PRIMARY INDUSTRIES
AND RESOURCES SA

ENVIRONMENT IMPROVEMENT PROGRAM FOR THE BRUKUNGA MINE SITE

SUBMITTED IN COMPLIANCE WITH EPA LICENCE N^{O} 10577

Developed August 1999

Submitted November 1999

Prepared by

Mining Operations Unit
MINERAL RESOURCES - PIRSA
Primary Industries and Resources S.A.

TABLE OF CONTENTS

Page No

1. INTRODUCTION 1

2. ENVIRONMENT PROTECTION AUTHORITY LICENCE

2.1 Chronology of Licence Issue...2

2.2 Activities Authorised for the Site...4

2.3 Requirement for the Environment Improvement Program.........................4

3. BACKGROUND

3.1. Site History...4

3.2. Natural Acid Generation...5

3.3. Topographic Erosion and Geological Contribution to Soi 5

3.4. The Defunct Brukunga Mine Site Legacy...6

4. MANAGEMENT AND PUBLIC CONSULTATION

4.1. Brukunga Mine Site Remediation Board...9

4.2. Informal Liaison 10

4.3. Public Meetings...10

5. REVIEW OF CURRENT SITE ACTIVITY

5.1. Plant Operation..11

5.2. Water Interception, Mine-Side 11

5.3. Water Interception, Sand Tailings Side...11

5.4 Review of Historic Pump Operating Records 12

5.5 Water Quality Monitoring 16

6. STRATEGIES FOR ENVIRONMENT IMPROVEMENT

6.1. Continuing Water Interception, Neutralisation and Monitoring 17

6.2. Up-Grade of Mine-Side Water Interception..17

6.3. Interception of Artesian Spring 17

6.4. Continue Reduction of Tailings Surface Area.......................................18

6.5. Minor Treatment Plant Improvements 18

6.6. Study of Data Relating to Livestock Infertility 18

6.7. Study of Use of Precipitate Biosolids and Sludge in Rehabilitation 18

6.8. Study of Metal Levels in Soils 19

6.9. Concept Feasibility Study for Creek Isolation 19

7. CONCLUSIONS

7.1 The Long Term Goal..19

7.2 Objective and Strategies...19

TABLES

Table 1 History of EPA Authorisation for the Brukunga Mine Site…………………3

Table 2 Brukunga Tailings Dam Embankment Seepage and Site Rainfall…………..8

Table 3 Brukunga Mine Site Water Interception and Treatment for the Year 1999 14

Table 4 Brukunga Mine Site Water Interception and Treatment for the Year 1998 .....……………………………………………………...15

FIGURES

Figure 1 Brukunga Mine Site, Historic Seepage of Acid Water from the Tailings...........………………………………………………………7

Figure 2 Acid Interception and Acid Neutralisation for the Month of June 1999 ....………………………………………….…...13

Figure 3 Time-line for Brukunga Site Environment Improvement………………….21

Figure 4 Plan of Mine-Side Pump Locations…….……….………………………….22

APPENDICES

Appendix 1 Budget Costing, Mine Improvements

Appendix 2 Budget Costing, Studies and Investigations

Appendix 3 1975 AMDEL Report No. 1065. Figure 1. Brukunga Mine Sample Points, 4 December 1974.

Appendix 4 1975 AMDEL Report No. 1065. Figure 2. Fe, Cd, and Acid Values of Dawesley Creek in Mine, 4 December 1974.

Appendix 5 Brukunga Mine Site Public Meeting Reports

1. Brukunga Mine Site Remediation Board, *'Working Together'* October 1999
2. Notice of public meeting *'Let's Talk'*, held 3 November 1999.
3. Report of Brukunga Mine Site Public Meeting, 1:30 PM, 6 August 1997
4. Report of Brukunga Mine Site Public Meeting, 7:30 PM, 6 August 1997

1. INTRODUCTION

This 'Environment Improvement Program' (EIP) is prepared for the effective management of remedial activities conducted at the Brukunga Mine site, primarily for the twelve month to 30 June 2000. The EIP is a statutory requirement of condition 100-20 of Environment Protection Authority SA, licence N^{o} 10577 issued to PIRSA for the site.

Mining at the historic Gibraltar pyrite mine, located 4 km north east of Nairne, ceased on 31 May 1972. The mining leases held by Nairne Pyrites Pty Ltd expired in 1974 and the State Government accepted responsibility for rehabilitation of the site in August 1976, four years after mine closure. All activity conducted on the site since mine closure has been directed to quantifying and minimising the environmental impact of the natural process of acid rock drainage (ARD) and to rehabilitate the disturbed land.

The main environmental impact of Brukunga is its affect on downstream water quality in Dawesley Creek. Water seeping from the site and into Dawesley Creek contains high levels of sulphate and other metals, made soluble by the acid water.

