DUPLICATE R2004/00436

Diversion of Dawesley Creek at Brukunga Preliminary Feasibility Study

Primary Industry and Resources SA

PPK Environment & Infrastructure Pty Ltd
A Parsons Brinckerhoff Company

PPK House
101 Pirie Street
Adelaide SA 5000
PO Box 398
Adelaide SA 5001
Australia

Telephone: (61 8) 8405 4300
Facsimile: (61 8) 8405 4301

4August 2000
22M036A 00-0460-01

ABN 80 078 004 798

NCSI Certified Quality System to ISO 9001

Contents

Contents (Continued)

List of Tables

Contents (Continued)

List of Figures

Executive Summary

In response to a Brief issued on 6 March 2000, a preliminary feasibility study has been conducted into the diversion of Dawesley Creek to bypass the closed Brukunga pyrites mine site.

This would be part of a strategy to further prevent acid seepage from the site, particularly from the waste rock dumps, passing downstream. At present, partial interception is achieved by a series of wells from which seepage is pumped to a treatment plant where neutralisation of the acid water occurs.

The division of the creek around the some site would allow the existing creek bed to act as a sump to the lateral flow from the site. Retention of this flow would be achieved by a new downstream dam built to create a significant buffer storage basin for the acid waters, prior to their disposal by pumping to the treatment plant. A dam created to provide an upstream pond at the level necessary to divert the creek flow would also be provided.

Investigations included an hydrological study of Dawesley Creek flows, derived from records from the monitoring weirs upstream and downstream of the site and also on contributory flows that cross the mine site from the west.

A major component of the study was the investigation into the feasibility of constructing a bypass conduit to carry Dawesley Creek flows up to approximately the ARI (Average Recurrence Interval) one year flow, i.e. all flows except those greater than the flow that would run in the creek on the average once per year. Flows in excess of the ARI 1 year flow would enter the existing creek, flushing through the system. This flushing would occur when downstream flows would be diluted by high flows in the diversion.

The construction of such a conduit is shown to be feasible. The diversion cost is influenced by the requirement for rock cuttings for the channel over a proportion of its length and the need for some hundreds of metres of buried conduit under the CFS site.

Both upstream and downstream dams are shown to be feasible, the downstream site being suitable for the economical development of a storage basin of approximately 7.5 Ml capacity. This volume is estimated to be the full runoff from the mine site and western creeks of a one year ARI storm over the western catchments.

Since there is only approximately 30% spare capacity in the existing treatment plant, it is estimated that such a storage basin capacity is required to prevent too frequent a discharge of acid waters from the mine site to the downstream Dawesley Creek. It is predicted that any discharge would occur when strong diluting flows were running in the bypass channel.

It is noted in the report that future experience could show that it may be preferable to install a new water treatment plant near the downstream dam. This would ensure treatment capacity was available to limit discharge of acid affected water to only those times that Dawesley Creek flows were greater than the ARI one year flow, i.e. on the average once per year. Alternatively, the potential for significantly upgrading the capacity of the existing treatment plant should be investigated.

The estimated cost of implementing the diversion, including upstream and downstream dam construction and the disposal pump and pipeline, is approximately $2.5 million, including an allowance for engineering design and 10% contingencies.

Recommendations are made for comprehensive site investigation, including geotechnical investigation, if it is proposed to proceed to the design stage.

