m or span 100% of the main channel width;
- All new and any replacement culvert cells will be installed at or below bed level;
- Internal roof of the culverts will be >300 mm above ‘the commence to flow’ water level;
- Where the cell is installed at less than 300 mm below bed level, the culvert floor will be roughened throughout to approximately simulate natural bed conditions;
  - To the extent possible, box culverts will be used to facilitate fish passage at low flow depths. Footings will be considered over base slabs to maintain the natural bed channel through the culverts.
- Apron and stream bed scour protection must be provided in line with the design requirements of the Code; and
- The culvert will be installed at no steeper gradient than the waterway bed gradient.
Waterway crossings will comprise of box culverts located within the main channel. Box culverts allow the most efficient passage of flows and for preferential fish passage conditions. Furthermore, haul trucks can drive directly on the top of box culverts or link slabs with little to no earth fill required and hence the risk of sediment transport through scour is significantly reduced. Where appropriate, the box culvert height will match the depth of the main channel. This serves to minimise haul road filling on the approach to the culvert crossing whilst maintaining the existing bank full discharge conditions. Box or circular culverts will only be located on the overbank areas where filling is required on approach to the main channel crossing (refer to example crossing design in Figure 11-3).

![Figure 11-3 Example crossing design](image)

Flows that exceed bank full discharge will overtop the culverts and efficiently pass a floodway section, therefore minimising increases to flood levels upstream (flood afflux). As shown in Figure 11-4 and Figure 11-5, peak velocities are quite low for extreme events such as the 100 year ARI and PMF events, as would be expected from an estuarine system with low stream energy. The figures show in-channel velocities of less than 1 m/s and typically less than 0.5 m/s. It is therefore unlikely that river velocities will cause excessive scouring and sediment transport due to inundation of road surfaces or drainage infrastructure.
The critical case for flows over the floodway is for events that just overtop the road (i.e. lesser than the 100 year ARI or PMF). This is when the low flow depths result in relatively higher velocities and is where scour potential and hence contamination transport is at its greatest. Scour protection will be designed in accordance with Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways. These measures are self-functioning and hence appropriate for when operations are in caretaker mode during the wet season. These measures typically include, but are not limited to:

- Riprap scour protection aprons and stilling basins at culvert outlets where high velocities may develop;

- The use of concrete or cement stabilised fill and pavements for floodway crossings to reduce scour potential and subsequent migration of sediments; and

- The use of riprap or gabion mattresses on the downstream floodway embankment and culvert abutments to reduce scour potential.

In addition to the above measures it is also important to recognise that all works will be undertaken in the dry season and this will significantly reduce the potential for construction impacts associated with erosion and scour. After construction, the banks will be stabilised and vegetation allowed to establish.
11.4 Haul Road Drainage

As discussed in Section 11.3 of the Supplementary Report, Metro Mining has committed to design scour protection in accordance with Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways (Refer Section 11.4 of the Supplementary Report). These scour provisions may include:

- Maintenance of vegetation buffers at spoon drain outlets to intercept sediments prior to flow entering receiving waters;
- Rock dissipation aprons to return concentrated flow in spoon drains to sheet flow where drains are turned out to vegetated areas; and
- Check dams, geofabric and other liners where high velocities develop in roadside drains.

Regarding the sizing of the drains the following provides further information to that provided in the EIS. The size of the roadside drains are largely dictated by the depth of flow at the culvert crossing locations (i.e. the drain invert cannot be below the culvert invert level). The culvert designs are likely to be based on either 900 mm circular type or 1,200 x 1,200 box type. Therefore, the maximum drain depth cannot be more than approximately 1.5 m (900 mm + 600 mm cover or 1200 mm + 300 mm cover). The dimension of the drain will be dictated by the flow that must be transmitted and the gradient of the road. Typically speaking, a roadside drain will be a trapezoidal drain with a 1-4 m base width and depth from 0.3 m to 1.5 m.

Spoon drains may also be turned out to vegetated areas if velocities are shown to be too high. The exact locations of the spoon drains will not be known until the horizontal and vertical haul road alignment is finalised. If there is not sufficient vegetation to stabilise sediment loads discharging from spoon drains, dissipating rock aprons can be installed to return the concentrated flow to sheet flow. A commitment has been made to design these structures in accordance with Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways. Typical measures reduce erosion and scour potential are discussed in Section 11.3 of the Supplementary Report.

In general, box culverts will be installed at waterway crossing locations. If, however, circular culverts are installed on an overbank region (refer Figure 11-3), requiring placement of fill, drainage from the road surface will be directed to the ends away from the waterway. Silt traps or check dams will be installed at the end of the drains and the flow will be directed towards natural vegetation buffers thereafter to further trap sediment. This measure may not apply for box culverts where no cover fill is required i.e. the road surface is formed by the concrete culverts and link slabs.

11.5 Haul Road Inundation Period

EHP requested further information regarding the likely duration of flooding at the site and more specifically how long the port infrastructure may be inundated and for how long the haul road to the port may be unpassable for the 100 year ARI event. With the decision to utilize the approved SRBP MIA and BLF, and existing SRBP main haul road, the risk of inundation has largely been eliminated.

