25 January 2010

BROKEN HILL OPERATIONS PTY LTD

Rasp Mine - Surface Water Management Plan

Submitted to:
Broken Hill Operations Pty Ltd
Rasp Mine
130 Eyre Street
Broken Hill, NSW 2880

REPORT

Report Number: 097626108-003-R-Rev0

Distribution:

2 Copies - Broken Hill Operations Pty Ltd
1 Copy - Golder Associates Pty Ltd

A world of capabilities delivered locally

Golder Associates

Table of Contents

TABLES

FIGURES

APPENDIX

1.0 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) commissioned Golder Associates Pty Ltd (Golder) to prepare a Surface Water Management Plan (SWMP) for the proposed mining operations at the Rasp Mine located on Consolidated Mine Lease 7 (CML7) in Broken Hill, NSW. The SWMP will form part of the Part 3A application for approval from the NSW Department of Planning (DOP) and addresses the Director General's requirements as set out in the letter *Reference 07_0018* dated 29 March 2009 from DOP.

This report presents the details of the SWMP, including the recommendations for surface water management. The SWMP is based on the observations made during a detailed site visit and several discussions held with the BHOP staff. The SWMP identifies various stormwater management measures that are required on the mine site to facilitate operational and environmental management objectives. This report was prepared in general accordance with our proposal (Golder ref. 097626108-002, dated 23 October 2009), including additional requests arising from review and consultation during the preparation of this report.

2.0 SITE DESCRIPTION

The Rasp Mine lease (CML7) is located within the Broken Hill urban area. The mine site is bounded by Menindee Road to the north east, Holten Drive and Eyre Street to the south, South Road (Silver City Highway) to the west and Crystal Street to the north. Mining activity has been carried out on site for over 120 years and the entire site has been disturbed with little or no remnant native vegetation. The mine location is shown in Figure 1.

The mine is located at a high point in the regional topography and is a prominent feature in the town of Broken Hill. Most of the site is raised from the adjoining area in the form of an extensive mound, formed from waste rock storages. The site elevation in the west is approximately 340 mAHD and drops to approximately 307 mAHD near the South Road. The site elevation varies from 340 m AHD in the east to 323 mAHD in the west, approximately 23 to 32 m higher than the surrounding areas. Mount Hebbard is approximately 31 m high, the Old Tailings Dam is approximately 12 m high and the Miners Memorial is approximately 43 m above the Crystal Street level.

The total area of CML7 is approximately 346.3 ha. There are several surface exclusion zones within CML7. These exclusion zones are approximately 120.5 ha and are shown in Figure 1. BHOP is not responsible for surface water management in these exclusion zones and as such the proposed SWMP does not include management measures in the excluded areas.

The remaining 225.8 ha of the CML7 area for which this SWMP has been prepared includes 44.6 ha of either rehabilitated areas or areas unaffected by mining activity (Figure 1).

In addition there are a number of other occupiers conducting businesses within the area covered by this SWMP (225.8 ha) in CML7, these include:

- The Broken Earth Café;
- Miners Memorial;
- Communications tower;
- Tourists activities at Browns Shaft and Block 10 Lookout;
- Line of Lode Association buildings and residences; and
- Olive plantation.

The SWMP has accommodated the occupiers that contribute runoff to the proposed drainage features or are within the active mine site. Some of these occupiers are located outside of the active mine site on unaffected areas and were not accounted for in the SWMP. These occupiers include:

- Tourists activities at Browns Shaft and Block 10 Lookout;
- Line of Lode Association buildings and residences; and
- Olive plantation.

Under existing conditions, the design 100 year rainfall runoff event from the active mine area (approximately 181.2 ha) is contained within the site. Due to topography and existing drainage, parts of the exclusion zones contribute runoff to the active mine area. This area is approximately 5.7 ha and is included in the active mine area, bringing the total area for runoff containment to 186.9 ha. The rehabilitated area or the area unaffected by mining activities (approximately 44.6 ha) does not require stormwater containment. For events that are rarer than the 100 year event, the runoff from the site would overflow to drainage systems surrounding the mine. Overflow from Horwood Dam (200 year rainfall event) would enter a drainage swale adjacent to a quarry. Runoff along the northern site boundary will be contained in a northern drain up to the 100 year storm event. During rarer events greater than 100 years runoff would overflow onto the railway yard.

It is worthwhile to note that there has been no mining activity on site since 1991. Since then the mine site has experienced a 100 year storm event in 1992 and a 50 year storm event in January 1998. The existing measures on site including stormwater retention ponds have performed well during these events. No adverse impacts on the surrounding environment from these two events have been reported.

3.0 PROPOSED MINE OPERATIONS

The proposed mining operations in CML7 comprise underground mining of the Western and Centenary Mineralisation and remnant mining of the Main Lode. Underground mining will be accessed via a portal and decline from the base of the Kintore Pit. Ore would be transferred by trucks to the ROM pad and processing area located east of the pit. It is also proposed to construct and operate a minerals processing plant located in the south west corner of the Lease and two tailings storage facilities: TSF 1, a lift to the Old Tailings Storage, and TSF 2 deposition into Blackwood Pit. The layout of the proposed operations, including roads are shown in Figures 2 to 5.

The life of the tailings storage facilities has been estimated (*Tailing Storage Facility Feasibility Design* (Golder, 2009)) at 4.25 years for TSF 1 and 5.75 years for TSF 2. This SWMP has been prepared to address conditions during the first 4.25 years of the new mining operations and hence Blackwood Pit has been used as a storage facility to retain stormwater on site. The SWMP would need to be revised prior to the utilisation of Blackwood Pit as the tailings storage facility.