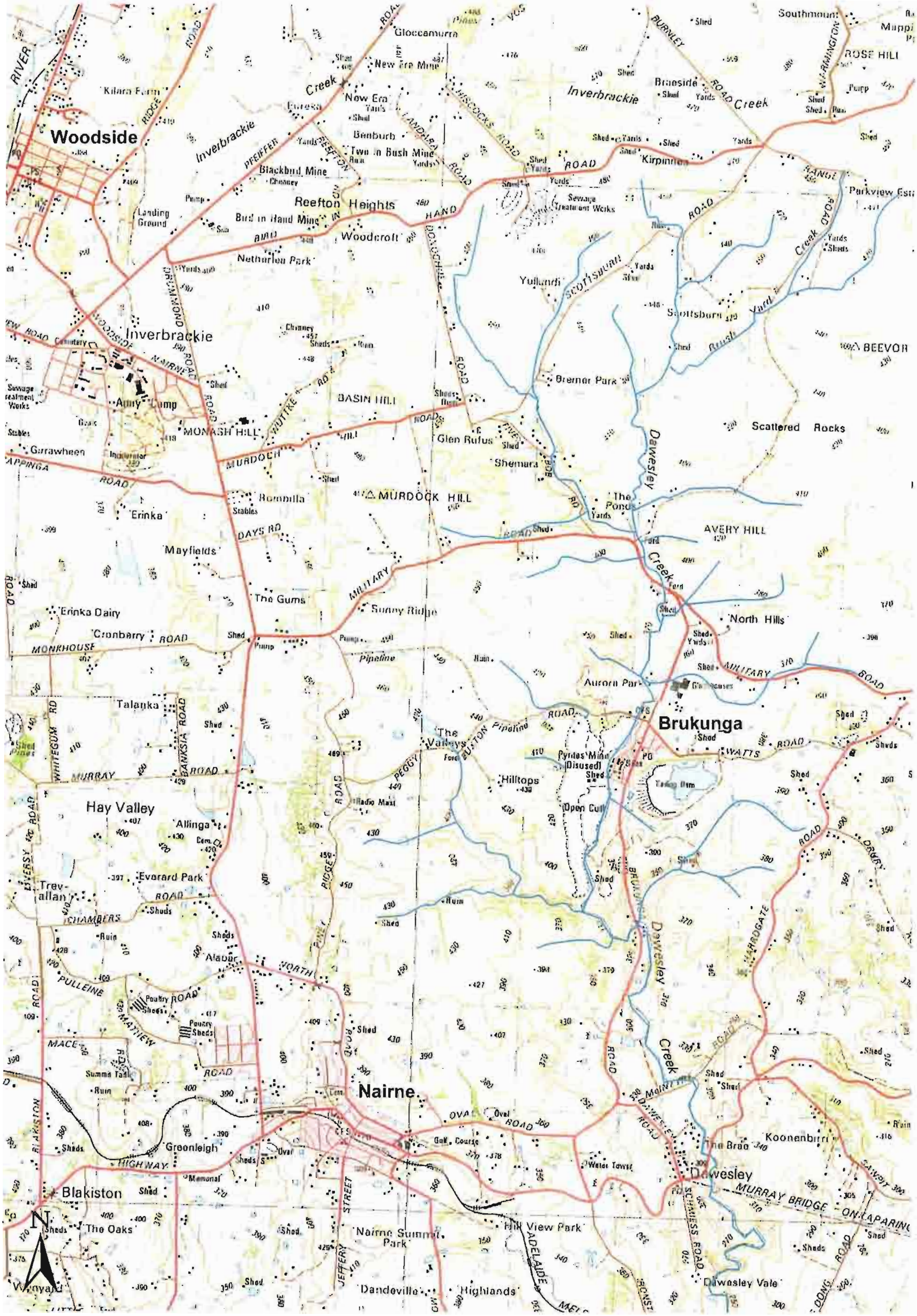
1. Introduction

This report presents the results of an investigation into the feasibility of diverting Dawesley Creek to bypass the Brukunga mine site. The project Brief issued on 6 March 2000 set out the study requirements which are principally directed towards a major reduction in the contamination of the downstream Dawesley Creek by acid rock drainage.

The principal components of the work relate to the diversion of the creek referred to above and the enhancement of present acid seepage interception arrangements. The present creek bed could then be used for seepage collection prior to the transfer of acid waters to existing treatment facilities.

In the study of the possible channel diversion, the principal input data are related to the hydrology of Dawesley Creek. Water Data Services, who presently monitor water flow stations associated with the Brukunga Mine site, have carried out the hydrological analyses reported in Section 3.

The location of the Brukunga mine and Dawesley Creek is shown on Figure 1.1. Dawesley Creek is typical ephemeral Mount Lofty Ranges stream. It is a tributary of Mount Barker Creek, which joins the Bremer River, eventually flowing into Lake Alexandrina. The streams serve an important function as a resource for supplementary farm water supply.



BRUKUNGA MINE REHABILITATION
Brukunga Location Map

FIGURE 1.1

2. Background

The Brukunga Mine is located about 45 km from Adelaide in the Mt Lofty Ranges, just north of the township of Nairne.

The mine was established in the aftermath of World War II when the State Government embarked on a program to broaden South Australia's economic base from agricultural production into a range of new industries. At the time, a world shortage of sulphur had resulted in higher prices for the mineral. This, together with a guarantee from the Commonwealth Government to pay a subsidy if the price of sulphur fell below a certain fixed price, lead the South Australian Government to encourage and sponsor the establishment of Nairne Pyrites Pty. Ltd.

The mining operation at Brukunga commenced in 1955, and supplied raw material for the conversion of pyrites to sulphuric acid and the manufacture of superphosphate fertiliser at Port Adelaide. Mining at Brukunga was carried out by open cut quarrying methods with on-site crushing and treatment.

By the early 1970s, however, sulphur was being obtained at a relatively low cost from Canada where the refinement of sour natural gas had resulted in large surplus stockpiles of sulphur. Consequently, the Brukunga Mine became uneconomical and production ceased in May 1972.

2.1 The Problem

Although Nairne Pyrites had maintained caretaker staff at the site, the residual sulphides in the quarry, waste rock dumps and tailings dam were actively oxidising and generating sulphuric acid via natural processes. The company was unable to check the gradual deterioration of the mine site and the resulting impact on surrounding areas. Acidification of the waterways downstream of Brukunga brought a spotlight on the developing problem, and in May 1977, the State Government accepted responsibility for the mine site and rehabilitation of affected areas following an agreement with Nairne Pyrites.

It is estimated that the total quantity of waste rock after cessation of mining amounts to approximately eight million tonnes. The waste rock contains an average of approximately 2% sulphur. The tailings dam, occupying what was a valley on the east side of Dawesley Creek, contains approximately 4.3 million tonnes of sand tailings, averaging approximately 1.7% sulphur. Leachate from the two main waste rock dumps are now the main source of sulphuric acid contamination to Dawesley Creek.

2.2 Prior Remedial Activities

The principal focus of earlier remedial activities has been on reducing the acid leachate from the tailings dam area which at the time was the main source of leachate. The tailings dam had been backfilled and capped and 40,000 trees planted at the site as part of the remediation process. Ponds at the base of the tailings dam collect surface runoff and seepage. Remediation carried out on the tailings dam has significantly reduced runoff and seepage from this source.