Since October 1980 the Engineering and Water Supply Department, SA Water Corporation and now the Department of Primary Industries and Resources SA have, on behalf of the State Government, operated an on-site acid water treatment plant. A network of pumps and sumps, have been established to intercept contaminated acid seepage water and move it to holding ponds for neutralisation. Operation of the plant has effectively brought seepage from the tailings retention dam under control and interception of seepage water from the mine-side has significantly reduced the load of metal contamination entering Dawesley Creek.

In March 1998 the State Government transferred responsibility for management of the Brukunga mine site activities from SA Water Corporation to Mineral Resources Group of the Department of Primary Industries and Resources SA (PIRSA). The Brukunga Mine Site Remediation (BMSR) Board was formed in May 1999 with the objective to establish the problems and their implications and to suggest solutions with outcomes to the Minister.

This program proposes the continued operation of the neutralisation plant into the foreseeable future, together with a number of progressive improvements to the mine-side water interception and to clean water separation. The effectiveness of the proposed alterations should be readily detected by established downstream flow-proportional water sampling.

The three established water quality monitoring programs will continue to provide invaluable historic data with which to quantify pollution levels and to access the effectiveness of work strategies conducted on site.

In addition four scientific and engineering studies are to be commissioned, namely to:

- Review by CSIRO of scientific material relating to livestock infertility at Brukunga;
- Examine the suitability of using biosolid soils and neutralising plant precipitation sludge, as ground cover for site rehabilitation;

- Examine the 'distribution of heavy metals' in soils and creek flats and downstream to Lake Alexandrina;
- Examine historic creek flow data to determine, 'concept feasibility for creek isolation', to isolate the mine site from Dawesley Creek by passing routine creek flow through a pipeline; and
- Dependant upon favourable results from the 'concept feasibility creek isolation study', to prepare a detailed engineering implementation study.

The proposal to pipe Dawesley Creek water flow past the site, and hence isolate all mine seepage water, offers the greatest potential to reduce environmental impact. However, the need to continue water interception and neutralisation activities will remain for the foreseeable future, to the extent that a significant additional volume of ARD water will require neutralisation and / or disposal by some other means, eg. by evaporation.

In addition to mine site activity the program in progress of installing stock fences along Dawesley Creek, downstream of the mine site, to exclude livestock from the contaminated water, will continue in cooperation with the affected landowners.

2. ENVIRONMENT PROTECTION AUTHORITY LICENCE

2.1 Chronology of Licence Issue

The Brukunga mine site is prescribed by regulation, Schedule 1, Part A, 4. (1), of the *Environment Protection Act, 1993* to be, *'an activity of environmental significance'*. Part 6, Division 2, clause 36 of the Act, requires that a licence be issued for *'prescribed activities of environmental significance*' and hence a licence is required for the Brukunga mine site although no commercial operations are performed on the site.

The first EPA licence for the Brukunga site, licence N^{o} 2343 commencing 1 May 1995, was issued to SA Water Corporation. A 'Water Monitoring Program', developed by SA Water Corporation was accepted by the EPA on the 2 August 1996. The EPA renewed the SA Water Corporation licence on 7 August 1997 for a further term of 24 months, to expire on 31 March 1999.

The EPA licence for the period 1 September 1998 to 31 March 1999 was transferred to the Minister for Primary Industries, Natural Resources and Regional Development, upon the issue of a new licence, N^{o} 10577 on 8 October 1998.

EPA licence No 10577 was renewed for a term of three months on 31 May 1999 and again on 15 July 1999 for a term of six months to expire on 31 December 1999.

See: Table 1 History of EPA Authorisation for the Brukunga Mine Site, (page 3).

2.2. Activity Authorised for the Site

EPA Licence No. 10577 issued to PIRSA for the Brukunga site authorises the following activities:

- pursuant to 3. (3) use as a waste depot for receipt of,
  a/ lime waste for use in the neutralisation plant,
  b/ digested sewage sludge for use in rehabilitation,
  c/ septic tank waste for use in rehabilitation,
  d/ dried (spadeable) sludge from septic tank effluent disposal systems for use in site rehabilitation; and
- pursuant to 4. (1) Brukunga mine site activities conducted to minimise impact and rehabilitate the site.

2.3 Requirements of the Environment Improvement Program

Condition 100-20 of licence N° 10577 requires the licensee to produce an Environment Improvement Program (EIP) acceptable to the EPA. The EIP must be;

> *"based on best available technology economically achievable"* and must, *"describe a course of action to be taken by the Licensee with the objective of reducing environmental harm caused by seepage, runoff, discharges or emissions from the site. The EIP must cover a period not more than five (5) years."*
>
> *"The EIP shall take into account any relevant local community concerns and EPA preference for:*
>
> *(a) Practices that will reduce runoff and seepage from the site.*
>
> *(b) Water quality conditions immediately downstream of the mine site that would support a healthy aquatic ecosystem and be suitable for stock and irrigation.*
>
> *(c) Practices that will minimise the generation of dust.*
>
> *(d) Rehabilitation of the site."*

3. BACKGROUND

3.1 Site History

The town at Brukunga, located 5 km north-east of Nairne and 50 km from Adelaide in the Mt Lofty Ranges was established in 1952 specifically to house the workforce of the Gibraltar Pyrite Mine.