4.0 OBJECTIVES

The main surface water management objectives for the BHOP mining operations are to:

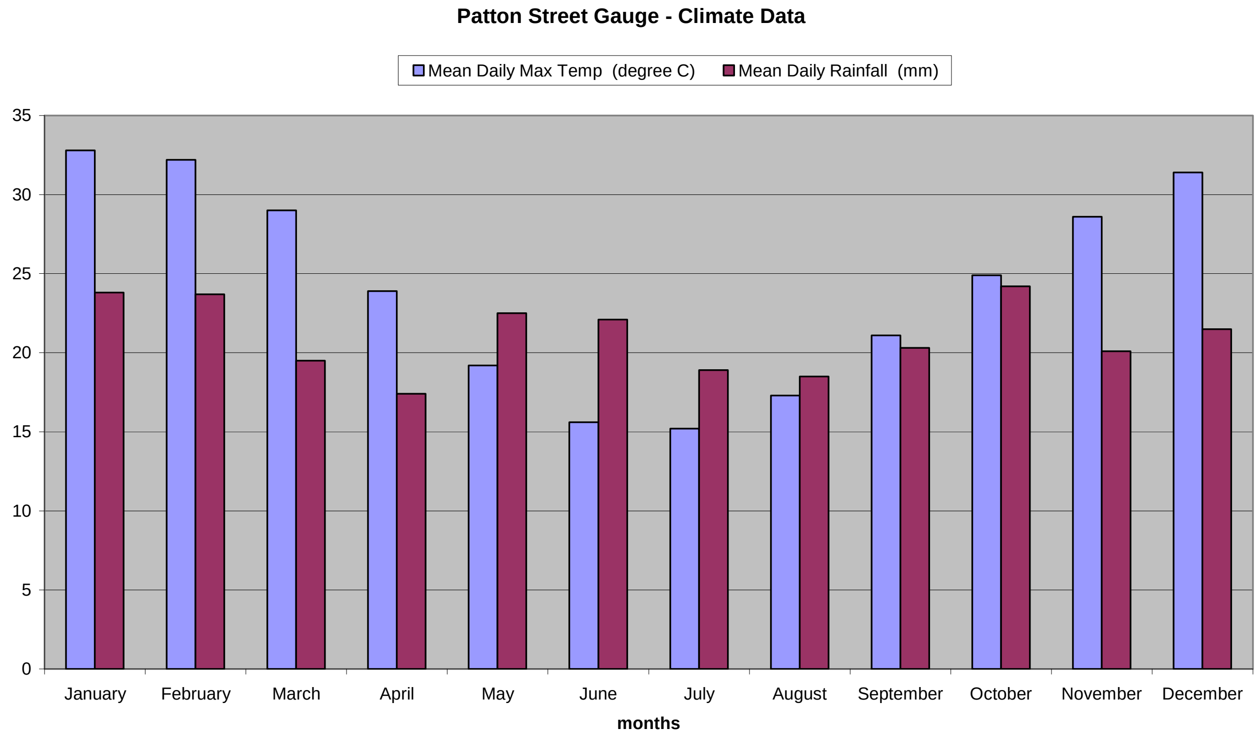
- Prevent discharge of surface waters from active mine areas off-site;
- Minimise disruption to the mining activities and provide a safe working environment; and
- Identify erosion and sediment control measures for the site.

In this regard the relevant state and national guidelines have been followed for best management practices for water management.

5.0 LOCAL CLIMATE

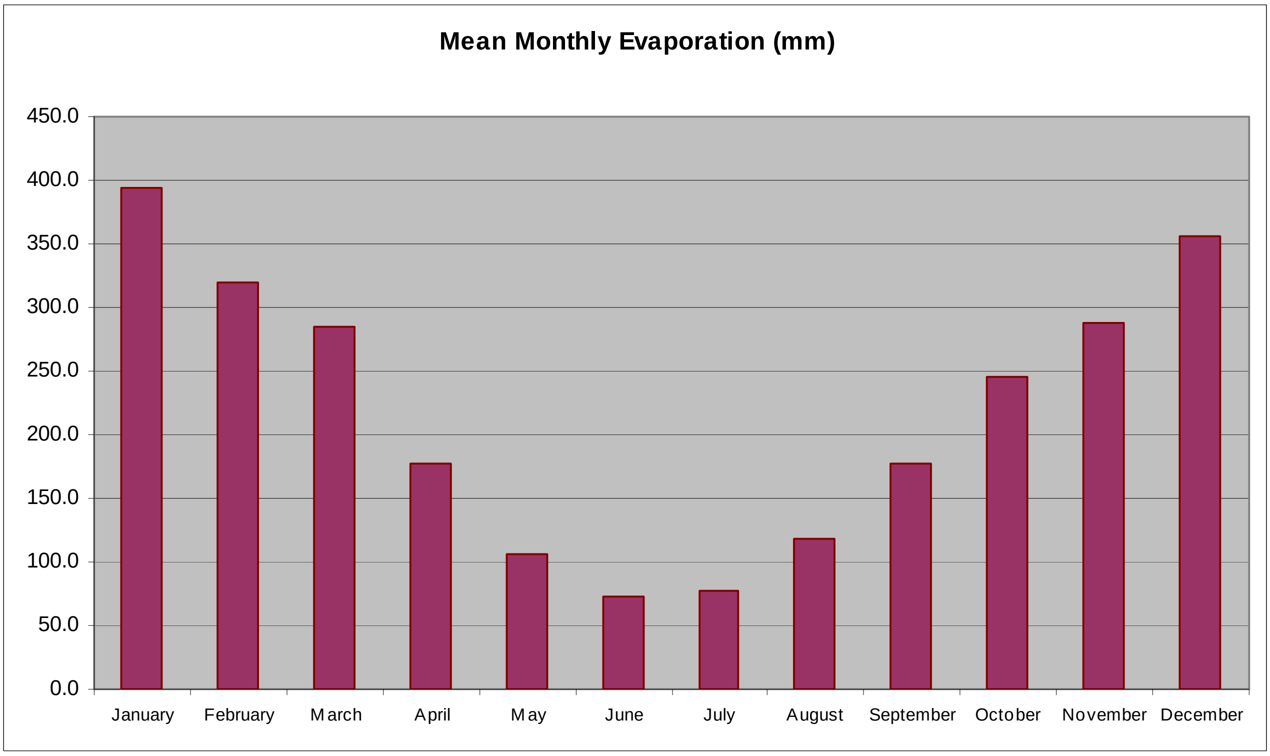
The local climate is arid with an average annual rainfall of approximately 250 mm. A review of the Bureau of Meteorology (BOM) Patton Street Site climate data for the last 120 years indicates that the mean monthly rainfall varies in a narrow band from 17-24 mm during the year. The monthly mean maximum temperature varies from approximately 33°C in January to 15°C in July. The following graph shows the monthly variations for rainfall and temperature.

Graph 1: Mean Monthly Rainfall and Temperature for Broken Hill



The average annual evaporation is approximately 2,614 mm. This estimate has been derived from the BOM data gathered at Stephens Creek Reservoir (Station No. 047031) which is approximately 16.7 km east of Broken Hill. The evaporation rate varies from approximately 11.5 mm/day in December to 2.4 mm/day in June. The monthly variations for evaporation are presented in Graph 2.