In 1980, an acid neutralisation plant was commissioned by the State Government. The plant is located north east of Brukunga township, and operates mainly in winter. Acid leachate from the two waste dumps and quarry is collected in ponds and seepage wells, and pumped to the treatment plant. This combines with the acid waters collected by the various facilities on the east side of Dawesley Creek. An alkali (lime) is added to the acidic water to be precipitated in a settling tank. The final product water, near the neutral value of pH 7, is then released into the nearby Dawesley Creek.

The sludge (predominantly gypsum) is placed in sludge lagoons at the site, while the release water is passed into a first holding pond on site, and then a second near the creek, before entering the creek. Even though collection and treatment has continually been expanded and improved over the last decade, the impact on Dawesley Creek of the un-intercepted portion of acid seepage has continued.

2.3 Possible Remedial Activities

The release of treated waste from the mine site into Dawesley Creek has been licensed. A requirement of this license is for an Environmental Improvement Program to be established to meet the principal objective of the EPA Act. A Brukunga Mine Site Remediation Board has been established and public forums have been held.

Water quality monitoring is being undertaken in the creek, upstream and downstream to better determine the extent of the impact of the site on Dawesley Creek and provide data for the consideration of remediation measures.

A number of activities associated with improving the water quality are in train, or could be expanded or carried out in the future:

- Interception of seepage from the tailings dam to dramatically reduce the volume of fugitive leachate from this area.
- Improvements in surface water drainage around tailings dam storage area.
- Installation of addition seepage wells along the creek to further reduce leachate entering the creek from the mine area.
- Further modification and expansion of the acid leachate collection system.
- Improvements to the treatment plant.
- Construction of a new slurry pipeline from the treatment plant to the main mine site for storage in drying lagoons and possible future use of sludge as a capping medium.
- Diversion of stormwater away from the site to reduce the total volume of contaminated water.
- Removal and rehabilitation of the neutralisation plant sludge storage ponds.
- Installation of additional surface drainage across quarry benches.
- Evapo-transpirative cover over the waste rock dumps.
- Tree planting.
- Use of biosolids to encourage growth.

- Relocation of part of the rock dumps to the quarry and the re-contouring of all slopes.
- Filling and sealing voids on the quarry benches.

Some of these measures are for the long term and could be of very high cost, such as the re-location and capping of waste rock back to the quarry. Others, such as tree planting, are on-going and are achieving significant improvements.

However, it has been noted that a significant further improvement of downstream water quality could be achieved if the clean stream water could be isolated from the mine site seepage by diverting it past the site. The existing stream bed could then act as a collection sump for the acid seepage waters which could be collected and de-acidified prior to again joining the clean bypass waters. This possible diversion scheme is the option addressed in this report.

2.4 Diversion Proposal

The diversion of Dawesley Creek around the mine site and enhanced provisions for seepage collection and treatment, although simple and direct in concept, present several aspects which must be studied in detail so that appropriate solutions may be canvassed. These areas principally relate to the hydrology of all the streams and creeks in the area of interest and the engineering feasibility and cost of implementation. The hydrological matters have great importance because of the statistical or probabilistic nature and great variability of flow in streams such as Dawesley Creek.

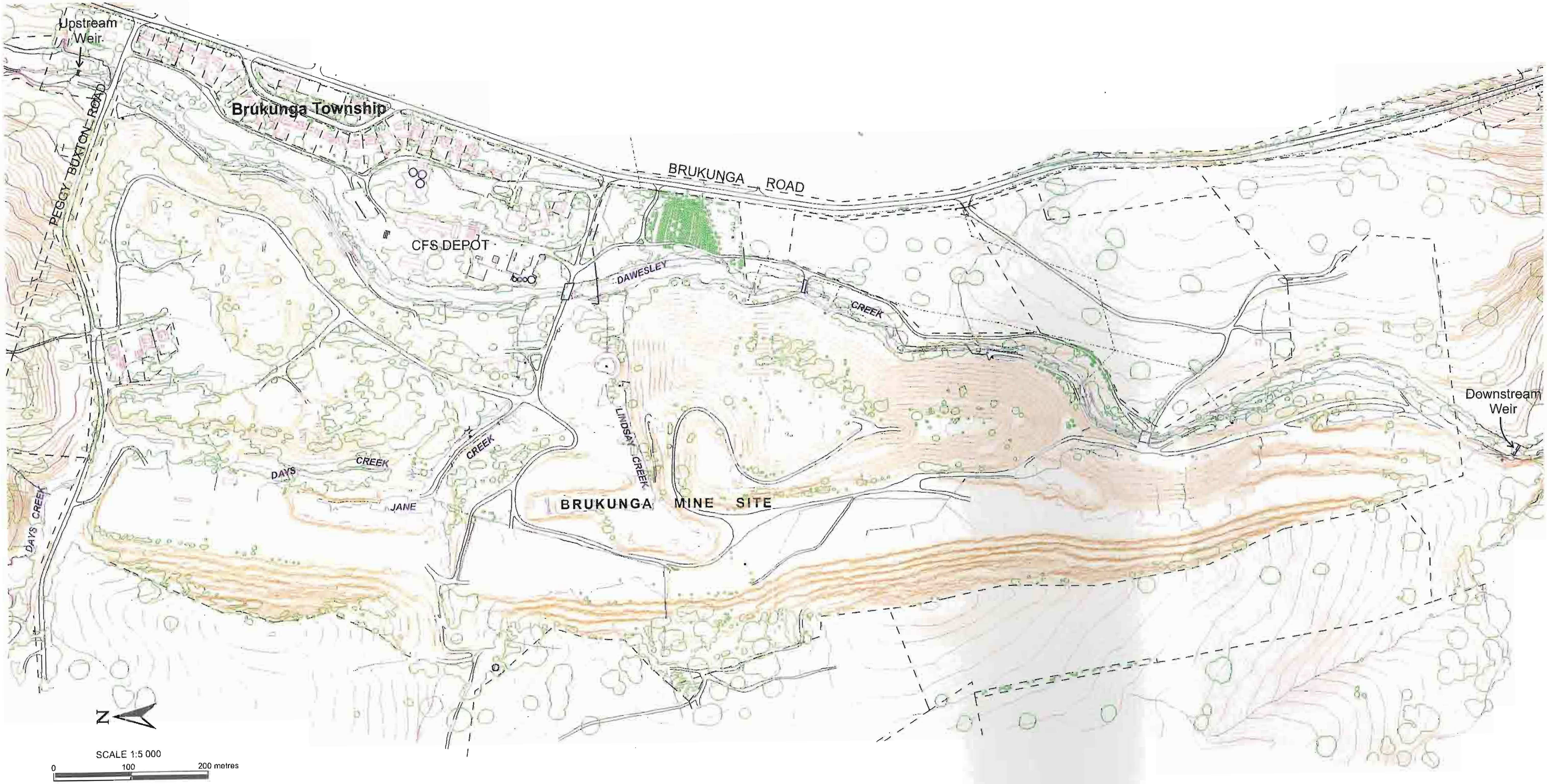
It is accepted in our Brief that, although the Dawesley Creek flow should pass through the diversion most of the time, it is possible to envisage that the highest flows, e.g. the flows which would occur on average less than once per year, could exceed the capacity of the bypass arrangements and the excess could flow down the existing creek bed. This would then flush through the seepage collection facilities and rejoin the diverted flow downstream of the site. The excess flow, although possibly polluted by seepage water, would be diluted when mixed with the high bypass flow.