A bulk sample of ore was excavated for metallurgical studies in 1952 and quarry production commenced in 1955. Some 5.58 million tonne of iron sulphide ore (predominantly pyrite and pyrrhotite) at a grade of 11% sulphur was quarried for a calculated value of $(1998)145 million. The ore was crushed, ground and processed by flotation to produce a concentrate that was trucked to Nairne and then railed to Port Adelaide. Operations ceased on 31 May 1972, as a direct result of the withdrawal of the Federal Government pyrite subsidy.

The sulphide concentrate was used as a source of sulphur, for the manufacture of sulphuric acid at a plant located at Birkenhead, Port Adelaide. The sulphuric acid was used to produce superphosphate fertiliser, a commodity in great demand in the 1950s because of accelerated land clearing for agriculture, after the return of servicemen from the Second World War.

The South Australian Government encouraged and sponsored the formation of a company to operate the Gibraltar Pyrite Mine in the late 1940s. Nairne Pyrites Pty Ltd was formed as a consortium of three (3) fertiliser companies and a South Australian mine operator, namely Cresco Fertilizers Ltd, The Adelaide Chemical and Fertilizer Co Ltd, Wallaroo-Mount Lyell Fertilizers Ltd and The BHP Co Ltd. No mining activity has occurred on the Brukunga site since mine closure in May 1972.

3.2 Natural Acid Generation

Acid rock drainage is generated by the natural oxidation and breakdown of sulphide minerals, mainly pyrite and pyrrhotite that occur in the ground. Small amounts of sulphide minerals were discarded with the waste rock into dumps during quarrying. The rock dumps contain an estimated 1 to 2% sulphur. Fine sand and clay particles, tailings from the metallurgical concentrator, contain minerals with an estimated 1.4% sulphur. The tailings were hydraulically placed into a large sand heap, the tailings retention dam, located east of main road. Iron sulphide minerals with an average grade of 11% sulphur still exist to depth in the quarry floor, as three parallel ore lenses dipping to the east at 70 degrees.

Iron sulphides oxidise to sulphates and dissolve in water to produce a weak acid solution with pH as low as 2.3. Metals that occur in association with the iron sulphides, eg, copper, zinc, manganese, cadmium etc. are relatively insoluble in water but are significantly more soluble in acid. Hence, the metals present at Brukunga dissolve and are transported by runoff and seepage water that results in downstream creek pollution.

3.3 Topographic Erosion and Geological Contribution to Soil

The greywacke mica schist and quartzite are part of the geological ‘Nairne Pyrite Member’ of the ‘Talisker Calc-siltstone’. The formations extend north and south for some 80 km. There are numerous examples where natural erosion has cut deeply across the pyrite lodes in shaping the topography.

On the north boundary of the quarry, Days Creek cuts east across the Brukunga sulphide lodes, along Peggy Buxton Road. At the southern boundary of the quarry Dawesley Creek cuts west and then east across the sulphide lodes. Significant topographic erosion is apparent 1,300 metres along strike and south downstream of the quarry, having carried soil debris east towards the ‘Old Swimming Pool’ flat in Dawesley Creek. Pyritic rock outcrop has been identified at Old Melbourne Bridge Road and is aligned with the Dawesley Creek flat.

The structure and make-up of soils and metal distribution in the region should be considered in relation to the topography and geology of the area.

3.4 The Defunct Brukunga Mine Site Legacy

Quarry operations at the Gibraltar mine resulted in the deposition of some 10 million tonnes of waste rock into two large rock dumps on the western edge of Dawesley Creek and a small dump, located east of Dawesley Creek at the southern end of the quarry. The rock dumps contain minerals with an estimated 1 to 2% sulphur.

Milling operations resulted in some 4.24 million tonne of sand and clay tailings hydraulically placed in a retention dam, located in a broad valley to the east of main road. The mill tailings contain an estimated 1.4 % sulphur, mainly as pyrrhotite and are the remnant 76% of quarried ore, that was ground to 55% passing 75 µm, to liberate the fine sulphide particles (Armstrong A.T., SA Mining Review N^{o} 96 1952).