Graph 2: Mean Monthly Evaporation for Broken Hill



Evaporation far exceeds the rainfall in the Broken Hill area. The mean monthly evaporation is more than 16 times the mean monthly rainfall in January and approximately 4 times in July.

5.1 Design Rainfall Data

The design rainfall data was sourced from the BOM and is presented in Table 1 below.

Table 1: Rainfall for Various Design Events

DURATION	Rainfall (mm)			
	10 years ARI [1]	**20 years ARI**	**50 years ARI**	**100 years ARI**
30Mins	23.7	28.3	34.5	39.3
1Hr	30.9	36.8	44.9	51
2Hrs	38.2	45.6	55.8	64
3Hrs	42.6	51	62	71
6Hrs	51	61	75	86
12Hrs	61	73	90	104
24Hrs	73	87	108	124
48Hrs	83	101	124	142
72Hrs	87	105	130	149

Note: 1. ARI = Annual Recurrence Interval

The data for the 100 year ARI was used in the catchment analysis carried out for the preparation of the SWMP.

6.0 SURFACE WATER MANAGEMENT GOALS

The existing landform on site and the arid climate conditions provide unique opportunities to develop a SWMP that satisfies the operational requirements of the mining activity and prevents release of runoff from active areas of the mine site.

The primary feature of the proposed SWMP is the provision of small ponds/storages, spread throughout the mine site, that temporarily hold surface water runoff. Due to high evaporation rates, this runoff would be expected to evaporate in a relatively short period following storm events. This arrangement prevents runoff from leaving the active mine site and allows the suspended particles to settle in the ponds/storages, allowing better management of contaminated sediment on site.

A set of goals have been identified to guide the preparation of this SWMP. These goals are described below:

- Retain runoff from a 100 year ARI rainfall event from all active mine areas. The high evaporation rate would allow retained water to evaporate in a relatively short period. This goal will minimise impact on the downstream environments.
- Retain runoff locally in small ponds/storages at various locations on the mine site, utilising the existing landform where feasible. This would:
  - eliminate the need to construct a large storage and avoid hazards associated with large storages;
  - help in the sedimentation process that would remove suspended solids from the runoff; and
  - minimise erosion potential by eliminating the requirement to carry large discharges to a smaller number of large storages.
- Provide appropriate spillways for the local ponds to convey flows greater than the 100 year runoff event.
- Use BHP Pit and Blackwood Pit for discharge of local catchments. This would minimise the need to construct a large storage.
- Use the available capacity of Horwood Dam to contain the 100 year runoff event from various subcatchments that report to this dam.
- Divert runoff away from Kintore Pit to minimise the flooding risk in the pit and to minimise the impact on mining operations (as the portal and decline for the proposed underground operations are located in the base of Kintore Pit)
- Divert runoff away from Little Kintore Pit to storage S17 to minimise the risk associated with unregulated discharge down the unused shaft
- Provide sediment control ponds in the active mine processing area to minimise the movement of contaminated runoff to local downstream storages. This measure would provide the first level of protection for control of contaminant movement to Horwood Dam. A second level of protection would be provided by the downstream ponds/storages where sedimentation would allow further stripping of the contaminants from the runoff.
- Provide appropriate sediment and erosion control measures on site. Prevention of erosion on site will minimise the production of loose sediment that may otherwise become airborne and create a dust hazard for the surrounding urban area. This measure would be further assisted by the air quality monitoring program at the site.

The above goals provide the necessary criteria for the development of the SWMP.

7.0 PROPOSED DRAINAGE LAYOUT

The proposed drainage layout is based on the criteria presented above. Provision has been made to safely discharge a higher intensity event by providing spillways for various storages. The locations of spillways are marked on the proposed drainage layout (Figures 2 to 5).

Based on the runoff management criteria, the mine site was subdivided into small catchments enabling where possible for the runoff from each catchment to be retained within the catchment by providing bunding along its boundary. Where feasible the runoff from these catchments is diverted to the BHP Pit and Blackwood Pit. A catchment analysis is presented in Section 7.2 that provides details of the runoff management for various catchments. Table 2 and Figures 2 to 5 provide the details of these catchments.

Table 2: Catchment Details

Catchment No.	Storage/Description	Area (ha)	Runoff Volume (m^3)
Kintore Pit		13.95	10,230
Little Kintore Pit		2.42	1,800
1A	S1A	3.48	2,550
2	ROM (S2)	6.53	4,790
4		1.33	980
3		0.48	350
1	Large Drain	4.32	3,170
5		1.57	1,150
6		1.55	1,140
7		1.10	810
10		7.15	5,240
8	S8	0.89	650
9A	S9A	0.61	450
9B	S9B	0.59	430
11A	S11A	1.78	1,310
11B	S11B	1.90	1,400
12	S12	0.55	400
13A	S13A	6.27	4,600
13B	S13B	1.39	1,020
18	S18	1.45	1,060
14	Drain/sediment retention ponds	2.07	1,520
15		0.63	460
16		0.83	610
17	S17	2.41	1,770
37		2.66	1,950
39	S39	1.90	1,390
40	S40	0.38	280
42		5.06	3,710
20A		6.94	5,090
20B		1.80	1,320
Horwood Dam		5.39	3,950
19	Mt. Hebbard	5.18	3,800
21A		1.14	840
21B		1.80	1,320
22		4.14	3,040

Catchment No.	Storage/Description	Area (ha)	Runoff Volume (m^3)
23	S23	1.43	1,050
23A		1.70	1,250
24		1.46	1,070
25	S25	3.62	2,660
26	S26	1.58	1,160
27		1.08	790
28		2.40	1,760
32		1.92	1,410
34		2.65	1,940
36		2.28	1,670
BHP Pit		6.19	4,540
29		2.52	1,850
31B	Drain	1.54	1,130
31A	S31A	2.96	2,170
30		1.23	900
47		2.60	1,910
46		1.01	740
33		1.91	1,400
35	S35	6.13	4,490
43	S43	1.09	800
38		4.02	2,950
41		1.85	1,350
Blackwood Pit		15.04	11,030
44	S44	3.86	2,830
45	S45	1.00	740
TSF 1		11.61	8,520
Decant Dam		0.59	430
TOTAL		**186.9**	

7.1 Runoff Estimation

The proposed drainage concept is based on retaining the runoff volumes from a 100 year ARI rainfall event from active mine areas. The runoff volumes are dependent on the soil types present on the mine site and their infiltration capacity. High traffic areas or areas subject to other activity that causes compaction of the soils would generally produce greater runoff volumes. However, other areas, in particular the depressions in various subcatchments have developed a hard clay layer due to sediment deposition in regular rainfall events, and is likely to be equally resistant to infiltration. Hence, for the purpose of catchment analysis, a single soil type has been considered.