With this principle applying, the diversion facility can have a known capacity, much less than the high flows in the creek that might occur during rare floods.

Similar considerations may be applied to lateral flows through the mine site itself which pick up acid contamination to form the leachate which is to be dealt with by water treatment. These matters are dealt with in detail in the report.

The other main area of concern is the engineering feasibility of carrying out stream diversion works in the Brukunga terrain and of providing new seepage collection and disposal arrangements. These matters and their effects on costs of implementation are also main components of the study.

Figure 2.1 shows the Brukunga mine site, the location of Dawesley Creek in relation to the mine site, and other significant features that impact on the potential for stream diversion.



Legend
Banks
Building
Fence
Index contour
Minor contour
Playground
Power
Road
Shed
Structures
Vegetation
Water features
Water structures

BRUKUNGA MINE REHABILITATION
Dawesley Creek at Brukunga Mine Site

FIGURE 2.1

3. Hydrology of Dawesley Creek System

3.1 General

To assess the impact of surface runoff from the Brukunga Mine on Dawesley Creek five water quality and quantity hydrometric stations were established in 1993:

1. AW426658 - Dawesley Creek upstream of Brukunga Mine
2. AW426659 - Dawesley Creek downstream of Brukunga Mine
3. AW426660 - Days Creek at Brukunga Mine
4. AW426661 - Lindsay Creek at Brukunga Mine
5. AW426662 - Jane Creek at Brukunga Mine
6. AW426665 - Rainfall at Brukunga Mine

In addition to these sites there is also a flow-monitoring site, Dawesley Creek at Dawesley (AW426558), which is four kilometres downstream from AW426659. SA Water (then EWS) installed this site in 1978.

The purpose of the following hydrological analysis is to determine the Average Recurrence Interval (ARI) of the 1 in 1 year flow of Dawesley Creek just prior to the Brukunga Mine site.

3.2 Dawesley Creek Hydrometric Sites - Site Descriptions

3.2.1 AW426658 - Dawesley Creek Upstream of Brukunga Mine

Period of Record: 20/7/1993 to Current.
Catchment Area: 24.2 square kilometres.

Upstream, Dawesley Creek rises in the hills behind Lobethal township, and collects water from the surrounding catchment. A major input to the Creek is the Lobethal sewage ponds (Bird-In-Hand Sewage Treatment Works), from which water is periodically released. It is generally considered that the water upstream of the mine is polluted through excessive nutrients.

At this site, flow and water quality is measured prior to contamination by the mine site. The catchment above this site is undulating to hilly and is primarily used for farming activities such as stock grazing and dairy.

3.2.2 AW426659 - Dawesley Creek downstream of Brukunga Mine

Period of Record: 29/7/1993 to Current.
Catchment Area: 27.3 square kilometres.

Located at approximately 4 km downstream of AW426658.

Dawesley Creek downstream of Brukunga, first joins Nairne Creek then Mt Barker Creek, before draining into Bremer River, which eventually drains into Lake Alexandrina.

Between the upstream and downstream site, acid drainage from the disused open cut pit and tailings dumps, is collected in sumps and pumped into a neutralisation plant nearby, before treated water is drained back into the Creek. Despite this interception the stream is contaminated by leaching and surface runoff from the mine site.