The east-west BH1 haul road is only inundated at waterway crossing locations i.e. has immunity from the PMF event rising from the Skardon River; however, at waterway crossings a two year ARI or bankfull discharge immunity has been conceptualised. The flood immunity of the crossings can be increased; however, this is not proposed due to the minor impact of flooding to dry season.
operations and nil impact on wet weather access to port facilities due to no connectivity between the east-west BH1 haul road and the MIA.

The mine is only operational during the dry season and thus operational impacts associated with inundation at crossing locations has little potential operational impact. The preferred waterway crossing solution is therefore focused on reducing environmental impacts. Crossings are conceptualised to pass low flows up to bank full discharge through the culvert crossing, which reduces the haul road elevation and associated filling within the waterway. Flows above bank full discharge will pass over an engineered floodway arrangement (refer to Figure 11-3) to minimise scour and sediment transport, and impacts to flooding.

### 11.6 Haul Road Flood Design

In general, roads are constructed at grade and the risk of flooding the road managed through the incorporation of roadside drains. The roadside drains both collect runoff from the road surface and intercept sheet flow from external catchment prior to runoff flowing across the road. The roadside drains direct water to culvert locations at haul road watercourse crossings where runoff can be discharged to receiving waters and scour potential appropriately managed. If excessive flows or velocities develop in a roadside drain prior to a culvert crossing, the drain will be turned out to a vegetated area via a spoon drain and the concentrated flow returned to sheet flow. This approach reduces the amount of embankment construction required and the amount of disturbance required by opening a borrow pit to source embankment material.

The detailed design of the road is yet to be completed; however, the culvert crossings have been sized for a two year ARI flood event and the floodway arrangement conceptualised. There is also a commitment for scour protection measures at crossing locations to be in accordance with Austroads. The commitment made in the EIS is to use best practice road design in combination with adopting a lower flood immunity for the road at watercourse crossings, which reduces the barrier to flood flows caused through construction of the road.

The impacts associated with haul road crossings represent that excessive flood afflux, scour and sediment transport are possible due to filling within the watercourse and via flooding over the road. The management measures prescribed in the EIS (Table 11-14) include:

- Construct low flow culvert and floodway arrangements at drainage crossing locations to reduce impact on flood afflux; and
- Incorporate scour protection measures to culvert and floodway structures to be consistent with Austroads Guidelines and as per the ESCP.

Section 11.9.1 of the EIS details the management and mitigation measures further.

### 11.7 Bridge Structures

Metro Mining has stated in the EIS (see Section 11.5.2 of the EIS) that it will not operate during the wet season and as such the need to maintain wet season accessibility through the haul road crossings is not required, consequently no bridge structures were ever proposed for the Project. A table (Table 11-3 in the EIS) showing potential culvert sizing required to provide wet season immunity identified two areas where a bridge structure would be required, and had wet season access been required, a bridge structure would have been considered. However, given the decision to utilize the SRBP MIA, BLF, RoRo and main haul road there is no requirement for any bridge structures to be considered for the Project.
11.8 Regulated Structures

No regulated structures proposed for the Bauxite Hills Project.

11.9 Cumulative Impacts

Section 11.8 of the EIS determined that the development of both the Project and the SRBP within the Skardon River catchment had little to no measurable cumulative impact on flooding. This was due to:

- The flood wave that causes peak inundation and velocities shown in Section 11.4.2.3 of the EIS arises from catchment runoff further upstream of the developments, which is unaffected by mining;
- The location of both the Bauxite Hills Project MIA and SRBP MIA outside PMF inundation extents;
- The negligible impact of the BLF and RoRo facility on flooding due to the insignificant change to flood conveyance or floodplain storage;
- The location of mining pits above the Skardon River PMF inundation extents; and
- The Project’s approach to install low flow culvert crossings that minimise filling within waterways and therefore minimise the associated barrier to flood flows.

The EIS concluded that:

There is therefore no likely cumulative impact on flooding within the Skardon River as a result of the developments.

Since development of the EIS, Metro Mining has taken the decision to utilise the SRBP MIA and BLF rather than construct separate stand alone MIA and BLF infrastructure. This decision to utilise the approved SRBP infrastructure results in reduced cumulative impacts to flooding by eliminating the standalone MIA, BLF and RoRo development. Furthermore, Metro Mining will utilise the existing SRBP main haul road and has relocated the BH1 haul road to higher plateaus, which has the effect of reducing impacts to flooding by:

- Eliminating haul road crossings and maintaining existing vegetation within the tidal zone;
- Providing flood immunity up to and including the 100 year ARI event; and
- Allowing construction of shorter crossings through well-defined channels, thus producing a reduced potential restriction to flood flows.

The approved SRBP includes a crossing of the Namaleta creek as well as mine pits within the Namaleta Creek catchment, with only minor impacts to flood behaviour predicted. The Project accommodation camp and mine pit excavations are within the elevated areas of the Namaleta Creek catchment and near the divide with the Skardon River catchment. The Project does not propose any development within the Namaleta Creek floodplain area. There is therefore no cumulative impact on flooding predicted for the Namaleta Creek as a result of both developments, although the SRBP will impact on flooding in this region.

The use of the SRBP MIA for the Bauxite Hills Project removed the requirement for a separate standalone MIA. Consequently, there will be no cumulative impacts to assess in regard to potential regulated structures such as the originally proposed Bauxite Hills sediment ponds.