Before runoff can occur, a portion of rainfall is lost to infiltration. This rainfall loss is termed as ‘Initial Loss’. As the runoff develops, the infiltration continues during the rainfall event, albeit at a smaller rate. This rainfall loss is termed as ‘Continuing Loss’. For design rainfall events such as the 100 year ARI event, the Australian Rainfall and Runoff (AR&R; Engineers Australia, 1987) recommends that an Initial Loss of 15 mm and a Continuing Loss of 4 mm/hr should be adopted for arid zones of New South Wales. However, previous studies by John Miedecke and Partners (October, 1993) have established an initial loss rate varying from 10 to 20 mm and a Continuing Loss rate of 2 mm/hr from the analysis of the December 1992 storm event at the Rasp mine, this event was close to the 100 year rainfall event. The rainfall loss guidelines provided in AR&R are general in nature and are applied over a wide area. John Miedecke and Partners (October, 1993) analysed a local storm and derived the rainfall losses based on the observed flood behaviour on site. Although this analysis was not conclusive, it still provides a better estimate than the general guidelines provided by AR&R. Based on this the rainfall losses as determined in the October 1993 report have been adopted i.e. an initial loss of 10mm and a continuing loss of 2mm/hr. The adopted loss rates are deemed to be conservative and would provide a safety factor for the runoff estimates undertaken for the SWMP.

The adopted loss rates were used in conjunction with the design rainfall (Table 1) to derive the rainfall excess or the volume of runoff from each catchment. The rainfall excess for the 100 year event is presented in Table 3.

Table 3: Design Rainfall Excess for 100 Year Event

DURATION	Rainfall Excess (mm)
30Mins	28.3
1Hr	39.2
2Hrs	49.6
3Hrs	55.4
6Hrs	64
12Hrs	70
24Hrs	***73***
48Hrs	67
72Hrs	62

The critical duration for the 100 year event is the one that corresponds to the largest rainfall excess and hence the largest volume of runoff. For the 100 year event, the critical rainfall excess occurs for the 24 hour event and is equal to 73 mm (highlighted in the above table).

7.2 Catchment Analysis

The catchment layout generally conforms to the existing landform. Where practical, a catchment area has been reduced to minimise the requirement of storage within the catchment. Generally the entire catchment acts as storage for the design rainfall event. For large catchments or catchments where significant mining activities are to be undertaken, dedicated water storages have been recommended. Table 4 summarises the required storages for various catchments. The existing capacity of the storages listed in Table 4 and the capacity of all drainage pipes will be assessed prior to final design. If required, storages will be desilted to obtain the required capacity. The integrity of bunds surrounding storage areas will also be assessed. The following sections provide details of the catchments with regard to runoff management, and recommendations to enhance management of runoff. The recommended management measures can be modified on site for ease of construction based on topography and site conditions, while maintaining the integrity of the proposed drainage concept.

Table 4: Storage Requirements

Pond	Reporting Catchments	Runoff Volume for storage (m^3)	Surface Area of storage (m^2)	Depth of Inundation (m)	Height of required bunding (m)	Comment
S1A	1A	2,550	16,000	0.2	0.5	
West Drainage Ditch	1,3,4	4,500	NA	NA	NA	Overflows to Storage 1A in events exceeding the 1:100 year
S2	2	4,790	7,970	0.6	0.9	Overflow reports to S12
S8	8	650	1,100	0.6	0.9	
S9A	9A	450	610	0.7	1.0	Overflow reports to Storage S9B
S9B	9B	430	1,090	0.4	0.7	
S11A	11A	1,310	6,800	0.2	0.5	Overflow reports to Storage S12
S11B	11B	1,400	3,680	0.4	0.7	Overflow reports to Storage S12
S12	12	400	2,620	0.2	0.5	Overflow reports to Storage S13A
S13A	13A	4,600	10,140	0.5	0.8	Overflow reports to S17
S13B	13B	1,020	4,810	0.2	0.5	Overflow reports to the drain along Little Kintore Pit
S17	5,6,7,10,14,15,16,17,18	Note 2				Overflow reports to Horwood Dam
S18	18	1,060	1,610	0.7	1.0	Runoff from this catchment would overflow into Storage S17
S21A	21A	840	8,100	0.1	0.4	
S22	21B,22	4,360	9,370	0.5	0.8	
S23	23	1,050	620	1.7	2.0	Runoff from this catchment would overflow along a drain adjacent to the railway
S25	24, 25	3,720	6,000	0.6	0.9	
S26	26	1,160	1,600	0.7	1.0	Overflow reports to BHP Pit
S29	29,30	2,750	5,110	-	-	Storage S29 is located on exclusion zone. No works required
S31A	31A, 31B, 47	5,210	6,160	0.8	1.1	
S35	33,35	5,900	20,280	0.3	0.6	Needs -regrading. Overflow reports to Blackwood Pit
S39	39	1,390	3,640	0.4	0.7	Overflows to eastern drain then to Horwood Dam
S40	40	280	1,620	0.2	0.5	Overflows to eastern drain then to Horwood Dam
S43	43	800	2,310	0.3	0.6	Overflow reports to Blackwood Pit

Pond	Reporting Catchments	Runoff Volume for storage (m^3)	Surface Area of storage (m^2)	Depth of Inundation (m)	Height of required bunding (m)	Comment
S44	44	2,830	2,840	1.0	1.3	Excavation will be required to create this storage
S45	45	740	2,710	0.3	0.6	Overflow from this area will report to Storage S44
S46	76	740	1,340	0.6	0.9	
Mt Hebbard	19	3,800	18,290	0.2	0.5	Overflow reports to S22
BHP Pit	27,28,32,34, 36,BHP	12,110				
Blackwood Pit	38,41, Blackwood	15,330				
Horwood	20A, 20B, 37, 39, 40 and 42	Note 3				

Note:
1. The surface area for the storages has been estimated based on preliminary investigation of the site. If during construction of these storages larger surface area is accommodated, the required depth will reduce which can be estimated from the above table.
2. S17 storage estimations are provided in Section 7.3
3. Horwood Dam storage estimations are provided in Section 7.3

7.2.1 Western Catchments

Catchment 1A, 1, 3 and 4

Catchment 1 consists of the area that contains the slope along the western raised landform (Figure 2). The runoff from this area is captured in an existing drain (West Drainage Ditch) at the base of the raised landform. The integrity of this drain will need to be assessed to convey the 1:100 ARI storm event through a box culvert under the railway as shown in Figure 2 to Storage S1A that has the capacity to retain a 1:500 rainfall event from catchments 1A, 1, 3 and 4. A spillway from this water storage area will allow water to leave the site during rainfall events greater than approximately 1:500 ARI. The available storage of S1A is estimated using topographic mapping and will require confirmation prior to spillway construction.