3.2.3 Days, Lindsay and Jane Creeks

Lindsay, Days and Jane Creeks are monitored tributaries that flow into Dawesley Creek from the west between the upstream and downstream sites. Days, Lindsay and Jane Creeks have small modified catchments, the largest being Days Creek with a catchment area of 1.2 square kilometres. Each of these streams have catchment areas which include areas within the mine site.

Most of the flows from these creeks are intercepted and lime treated off-site prior to entering Dawesley Creek; however, under high flow conditions some water will bypass to Dawesley Creek.

3.2.4 Small Catchments to the East of Dawesley Creek

Between the upstream and downstream sites, largely un-monitored flows from the east enter Dawesley Creek from the following areas: -

- Urban runoff from the Brukunga township.
- Lime treated (to neutralise the acid) water from the treatment plant. A proportion of this water is intercepted from Lindsay, Days and Jane Creeks.
- A small rural catchment of approximately 2.8 square kilometres.

The treatment plant lies near the site of the tailings dam, and neutralised water is returned to the Creek via holding ponds and channels. It is anticipated that this flow would contribute little to flood events. Run-off from the tailings dam area, township and associated rural catchments within the eastern catchment do contribute increases in flow.

3.3 Analysis - Determination of the One in One Year Average Recurrence Interval Flow in Dawesley Creek

3.3.1 Method

As previously mentioned (Section 2.4) it is recommended that low to medium flows be diverted through a closed system past the mine. Excess water during high flows would be allowed to flow down Dawesley Creek to provide a flushing effect and dilute contamination in the channel. To establish the design capacity of the diversion channel an Average Recurrence Interval (ARI) for the 1 in 1 year flow event was selected.

To determine the 1:1 ARI flow, the Log Pearson III Distribution method was used. This method is recommended and described in Section 10.5 of the reference Australian Rainfall and Runoff (ARR) - Volume 1 (Revised Edition 1987). With this method either Annual or Partial series may be used. Both series were tested and it was found that a more reliable estimate was obtained by using a Partial Series. This is because it was found that the Annual series distribution resulted in a 'negative skew' which according to ARR is not suitable for determining low ARI's such as the 1:1. The 'fit' was also poor. The Partial Series analysis gave a 'positive skew' and a better line 'fit'.

3.3.2 Flow Data

Before the Log Pearson analysis was carried out the flow data for the upstream site (AW426658) was carefully compared with the flow at the downstream site (AW426659). It was found that the medium and high flow events did not correlate very well with the downstream site (AW426659) and in many instances the peaks were higher than the downstream site, which is not possible. The reason for this discrepancy is that the weir calibration at the upstream site overestimates the flow because at approximately 0.2m (head of water) the weir is effected by tail-water. This effectively reduces the flow for a given water level and the weir calibration no longer holds true (flow is over-estimated).

The SA Water hydrometric site at Dawesley (AW426558) has 22 years of reliable flow data. A correlation between the two sites, AW426658 and AW426558, was carried out. There was a good correlation between the two sites, in particular for the low to medium flows (up to 3 cumecs). This correlation was used to correct and extend the flow data at the upstream site (AW426658). The modified flow data was used to estimate the ARI 1:1 year flood event.

3.3.3 Log Pearson III Analysis - Upstream Site (AW426658)

HYDSYS, a hydrological data analysis software package, was used to carry out the Log Pearson III data analysis. The system establishes a Partial Series according to the following definition: -

'A partial peak is defined as an event which exceeds a discharge of Q_{min} then drops below Q_{min} again, with independent peaks being at least T_{min} minutes apart. Peaks less than T_{min} minutes apart are deemed to be related events, and the highest peak only is taken. If Q_{min} is specified too high, there may be fewer partial peaks than there are years of record'.'

Different Partial Series were calculated, by changing the Q_{min} and T_{min} values. It was found that the ARI 1:1 year ranged from 0.8 m^3/sec to 4.5 m^3/sec.

ARR recommend that the partial series should have no more than 3 to 4 flood peaks per year. Using this as a guide and by trial and error a Partial Series was established from the extended flow data where Q_{min} was set at 3.5 m^3/sec and T_{min} was 1,440 minutes.

By adopting this Partial Series the Log Pearson III analysis estimated that for an ARI of 1:1 years the flood peak is approximately 4.5 m³/sec (see Figure 3.1). Note that the flow that might occur on the average once in 200 years is approximately 20 m³/sec.