Soon after mine closure in 1972 it became evident that there were significant environmental problems. The Australian Mineral Development Laboratories (AMDEL) reported that the large tailings dam, containing a backed up lake of acid water, was seeping acid water at the toe at a rate of 100,000 kl/a (reference: p.21 Blesing and Lackey, AMDEL Report No. 1065, 1975). The lake was increasing in size and not evaporating as expected, as water seepage captured in ponds at the toe, was pumped back to the lake. At times major quantities of acid water entered the creek, overflowing from the holding lake on top of the tailings dam. The report concluded that to control seepage from the tailings dam, the lake needed to be drained.

An acid neutralisation plant was designed by AMDEL and commissioned by the EWS in 1980, to treat the acid lake water and to release the treated water to Dawesley Creek. The treatment plant has operated for some 19 years and has successfully removed the surface lake of acid water from the tailings dam. The removal of the acid lake and the placement of an earth and vegetated cover over the sand tailings reduced water seepage through the sand tailings dam by as much as 60%.

See Figure 1. Brukunga Mine Site, Historic Seepage of Acid Water from the Tailings Wall, (page 7) and

Table 2. Brukunga Tailings Dam Embankment Seepage and Site Rainfall, (page 8).

AMDEL's Report No.1065 in 1975 also established, by point sampling and chemical analysis along Dawesley Creek in 1974 that,

> *'the major source of pollution in Dawesley Creek is the seepage from the rock dumps, the greater proportion contributed from the southern waste dump'*

By 1990, operation of the neutralisation plant has eliminated the acid lake that was located on top of the tailings dam. Acid-water seepage on the mine side is intercepted at eight points located west of Dawesley Creek. Five of the sumps are located along the toe of the southern rock dump and capture seepage water before it can enter Dawesley Creek. Only one pump at the north end of the northern rock dump and a small pump in Days Creek intercept seepage water from the northern dump for treatment.

The 1975 AMDEL described a point source where acidity and iron levels in Dawesley Creek effluent increased by 800% and cadmium levels increased by 300%. The point delineated as sample point No.20 (Figure 1, AMDEL Report No.1065) is located at the foot of the southern rock dump, (see Appendix 3 and 4). This point source of pollution is the site of the No.3 acid pump and has recently been identified from aerial photography to be the point of egress of the original creek bed, before it was buried under the southern end of the south, waste rock dump.

4. MANAGEMENT AND PUBLIC CONSULTATION

4.1 Brukunga Mine Site Remediation Board

On the 7 May 1999 the Brukunga Mine Site Remediation (BMSR) Board was formulated to develop strategies for remedial activities and to provide advice to the Minister for Primary Industries, Natural Resources and Regional Development.

The BMSR Board supersedes the Brukunga Taskforce, initiated by the Minister in August 1998 to respond to increasing public concern. The Brukunga Taskforce superseded the Brukunga Steering Committee, which was a government coordination committee for site activities between SA Water Corporation and Department of Mines and Energy with one local resident representative.

In March 1998 management of site activities was transferred from SA Water Corporation to Mineral Resources Group, Department of Primary Industries and Resources South Australia (PIRSA). PIRSA is responsible for implementing mine site rehabilitation programs as directed by the Minister.

The BMSR Board is structured to ensure strong community involvement. Current members are:

- Mr Hume Macdonald, Independent Chairperson;
- Dr Neville Alley, Director of Mineral Resources, PIRSA;
- Ms Carol Vincent, Councillor Mt Barker;
- Mr Peter Beaumont, Environment Officer Mt Barker Council;

- Mr Rolly MacDonald, Dawesley Catchment Landcare Group; and
- Debbie Johnson, BMSR Board Administrator

(See: Appendix 5, Item 1, Pamphlet *'Working Together'* October 1999)

4.2 Informal Liaison

The BMSR Board held a public meeting in the Brukunga hall at 7:30 PM on Wednesday 3 November 1999 to talk about environmental issues associated with Dawesley Creek. (See: Appendix 5, Item 2, Notice of public meeting, *'Let's Talk'*)

The Mine Site Supervisor and Project Engineer for PIRSA continued SA Water Corporation's practice and held an open-day for local residents on 7 October 1998. The open-day tour was attended by six adult and six children.

Students from the Flinders University, Adelaide University, SA University, O'Halloran Hill TAFE, Brighton High School and Lobethal Lutheran Primary School were all welcomed to the Brukunga mine site by the Mine Site Supervisor during the year.

ANSTO and the CSIRO use the Brukunga site as a laboratory for the development of environment monitoring techniques and regularly organise various student projects that use Brukunga for field research.

Four members of the Environment Protection Authority and four officers of the Environment Protection Agency inspected the site on 14 April 1999.

The public consultation process has been strengthened by the employment of Project Officers from Rural Solutions, PIRSA to liase with local property owners downstream and along Dawesley Creek. Discussions have been held to determine landowner use of creek water. A program of soil sampling to determine the metal content of creek flats and follow-up applications of agricultural lime, to reduce acidity, has been undertaken. Where property owners agree, fences are being erected along the Dawesley Creek to exclude livestock from taking water from the creek. Erection of fences and application of weedicide on some properties is complete and to be continued on other properties throughout the coming year.