Catchments 3 and 4 are minor catchments in the south-western corner of the site. These catchments will not be disturbed by mining activities and runoff from this area will be diverted to the same drain that Catchment 1 runoff reports to.

Required works include:

- Clean and check integrity of current ditch drain along the toe of the south-western raised landform.
- Grade Catchment 1A to retain overflow from ditch drain and install bunding, with spillway, around the ‘four pipes’.

Catchment 8, 9A and 9B

Catchments 8, 9A and 9B are located at the south-western corner of the site (Figure 2). Catchment 8 has an existing low lying area. It is recommended that this area be re-graded to form a storage area for this catchment (S8). Catchment 9 is divided into two areas (9A and 9B) and currently provides water storage in small depressions within both catchments. It is recommended that the capacity of the current two water storage areas be assessed and desilted if necessary to meet the retention requirements as outlined in Table 4. Runoff in this area is currently maintained by bundling along the boundary of the Lease. It is recommended that the integrity of this bunding is reviewed and repaired if required.

Required works include:

- Regrade Catchment 8 to form the storage area.
- Check capacity of current storages S9A and S9B and desilt if required.
- Check integrity of boundary bunding and repair if required.

Catchment 2, 5, 6, 7 and 10

The processing plant will be located at the south-western end of the site (Figure 2). Stormwater runoff in this area must be diverted away from the active area to minimise disruption to processing activities. Catchments 2, 5, 6, 7 & 10 are all within this process area. The runoff from these catchments is also likely to be highly contaminated. Sediment control ponds would therefore be required to capture the fines. Except for Catchment 2, all other catchments would ultimately discharge to Horwood Dam through the drainage network and water storage S17. The sediment ponds and associated drainage will be designed as part of the processing plant detailed design. Suggested drainage and sediment ponds are indicated in Figure 7.

The runoff in Catchment 2 will be diverted to a proposed pond (S2) on the western side of the catchment. This area will need to be re-graded to obtain a slope towards the proposed pond area. It is recommended that a spillway and drain be installed from S2 to Catchment 13A.

Required works include:

- Grade the area in Catchment 2 to create a new water storage area S2.
- Install a new drain and spillway from S2 to Catchment 13A.
- Install a new culvert between Catchment 10 to Catchment 14
- Water management features to provide for sediment control will be addressed in the detailed design for the processing plant.

Catchment 11A, 11B, 12, 13A, 13B and 14

Catchment 13B discharges into Catchment 13A (Figure 2). Catchment 13B will require re-grading when the proposed service road is constructed. To retain stormwater in this area it is proposed that a small pond be located within the loop (S13B) of the road as shown on Figure 2. The water from S13B will discharge to the drain along Little Kintore Pit. Catchments 11A, 11B and 12 (Figure 3) will have small ponds (S11A, S11B and S12) to capture local runoff. Once these ponds are full they will overflow to the existing drain which will deliver the water into the sediment retention ponds in Catchment 14.

Catchment 11B lies to the east of the haul road along the north-west boundary of the Kintore Pit. Storage will be provided in this catchment to prevent discharge into the Kintore Pit. Any overflow from this catchment would be diverted to Catchment 12.

Catchment 14 consists of the area south of Little Kintore Pit. It is recommended that two sediment retention ponds be constructed within this area which would receive runoff from the processing area and provide additional sediment control. The sediment retention ponds will be a series of two ponds connected via an overflow drain and discharge into S17 in Catchment 17. The existing vegetation within the sediment retention ponds will remain to prevent erosion and facilitate sediment deposition.

There is an existing drain along the western edge of Kintore Pit which currently discharges to Little Kintore Pit. This drain will be upgraded to convey the 100 year storm runoff from catchments 13A, 13B and 14 and made to discharge the runoff into the sediment retention ponds within Catchment 14. The sediment retention ponds will discharge to S17. An existing spillway into Little Kintore Pit will need to be removed to divert drainage from Catchments 13A, 13B and 14 away from the Little Kintore Pit and into the sediment retention ponds. Two existing pipes will also need to be removed or plugged to prevent drainage from sediment retention ponds flowing into Little Kintore pit.

Required works include:

- Regrade catchment 13B to retain stormwater.
- Construct sediment retention ponds to provide additional sediment control and maintain existing vegetation.
- Remove existing spillway into Little Kintore Pit and divert drainage to sediment retention ponds.
- Install culvert across the service road in Catchment 14.
- Plug or remove the two existing pipes between the sediment retention ponds and Little Kintore Pit.

Catchment 15, 16, 17, and 18

Catchments 15, 16 and 17 (Figure 2) all contribute runoff directly into S17. Catchment 18 contains a low point which ponds prior to discharging to S17. The overflow from S17 will run down a proposed channel to be constructed along the base of Mt Hebbard and toe of the Old Tailings Dam (TSF1) to Horwood Dam. This channel will have the capacity to convey the 100 year storm runoff, see Section 7.3. The channel would be wide enough to be used as an access roadway during dry periods.

Required works include:

- Install culverts in Catchment 15 and Catchment 16 to direct runoff to S17.
- Assess current bunding of Catchment 17 to meet water storage requirements as listed in Table 4 and maintain the integrity of the tank located within the Catchment area.
- Install a channel and spillway at the south-east corner of Catchment 17 to convey water to Horwood Dam.