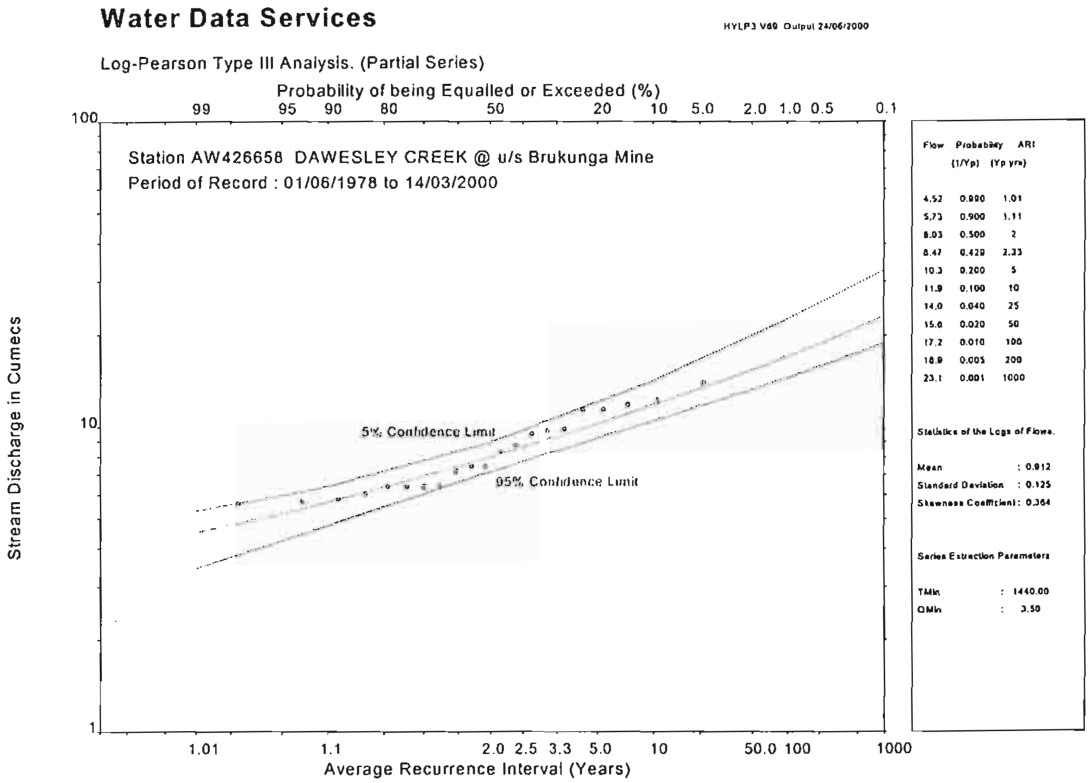


FIGURE 3.1
Log Pearson III Analysis - Upstream Site (AW426658)

3.3.4 Log Pearson III analysis - Days, Lindsay and Jane Creeks

A similar procedure as in Section 3.3.3. was used to determine the 1:1 year ARI flow for Days, Lindsay and Jane Creeks. The following results were obtained:

Stream	ARI 1:1 Flow m³/sec
Days Creek	0.061
Lindsay Creek	0.031
Jane Creek	0.043

However, the period of record for these creeks is not of sufficient length to give these figures reliability. The creeks are discussed in more detail later in the report.

3.4 Proposed Capacity of the Dawesley Creek Diversion

It is proposed to divert the ARI one year flow of 4.5 m^3/sec into a bypass to the existing creek. Figure 3.2 is included to illustrate the rarity of flows in excess of this. Note that flows are less than the ARI 1 year flow approximately 99.5% of the time.