4.3 Public Meetings

SA Water Corporation held two public meetings at Brukunga in August 1997. Presentations were given on the broad proposals contained in the draft EIP. Significant issue raised by the public, including the diversion of Dawesley Creek past the mine site, are incorporated into this EIP. A summary report of the issues raised at each of the meetings is given in Appendix 5.

5. REVIEW OF CURRENT SITE ACTIVITY

5.1 Plant Operation

The 1980 neutralisation plant is operated by two dedicated plant operators on a 24 hour needs basis to neutralise intercepted acidic water. The acid water is pumped from the two seepage ponds located at the toe of the tailings dam. Seepage pumps are activated in response to the level of acid water in the ponds, which is greatly influenced by rainfall.

Acid water at pH 2.3 is pumped to the top agitator tank where slaked lime is added to raise pulp pH to 9. The pulp gravitates through two more agitator tanks, each with a design retention time of 22 minutes. A chemical precipitate consisting mainly of gypsum with captured metals is formed and flocculant AP175 is added to aid de-watering in the thickener tank, which has a design retention time of 10 hours.

During the wet months of the year the plant is operated continuously above design capacity at 31 kl/hour to prevent a pond overflow and subsequent release of acid water. The higher throughput reduces retention time and results in a pulp underflow closer to 5% solids instead of the design 10% solids. Consequentially, more silt is carried by overflow water, which is settled in the first settling pond located behind the lime pond. The pond is de-silted by pumping to the sludge ponds on two or three occasions per year, to maintain settling capacity.

Settled water with pH 8.5 to 9.5 gravitates by open launder to the second reed filled settling pond located adjacent to Dawesley Creek before release into the creek at a pH 7.0 to 8.5.

5.2 Water Interception, Mine-Side

SA Water Corporation upgraded and increased the number of sumps on the mine-side, ie. to the west of Dawesley Creek that intercept acidic seepage water before it can enter Dawesley Creek. No water is taken from Dawesley Creek. Water flows from north to south, past the foot of the rock dumps, unhindered except for sewage build up, leaking from the Brukunga town septic pit located adjacent to the northern rock dump.

Eight mine-side pumps activated by float switches are located in various sumps on the mine side to move seepage water. Only three pumps, ie. No. 1, No. 3, and No. 7 deliver intercepted seepage water via two pipelines, east across main road to the two seepage ponds located at the foot of the sand tailings dam. (See: Figure 4, Mine-Side Pump Locations, page 22).

5.3 Water Interception, Sand Tailings Side

Water seepage from the tailings dam side, ie. seepage water from the eastern side of Dawesley Creek is well controlled. Water seeping from the tailings wall is measure daily over a 'v-notch' weir before being captured in the acid seepage ponds. Acid water seepage is captured direct from the tailings by a 7 m deep well located west of the precipitate sludge ponds. The 'tailings well pump' pumps a considerable quantity of water direct to the plant for treatment during the wet, typically winter months.

The acid water ponds were roughly constructed and water leaking westward is intercepted by a 'French drain' located east of main road and is returned to the pond by the 'seepage well pump'. In addition a second 'French drain' is located west of main road and intercepted acid seepage water is returned by Mine Pump No. 6 to the acid pond. It is estimated 95% of seepage from the tailings-side is captured for treatment.

5.4 Review of Historic Pump Operating Records

A study of current and historic pump monitoring records kept by the Mine Site Supervisor were used to prepare a water balance for plant and pump operations. A schematic cross-section from west-to-east aids understanding of water interception and the movement of water on the site.

An example of the schematic presentation, for the month June 1999 is displayed as Figure 2. Current data for this year 1999 and historic data for 1998 are presented in Tables 3 and 4 respectively.

Interpretation of this data indicates that:

- Only a minor portion of the water intercepted for treatment is captured from the mine-side, ie. in this year 1999 to-date only 21% of intercepted water came from the mine-side of the property and in 1998 the figure was 31%;
- The majority of intercepted water comes from the sand tailings dam side of the property, ie. 60,900 kilolitres in 1998. Hence, there is no indication that the neutralisation plant will not continue to be required to control from the sand tailings dam; and
- A considerable proportion of the water that is intercepted on the mine-side is delivered by the No 3 mine pump, ie. 61% in 1998 and 44% to date in 1999. It is noted that this point location was identified by AMDEL 1975 as a sudden and significant source of high acid and metal contamination. The records indicate that acid and iron levels in water at this point increase by a factor of 8 and cadmium levels increase by a factor of 3.