7.2.2 Central Catchments

Catchment 19, 20A, 21A, 21B and 22

Catchments 19, 21A, 21B and 22 will contribute runoff to S22 located in Catchment 22 (Figure 3). Catchment 19 comprises of Mt Hebbard and has a bunding around the top of the mound, which can contain the runoff from the 100 year 24 hour storm event. Overflow from the top of Mt Hebbard will discharge to S22.

Catchment 21A will store the 100 year 24 hour storm event and will overflow into Catchment 21B for larger events. Catchment 21B will report to a drain on the western side of the haul road and then via a pipe or causeway to storage S22.

Required works include:

- Construct new drains / pipes or causeway along Catchment 21B and Catchment 22 to direct water into S22.

Catchment 23, 23A, 24 and 25

Catchment 23 is a small catchment along the northern edge of the mine site, north of Kintore Pit. Runoff within this catchment will pond in S23 prior to discharge into the northern drain (Catchment 23A) onsite which is adjacent to the railway. The capacity of S23 and the onsite drain will be assessed and measures will be taken to obtain the required capacity for a 100 year storm event.

Catchment 24, located at the north-east corner of Kintore Pit (Figure 3), currently discharges into this Pit. For safety reasons it is recommended that this area is re-graded away from the active Pit towards Catchment 25. This can be accomplished when the proposed haul road is constructed. This will involve lowering of the proposed haul road elevation and filling of the area adjacent to the Pit. A culvert will be required to convey the flow from Catchment 24 into Catchment 25 through the road embankment. The runoff from Catchment 25 will report to storage S25 (Figure 3). Overflow from S25 will enter the northern drain adjacent to the railway.

Required works include:

- Install a bund between Catchment 24 and Catchment 21A.
- Fill and regrade Catchment 24 to direct runoff to Catchment 25.
- Install a culvert between Catchment 24 and Catchment 25 to convey runoff.

Catchment 26, 27, 28, 34 and 36

A small area of BHP Pit is currently used for explosive storage. The Pit provides ample capacity for discharge of surface runoff from the surrounding catchments. Catchments 26, 27, 28, 34 and 36 will discharge into BHP Pit (Figure 4). Catchment 26 (Figure 4) will have a proposed pond located at its eastern boundary and the current spillway will direct water into BHP Pit away from the explosives store.

An existing drain is located in Catchment 34 along the approach road to the parking area. This drain has a limited capacity and discharges into BHP Pit. It is recommended that Catchment 34 be re-graded and a spillway be constructed as shown on Figure 4 to avoid excess water being diverted to the existing drain running along the car park approach road.

In Catchment 36 a drain will be required along the road way to capture runoff from the steep slope on the northern side of the road. The haul road will be graded so that runoff from the road will discharge into the proposed drain.

Required works include:

- Regrade catchment 26 to direct water to S26 and install spillway into BHP Pit.
- Assess current storage capacity of S26 to meet requirements in Table 4.
- Regrade and construct spillway from catchment 34 to BHP Pit.
- In catchment 36 install a drain along the road and regrade to direct runoff to the proposed drain.

Catchment 32

The parking area for the Broken Earth Café and Miners Memorial is located in Catchment 32 (Figure 4). This catchment is approximately 30% impervious and under existing conditions discharges into Catchment 34 via a pipe culvert. It is recommended that the discharge capacity of this pipe culvert be assessed to carry a 100 year event. If the capacity is found to be insufficient additional pipes will be installed.

Required works include:

- Assess current discharge capacity of existing pipe from Catchment 32 to Catchment 34, install additional pipe work if required.

Catchment 29, 30, 31A, 31B, 46 and 47

Catchment 29 (Figure 4) drains to the north along the approach road to the car parking area. Catchment 30 consists of the slope area to the north west of the Broken Earth Café and Miners Memorial, which drains to a pond in Catchment 29. The runoff within Catchment 29 currently ponds in S29 which has the capacity to contain the 100 year runoff event. A portion of Storage S29 is located within a surface exclusion area and under existing conditions water naturally overflows down the slope of the landform onto the roadway and towards S31B. An overflow spillway and drain in this area can not be constructed. However, water from the roadway will enter S31A based on existing topography. Catchment 31A directly discharges into storage S31A (Figure 5).

Catchment 47 will be connected to Catchment 31A via an east-west proposed drain along toe of the slope (Figure 5). Catchment 46 contributes to a low lying area labelled as S46. The capacity of this storage will be assessed to obtain the required capacity of a 100yr storm event.

An existing low point located in Catchment 31A (S31A) will be used to store the 100 year storm event runoff from Catchments 31A, 31B and 47. The proposed pond/storage will require excavation to obtain the volume required to store the 100 year event.

Required works include:

- Provide drain in Catchment 47 as shown in Figure 5.
- Assess capacity of S46 and increase capacity, if required. Also assess requirements for fencing of area taking into account local housing.
- Assess capacity of S31A and increase, if required, as per Table 4.

Catchment 33 and 35

Catchment 33 currently discharges into Catchment 35 via two pipe culverts. It is recommended that the discharge capacity of these pipes be assessed to carry a 100 year event. If the capacity is found to be insufficient additional pipes or a spillway will be installed to convey the 100 year flow into Catchment 35. It is also recommended that Catchment 35 be re-graded and bunds be constructed to create a pond (S35) to contain the 100 year storm event from both catchments. The overflow from S35 will discharge to Blackwood Pit for the next few years until the Blackwood Pit is developed as a secondary Tailings Storage Facility (TSF2). Prior to the use of TSF2 the stormwater management in this area will be revisited to direct stormwater runoff away from Blackwood Pit.

Required works include:

- Assess current discharge capacity of existing pipes from C33 to C35; install additional pipe work or spillway, if required.
- Regrade and construct bunding to create pond storage, install a spillway from this pond to Blackwood Pit.

7.2.3 Eastern Catchments

Catchment 38, 41, 43 and 45

Catchments 38, 41 and 43 currently discharge into Blackwood Pit (Figure 5). Catchment 38 is graded towards Blackwood Pit and runoff from this area will pool in shallow areas before eventually flowing over the road and into the Pit. Catchment 43 lies to the east of Blackwood Pit and is relatively flat but contains a small low lying area (S43). The overflow from S43 will report to Blackwood Pit. Runoff from Catchment 41 flows down the road and into the Pit via the old pit haul road. As stated above, prior to the use of TSF2 the stormwater conveyance in these areas will be revisited to direct stormwater runoff away from Blackwood Pit.