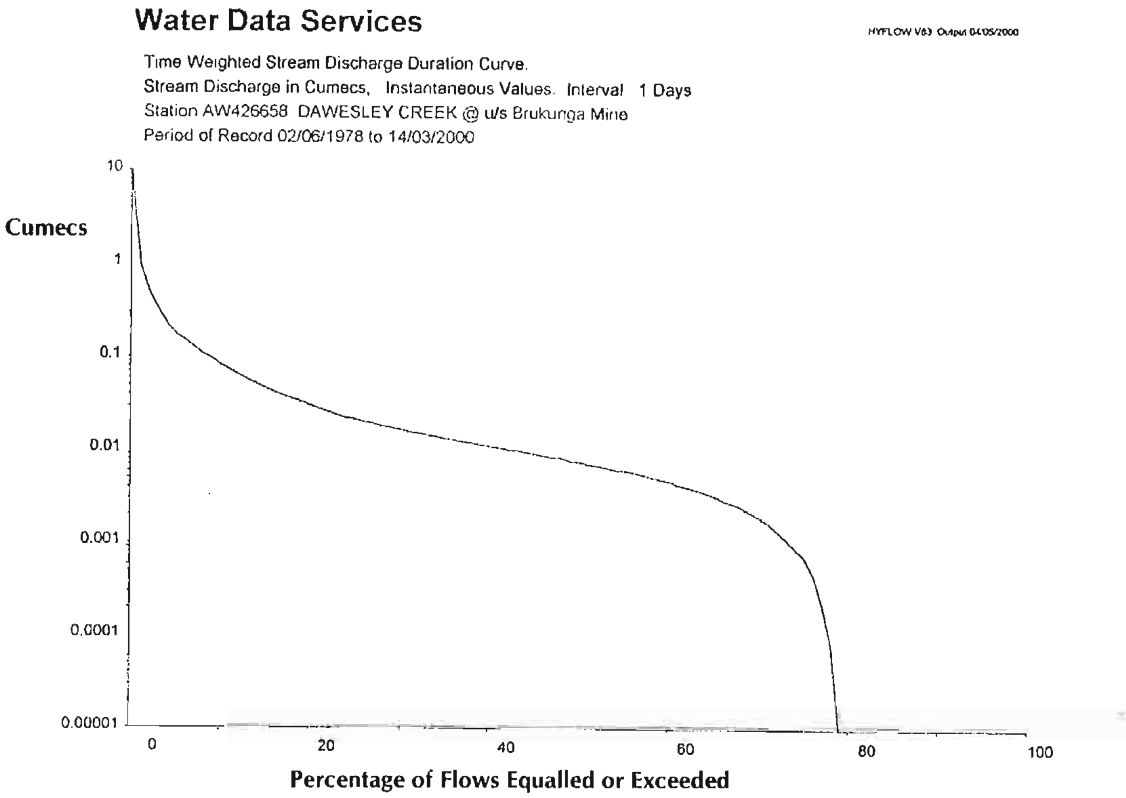


FIGURE 3.2
Dawesley Creek — Discharge Duration Curve

4. Water Balance of Mine Site

4.1 Introduction

Hard-rock mining can have a significant effect on local hydrology. In the case of Brukunga, mining has created walls and benches of hard rock, which shed a large proportion of the rain that falls upon them, increasing runoff compared to the pre-mining landscape. The waste rock dumps are in general more porous than the previous landscape, and may have less surface runoff, but because of the lie of the land act as 'sponges' that will release infiltrated water at a faster rate than the original soil profile. The overall result is that the contribution of surface water from the mine, much of it contaminated, is relatively greater for the area of catchment involved than the rest of the catchment of Dawesley Creek.

4.2 Semi-quantitative Water Balance Model

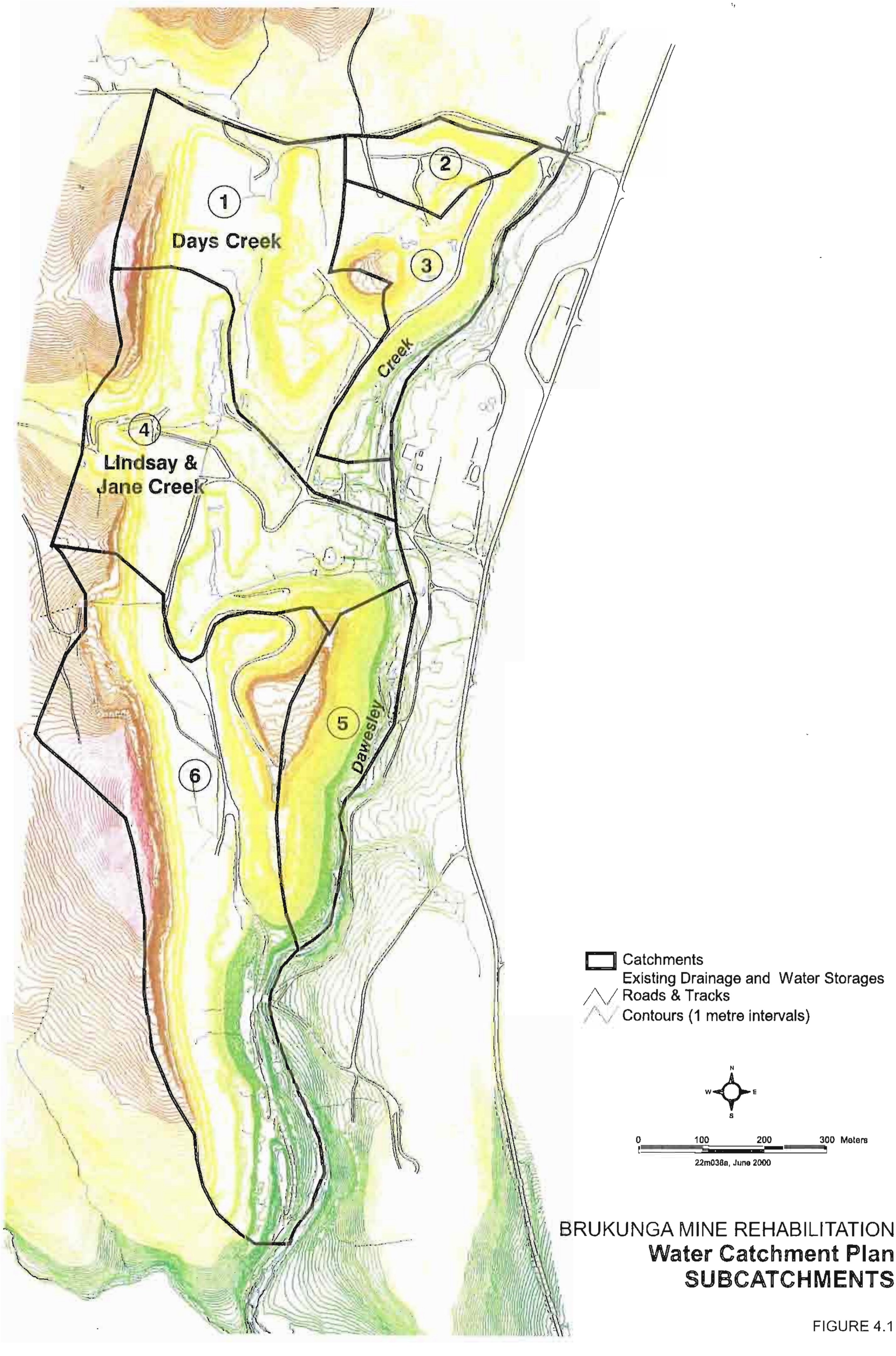
For a first-pass estimate, the mine area has been divided into six subcatchments based on detailed topography and known drainage diversions (Figure 4.1). A schematic showing expected water flows, including pumping to the water treatment plant and leakage or overflow from water management structures is shown in Figure 4.2.