See: Figure 2. Acid Interception and Acid Neutralisation for the Month of June 1999, page 13;

Table 3. Brukunga Mine Site Water Interception and Treatment for the Year 1999; page 14; and

Table 4. Brukunga Mine Site Water Interception and Treatment for the Year 1998, page 15.

5.5 Water Quality Monitoring

Plant operating staff check water quality at the plant, clarifying pond, creek discharge, assay dam, Days Creek, above town, and at Melbourne bridge on a daily basis and record pH levels. The operating pH of the plant is continuously recorded and the digital indicator is used to vary pump speed to adjust plant pH to 9.

In August 1996 a 'water monitoring program' was developed for the site and agreed to by the EPA. The program consists of three parts, as required by EPA licence condition No. 100-1, ie determine:

(a) annual and seasonal loads of heavy metals entering Dawesley Creek from the site;

(b) the temporal and spatial variations of pH and heavy metal concentrations within the zone of impact; and

(c) the extent of impact on Dawesley Creek and the Bremer River by undertaking a quarterly macroinvertebrate study.

Contractor, Water Data Services (WDS) installed and operate flow proportional monitoring samplers on Dawesley Creek, located above and below the mine site. Samples are collected on a two-weekly basis and are submitted to Australian Water Quality Centre (AWQC) for chemical analysis. The five continuous flow monitoring weirs were installed in 1993 and data is retrieved quarterly and stored on Department of Environment, Heritage and Aboriginal Affairs (DEHAA)'s 'HYDSYS Water Data Archive'. Three composite samplers were installed in January 1998 and assay sampling commenced on 3 February 1998. The flow recordings and analysis of composite samples enable metal loads to be calculated.

PIRSA' plant operating staff collect water samples on a monthly basis from eight locations along the creek system, in bottles supplied and collected by AWQC. The NATA approved laboratory at AWQC conduct chemical assays of all water samples and provide reports. The monthly spot samples give an indication of seasonal and spatial variation in water quality.

Water samples are analysed for:

TDS	Iron	Sulphate
Aluminium	Manganese	Chromium
Cadmium	Nickel	Zinc
Lead	Copper	

Dr P Suter performed an initial assessment of the ecological impact on Dawesley Creek in December 1993. This assessment indicated the impact extended downstream at least to the confluence of Mount Barker Creek and Bremer River. On a quarterly basis, AWQC's Senior Biologist collects water samples from the creek system to determine species richness and hence an indication of variation in ecological impact.

Water monitoring results are reported to the EPA for a twelve-month period to December in each year, as a requirement of licence condition No. 100-6.

6. STRATEGIES FOR ENVIRONMENT IMPROVEMENT

6.1 Continuing Water Interception, Neutralisation and Monitoring

Historic records of water interception and treatment indicate that the continuing operation of pumps and treatment plant is essential to reduce metal release and environment impact.

See Appendix 1, Item 1.

6.2 Upgrade of Mine-Side Water Interception

A study of historic mine site water interception records and an inspection of the mine water collection sumps indicates a significant increase in water seepage could be captured from the mine-side simply by increasing the depth of the sumps. This is particularly important at the two identified locations on the mine-side, ie pumps No. 3 and No. 1 located adjacent to the southern rock dump where high pollution entry sources were recorded (AMDEL 1975).

A study of a 1940's pre-mining aerial photo revealed that the original bed of Dawesley Creek passes under the southern rock dump and exits at No. 3 pump. This observation explains the relatively high volume of water collected by this pump and also indicates it's significance as a source of high pollution (reference, Blesing and Lackey, p.5, AMDEL Report No. 1065, 1975).

Costing for a proposal to improve seepage capture is presented in Appendix 1. Further significant improvements can be made by relative minor works to mine-side seepage interception for a budget cost of $55,300. Separation of other clean runoff water will further reduce the volume of water that is contaminated.

See: Appendix 1, Item 2.

6.3 Interception of Artesian Spring Water

Further study of a pre-mining 1940's aerial photograph revealed the location of the upper farm-dam that is now buried under the sand tailings dam. It is alleged that the dam was fed by a spring. In March 1999 a rubble road was constructed to access the site and in August a 1.5 metre diameter well-pipe was pushed down 12 metres into the tailings using an excavator. Water rising in the well is above the water level of the surrounding precipitate pond and had a pH 6.5. A sample of water sent for chemical analysis reported pH 7.5, sulphate 1,890 mg/l, aluminium 0.377 mg/l, cadmium 0.0051 mg/l and iron 0.494 mg/l. An attempt was made to clear the well by pumping but the surrounding sludge became unstable. Work was halted until the dam can be backfilled with rock sometime in February 2000. It is hoped that relatively good quality artesian water can be redirected around the tailings dam, hence reducing seeping through the sand tailings.

See Appendix 1, Item 3.1.