Catchment 45 has a pond (S45) that stores water before discharging to Catchment 43 via an existing culvert. The capacity of this storage and conveyance of the existing culvert will be assessed to obtain the required runoff and flow capacity of a 100yr storm event.

Required works include:

- Assess capacity of S45 and existing culvert between Catchment 45 and Catchment 43.
- Increase capacity of S45 and pipe to ensure 100 yr runoff from Catchment 45 is diverted to Catchment 43 and ultimately into Blackwood Pit.

Horwood Dam and Catchment 20A, 20B, 37, 39, 40 and 42

The immediate catchment area of Horwood Dam is approximately 5.39 ha. Catchments 20A, 20B, 37, 39, 40 and 42 all report directly to the Horwood Dam (Figure 4). The combined area of these catchments is approximately 19 ha. The Horwood Dam is the largest storage on the mine site and has a capacity of approximately 29,400 m^3 to an elevation of 299.0 mAHD. This elevation represents 0.5 m of freeboard below the top of the embankment that runs along the Lease boundary. Figure 6 shows the topography of this Dam, the estimated storage volumes are listed in Table 5.

Runoff from storage S17 will be diverted to Horwood Dam via the drainage channel along the toe of the existing Tailings Dam TSF1. Catchment 20A consists of the southern slope of the TSF1 where the runoff will flow down the proposed channel.

Catchment 37 discharges over the road directly into Horwood Dam (Figure 4). Catchments 39 and 40 both have low lying areas which act as storage ponds (S39 and S40, respectively). Overflow from S39 and S40 runs down the slope and into an existing drain to Horwood Dam. The existing drain also acts as an access road during dry periods of the year. Catchment 20B and 42 contain the existing drain and includes the north east batters.

No additional works are required within the catchments listed in this section.

Catchment 44

Runoff from Catchment 44 collects in an existing low lying area labelled as S44 within the catchment (Figure 5). This storage will be assessed to obtain the required capacity for a 100 year storm event. As part of the assessment the bund integrity will also be reviewed.

Required works include:

- Assess capacity of S44 and the bund integrity surrounding the storage.

Catchment TSF1

The future design and storage capacity of TSF1 has been addressed in Golder Associates design report *Tailings Storage Facility Feasibility Design* (Golder 2009). TSF1 is separated into two cells (north and south) by a dividing wall. Under existing conditions the overflow from the south cell currently discharges to S22 and overflow from the north cell discharges to Horwood Dam. During the operational use of TSF1 there will be two stages. During Stage 1 overflow from the north cell will be directed to the south cell and ultimately discharge to S22 during the Probable Maximum Precipitation (PMP) runoff event. During Stage 2 the overflow direction will be reversed and water from the south cell will be directed into the north cell and ultimately into Horwood Dam during the PMP runoff event.

During operations any excess process water, bleed water from the settled tailings and rainfall runoff will collect in a pond on the surface of the tailings storage prior to being pumped to the proposed Decant Dam. Once the TSF1 is decommissioned the facility will have a capacity to contain a 3 hour PMP event. During larger storm events overflow from the TSF1 will discharge to Horwood Dam via an overflow spillway.

7.3 Horwood Dam and Storage S17

The two major storages apart from the BHP and Blackwood Pits are the Storage S17 and Horwood Dam. The Storage S17 lies to the west of Mt Hebbard (Figure 4) and Catchments 5, 6, 7, 10, 15, 16, 17, and 18 report to this storage. The storage capacity for these storages is provided in Table 5 below:

Table 5: Major Storages

Storage	Bunding Elevation	Proposed Spillway Elevation	Storage	
			To the Bunding Elevation	To the Spillway Level
Horwood Dam	299.5	299.0	38,000	29,400
S17	310.6	310.0*	16, 700	9,200

* This level corresponds to the outlet elevation of storage S17

*The estimated bunding and spillway elevations are preliminary and are subject to change during detailed design

7.3.1 Hydrologic Modelling

A hydrologic model was developed to estimate the runoff attenuation provided by the two storages. The model was based on the RAFTS modelling system, which is an industry standard for modelling of runoff-routing processes in a catchment (XP-Software, 2009). Catchments 5, 6, 7, 10, 14, 15, 16, 17, 18, 20A, Horwood, 20B, 37, 39, 40 and 42 were included in the model. Catchment characteristics such as slope, surface roughness, imperviousness and rainfall losses were included in the model. Storage S17 and Horwood Dam were represented as basins in the model.

Model runs were carried out for the standard durations as per AR&R for the 100 year event. Model results indicate that S17 provides significant attenuation of peak flow and can hold a substantial component of the 100 year runoff from the reporting catchments. The peak flow arriving at S17 is approximately 5.6 m^3/s and the peak flow leaving S17 is approximately 0.4 m^3/s. The maximum storage provided by S17 is 10,900 m^3.

Overflow from S17 would be conveyed to the Horwood Dam via a drain, which runs along the eastern toe of Mt. Hebbard and TSF1 and is currently used as an approach road. This drain would also carry the local runoff generated from the eastern slopes of Mt. Hebbard and TSF1 (Catchment 20A). The overflow discharge from S17 is not critical for the design of this drain. The critical discharge in the drain occurs from the local catchment (20A) during the 100 year 1 hr storm event, which is approximately 1.5 m^3/s. The drain has existing side slopes of 2:1 and a 3 m base width, which is sufficient to convey this discharge. The maximum depth which would occur within the drain is approximately 0.33 m, close to the Horwood Dam.

The 100 year runoff reporting to the Horwood Dam is approximately 21,740 m^3. This includes runoff from S17, Catchment 20A, the northern Catchments (20B, 37, 39, 40, and 42.) and the precipitation falling directly on Horwood Dam. The available capacity of this dam is sufficient to hold the 100 year runoff. Figure 6 shows the existing volume of Horwood Dam based on available topographic data.

8.0 EROSION AND SEDIMENT CONTROL

To minimise the risk of contaminant discharge offsite, effective erosion and sediment controls are required on the mine site. These controls would also serve to reduce the production of loose sediment on site, some of which can potentially become airborne and cause air pollution.

8.1 General Considerations

Erosion on the mine site has been successfully controlled by the placement of waste rock capping on slopes and most surfaces. This was part of the site remediation program to minimise dust from the site. Site inspections should continue to identify requirements for repairs. Revegetation has been previously attempted on site and was largely unsuccessful due to wind blown erosion of top soil and low precipitation.

The drainage design proposes a number of ponds/storages throughout the mine site. These ponds would effectively serve as sediment ponds and minimise the contaminant movement through the site. Regular cleaning of these ponds would be required to maintain the required storage for the purpose of surface water management. The sediments can be disposed of in either BHP or Blackwood Pit. Other arrangements can also be made to dispose of this sediment off site, but would require characterisation in accordance with the NSW DECCW (2009) waste classification guideline.

8.2 Process Plant

The process plant will be located on platforms at different elevations. The area surrounding the process plant will be active and produce more contaminated fines compared to the rest of the site. It is recommended that erosion and sediment controls be put in place in this area to minimise the volume of fines reaching the downstream storages including the sediment retention ponds, S17 and ultimately Horwood Dam.

To minimise erosion, a drainage ditch will be required to capture runoff which will run along the east side of the process plant and connect to the proposed eastern drainage ditch via the existing culvert. The proposed drain and erosion control measures are shown on Figure 7.

Relevant guidelines recommend various velocity reducing techniques and erosion control devices. One of the velocity reducing techniques that is recommended are gravel/rock check dams. Gravel check dams will be placed within the proposed drain to both slow down the flow and capture some of the fines. To increase the capture of fines and stabilise the drain, vetiver grass can be planted within the drain. This grass survives in very dry climates.

Within the process area there are two steep drops which occur from one platform to another, as shown on Figure 7. It is recommended that rip rap be placed along the steep slope to minimise erosion. At the bottom of each slope there will be a small depression which will reduce the velocity of the water and be used as a settling pond to settle fines during small storm events. At the junction of the slope and depression, further rip rap will need to be placed as an energy dissipater.

The existing culvert within Catchment 10 will connect the process plant drain to the proposed drain shown on Figure 7. The downstream end of the culvert entering this drain will require appropriate erosion protection such as a rip rap outlet.

The above comments are provided as a guide only as we understand that the stormwater management around the processing plant will be addressed at the detailed design stage of the project.

8.3 Discharge in to BHP and Blackwood Pits

A number of catchments discharge to the BHP and Blackwood Pits. The catchments contributing to BHP Pit during a 100 year ARI event are 27, 28, 32, 24 and 36 with a total runoff volume of approximately 12,110 m^3, as shown in Table 4. Storage S26, within Catchment 26, will be constructed to contain the critical 100 year runoff event. Overflow from S26 will discharge into BHP Pit, the discharge location will require reinforcement using riprap protection at the edge of the pit.

The catchments contributing to Blackwood Pit during a 100 year ARI event are 33, 35, 38, 41, 43 and 45 with a total runoff volume of approximately 15,330 m^3. Storage S35, within Catchment 35, and S43 within catchment 43 will both be constructed to contain the critical 100 year runoff event. Overflow from rainfall events greater than 100 years from S35 and S43 will discharge into Blackwood Pit, the discharge locations will require reinforcement using riprap protection at the edge of the pit.

9.0 SURFACE WATER MONITORING AND MAINTENANCE

The proposed drainage layout prevents runoff leaving the active area of the site up to the 100 year event. The remaining rehabilitated and unaffected areas are undisturbed and do not produce contaminated runoff. Hence contaminated runoff will not be released to the surrounding environment up to this event. For rarer events, any discharge to the surrounding environment is likely to become diluted during large scale flooding outside of the mine lease area. The risk to the receiving environment is therefore minimal.

Based on the above, surface water monitoring is not required at the site.

Regular inspection and maintenance of the stormwater management works, i.e. gravel check dams, rock spillways along the steep slopes, storages and culverts, will be required. The Soils and Construction Volume 1 (Landcom, 2004) recommends that an inspection of the stormwater management works be conducted on a weekly basis. Due to the small amount of rainfall in Broken Hill it is recommended that the stormwater management works be assessed on a quarterly basis and after each storm event. When sediment builds up along the drains and in the culverts it will need to be removed and stored on-site in a contained location.

10.0 RARE RUNOFF EVENT

Runoff from events rarer than the 100 year storm event is likely to discharge offsite into adjacent drainage systems that surround the mine. This overflow can also occur for storages along the boundary of the mine. Some storages have the capacity to hold runoff from events greater than the 100 year. The Horwood Dam, which is the largest storage on site, has a capacity to hold up to the 200 year event where as the storage 1A has a capacity up to the 500 year event.

11.0 RECOMMENDATIONS

The recommendations from the SWMP are summarised below:

- Provide various storages with capacities as defined in Table 5;
- Provide appropriate spillways for various catchments for discharge of runoff greater than 100 year event;
- Assess the bund integrity of various storages and provide adequate measures for safe storage of stormwater runoff;
- Provide erosion and sediment control measures on site;
- Undertake regular inspection and maintenance of drainage infrastructure;
- Provide appropriate measures to reinforce the entry channels that convey discharge to BHP and Blackwood Pits from the surrounding catchments; and
- Provide appropriate freeboard for design of various infrastructures.

12.0 REFERENCES

Engineers Australia: “*Australian Rainfall and Runoff*”, 1987

Golder Associates: “*Tailings Storage Facility Feasibility Design Ref: 087611001-012_R_Rev2* ”, report prepared for Broken Hill Operations Pty Ltd, December 2009.

John Miedecke and Partners: “*Stormwater Management Plan*”, report prepared in association with Water Studies Pty Ltd for Poseidon Mining Investments, October 1993

Landcom: “*Managing Urban Stormwater – Soils and Construction Volume 1 4th Edition*”, March 2004

XP-Software: “*XP-RAFTS Urban and Rural Runoff Routing Application – Version 2009*”, 8-10 Purdue St., Belconnen ACT 2617

Report Signature Page

Your attention is drawn to the document "Limitations", which is included in Appendix A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

M. Kennedy

Melanie Kennedy
Water Resources Engineer

Habib Rehman
Principal Water Engineer

MK,HR/HR,LJ/mk

A.B.N. 64 006 107 857

j:\hyd\2009\097626108 bhop swmp\correspondance\correspondence out\reporting\097626108-003\097626108-003-rev0\097626108-003-r-rev0-stage 2 swmp-final.doc

APPENDIX A
Limitations

LIMITATIONS

This Document has been provided by Golder Associates Pty Ltd ("Golder") subject to the following limitations:

This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, Golder's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
124 Pacific Highway
St. Leonards New South Wales 2065
Australia
T: +61 2 9478 3900