6.4 Continue Reduction of Tailings Surface Area

Progressively over the past 10 years a cover of rock, clay, soil and biosolds has placed over the surface of the tailngs dam. This work which enabled a vegetation cover to be established is nearing completion. The evapo-transpiration cover established reduces stormwater absorption and percolation. Historic record of seepage from the dam wall indicates that a reduction of up to 60% in acid seepage has occurred since treatment commenced.

Plant precipitate sludge produced each year is held in retention ponds that have been progressively reduced in area. No. 3 precipitate sludge pond was closed off in April 1999 and the surface area of the tailings open was reduced by a further 11,500 square metres. In February 2000 it is planned to further reduce the surface area of the dams by backfilling precipitate sludge pond No. 1 with rock and establishing a vegetative cover, (see Appendix 1, Item 3.2).

6.5 Minor Treatment Plant Improvements

An inspection of the plant revealed that acid and lime water enters the agitator tank at the surface and exits through the overflow located directly opposite, allowing float-off to occur and reducing effective retention time. A baffle plate is to be installed in front of each agitator outlet, to create under-flow and better mixing, (see Appendix 1, Item 4.2).

6.6 Study of Data Relating to Livestock Infertility

The CSIRO have been commissioned to conduct a desktop study of all available data on cadmium levels and any research on causal links to livestock and cattle infertility. The study in nearing completion, (see Appendix 2, Item 1).

6.7 Study of Use of Biosolids and Sludge in Rehabilitation

Sewage sludge from Mount Barker Council and dried and aged 'biosolid' soils from various SA Water Corporation waste water treatment plants, have been used over a number of years as nutrient rich soil cover for the tailings retention dam. Wet local council septic tank sludge is used as a capping and growing medium for vegetation on the tailings dam in summer and as rock dump cover in winter. Dried biosolids were placed over the small south-eastern rock dump in February 1998. The soil cover was planted with native tree seedlings in May 1999. The benefit of the use of biosolids and sewage sludge in rehabilitation is evident by fast establishing grass cover and the increased growth rate of trees.

As cover on the tailings dam is now almost complete the precipitate sludge produce in the neutralisation plant has been relocated to the mine-side, as cover over various rubble faces. The very fine precipitate sludge is mainly gypsum and jarosite that contains the various heavy metals captured from the treated acid water.

Concerns have been raised that heavy metals, particularly cadmium contained in the precipitate and biosolids could be re-mobilised by the acid environment on the mine-side and hence, result in an increase in metal concentrations in water seepage from the site.

On 5 October 1999 tenders were called for qualified consultants to submit a study proposal on the suitability of using precipitate sludge and biosolids in rehabilitation of the quarry and on rock dumps, (see Appendix 2, Item 2).

6.8 Study of Metal Levels in Soils

A study of metal levels in soil profiles commenced in August 99 by professional staff of the Geological Survey Branch - PIRSA. The work over a large area extending from north of the mine site and down to Lake Alexandrina is nearing completion, (see Appendix 2, Item 3).

6.9 Concept Feasibility Study for Creek Isolation

The proposal to divert Dawesley Creek water and take the pollution source off-stream is not new. It was suggested by AMDEL in 1975. Isolation by piping Dawesley Creek flow past the mine site offers the greatest potential to remedy downstream water contamination. A scope of work and tenders will be called for a concept feasibility study to determine the practicality and a budget cost for an isolation proposal. Depending on favourable findings, an implementation study could follow, (see Appendix 2, Item 4).

7. CONCLUSIONS

7.1 The Long Term Goal

The major long term goal for Brukunga mine site is to implement control measures that will prevent downstream contamination of water by heavy metals and sulphate and to return the water in Dawesley Creek to a quality suitable for agricultural and irrigation use.

This goal is to be achieved by implementing a combination of immediate short term and long term strategies. Notional timeline to achieve the long term goal is not predictable at this point in time.

7.2 Objective and Strategies

An immediate objective is to restrict livestock access to Dawesley Creek water where requested. Immediate strategies for the next 12 months are outlined in this Environment Improvement Program.

A significant short-term objective is to complete an investigation into the feasibility of diverting Dawesley Creek water past the mine site. Measures to be implemented, to improve the mine-side acid leachate collection network have potential to rapidly improve downstream water quality.

The ultimate land use for the mine site is envisaged to be natural vegetation.

Long term strategies may involve the following activities:

Filling and sealing excavations on the quarry benches;

Reshaping the north and south waste rock dumps with partial filling of the north and south cuts and partial covering of the main quarry bench with the waste rock.

The disposal of neutralisation plant sludge with waste rock during rehabilitation.

Final cover would require the import of large volumes, 800,000 m^3, of suitable cover material(s) eg. limestone or dolomite, in order to be effective.

Appendix 1 BUDGET COSTING, MINE IMPROVEMENTS

1. BUDGET COST: PLANT OPERATION AND SITE MAINTENANCE

Operate the neutralisation plant, purchase chemicals, repair pumps, monitor environment, maintain property fences, eradicate weeds, reduce bushfire hazard, etc. **$547,400 p.a.**

2. BUDGET COST: MINE SIDE INTERCEPTION UPGRADE

2.1 No1 Mine Pump			
Deepen sump, install 1.5 m dia well pipe	$700		
Concrete pipe	$2,500	$3,200	
2.2 No.2 Mine Pump			
Deepen sump, install 1.5 m dia well pipe	$700		
Concrete pipe	$2,500		
Electrical upgrade and installation	$5,000	$8,200	
2.3 No.3 Mine Pump			
Deepen sump, install 1.5 m dia well pipe	$700		
Concrete pipe	$2,500	$3,200	
2.4 No.5 Mine Pump			
Deepen sump, install 1.5 m dia well pipe	$700		
Concrete pipe	$2,500		
Electrical upgrade and installation	$5,000	$8,200	**$22,800**
2.5 Assay Dam relocation			
Excavate site and access drains	$7,500		
Install formwork and concrete	$20,000		
Electrical installation	$5,000		**$32,500**
2.6 Minor creek water separation			
Pipe 300 mm ◊ 650 m $24/m	$15,600		
Prepare and excavate line from ‘Lindsay Creek’	$3,000		
Pipe 300 mm ◊ 550 m $24/m	$13,200		
Prepare and excavate line from ‘Jane Creek’	$3,000		**$34,800**

3. BUDGET COST: TAILINGS RETENTION DAM IMPROVEMENTS

3.1 Intercept Artesian Spring

Install rubble access (completed Mar 99 as part of pond backfill)		
Concrete pipe 12 m, 1.5 m ◊, value $5,200 taken from existing stock		
Install pipe well and pump out sludge (Aug 99)	$1,400	**$1,400**

3.2 Continue Reduction of Tailings Surface Area

Excavate surface of No. 1 precipitate sludge pond, backfill with waste rock, cover with soil and vegetate surface.	**$85,000**

4. BUDGET COST: TREATMENT PLANT IMPROVEMENTS

4.1 Improve access and clean-off to lime recovery pond

Install concrete access and drain (completed Aug 99)	$5,350	

4.2 Improve Plant Efficency

Install mixing tank baffles (3x) to prevent float off	$600	**$5,950**

Appendix 2 BUDGET COSTING, STUDIES AND INVESTIGATIONS

1. BUDGET COST: CONSULTANCY REVIEW DATA ON LIVESTOCK INFERTILITY

CSIRO study to review scientific material relating to livestock infertility at Brukunga. The study was commissioned 12 May 1999 at cost estimate of $23,969. Less CSIRO's contribution $10,086	**$13,883**

2. BUDGET COST: CONSULTANCY EXAMINE USE OF BIOSOLIDS AND SLUDGE

Study to examine the suitability of using biosolid soils, septic tank sludge and neutralising plant precipitate sludge as ground cover for site rehabilitation.	**$40,000**

3. BUDGET COST: CONSULTANCY EXAMINE SOIL CONTAMINATION

Study to examine the distribution of heavy metals in soils and creek flats and downstream to Lake Aleandrina.

Worked commenced in house 11 August 99	$35,000	**$35,000**

4. BUDGET COST: CONSULTANCY CREEK ISOLATION

4.1 Concept Feasibility Study	$20,000	**$20,000**

4.2 Implementation

Design / Survey / Management		$100,000	
Concrete pipe, 1,050 mm ◊, $225/m for 2,000 m		$450,000	
	Contingency 10%	$45,000	
Site prep and install footings 20m intervals, 100 @ $3,000		$300,000	
	Contingency $30%	$90,000	
Weirs upstream and downstream, two at $20,000		$40,000	
	Contingency $30%	$12,000	
Pipe installation		$30,000	
	Contingency 30%	$9,000	
Transport $15 per tonne		$15,000	
	Contingency 20%	$3,000	**$1,094,000**

Appendix 3. 1975 AMDEL Report No. 1065

Brukunga Mine Sample Points 4 December 1974

Appendix 4. 1975 AMDEL Report No. 1065

Fe, Cd, and Acid Values of Dawesley Creek in Mine, 4 December 1974

Appendix 5. BRUKUNGA MINE SITE PUBLIC MEETING REPORTS

1. **Brukunga Mine Site Remediation Board, *'Working Together'* October 1999**

2. **Notice of public meeting *'Let's Talk'* held 3 November 1999**

3. **Report of 1:30 PM, 6 August 1997 Brukunga Mine Site Public Meeting, held at Brukunga Hall, Brukunga; and**

4. **Report of 7:30 PM, 6 August 1997 Brukunga Mine Site Public Meeting held at Brukunga Hall, Brukunga.**