The mine subcatchments were considered together with external subcatchments that contribute to flow in Dawesley Creek between the upstream and downstream gauging stations. Areas of the subcatchments were measured by planimeter. A water balance for that creek segment was estimated using catchment areas, approximate proportions of four categories of runoff characteristics, and known rainfall data. Using 1999 flow and rainfall data to calibrate, by trial and error, a spreadsheet model was used to estimate the average runoff coefficient and therefore flow contribution to the creek segment. The results of the model are summarised in the table below (Table 4.1). Data were considered on an annual basis only, and do not take into account the time variation of flow in shorter time periods.

The model corroborates the qualitative assessment, in that the mine site makes up about 24% of the catchment of the segment of Dawesley Creek between the two gauging stations, but is estimated to contribute 78% of the water flow. The relative contribution of Lindsay and Jane Creeks is particularly high because the catchment is all 'flat rock' that sheds about 70% of rain as runoff.

4.3 Implications of Water Balance Model

The relative contributions of the different sub-catchments allow prioritisation for exclusion of clean from the contaminated water. The proposed diversion scheme would intercept the eastern catchments of Brukunga Township and the tailings dam (via the treatment plant), and reduce the contribution of water to the isolated segment of Brukunga Creek by approximately 13%. Diversion of upper Days Creek, if feasible, would reduce flow by a further 7%. However, the diversion of the upper western

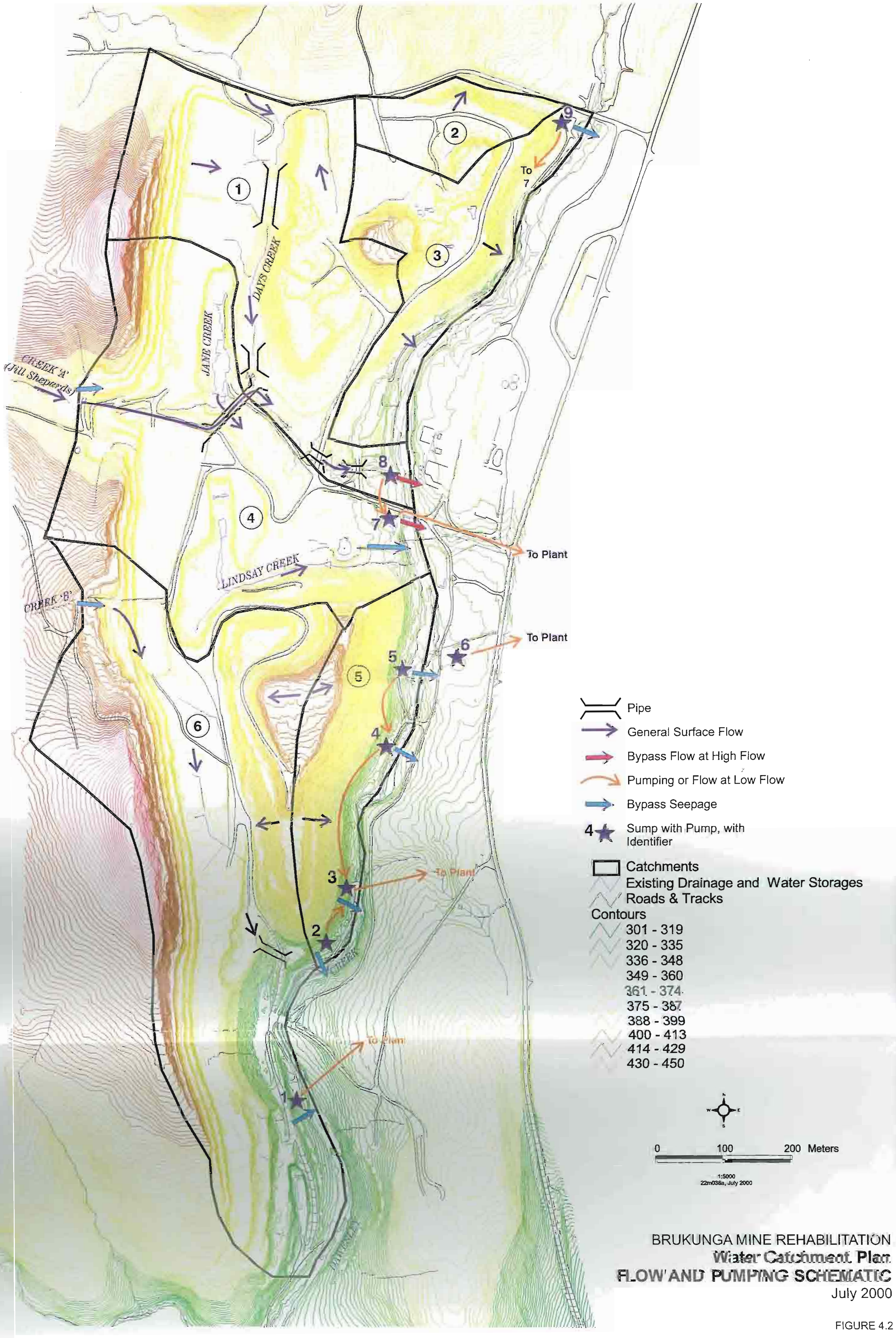


BRUKUNGA MINE REHABILITATION

Water Catchment Plan

SUBCATCHMENTS

FIGURE 4.1



BRUKUNGA MINE REHABILITATION

Water Catchment Plan

FLOW AND PUMPING SCHEMATIC

July 2000

FIGURE 4.2

creeks above the mine would only reduce creek inflow by approximately 2%, such that the priority of improving the diversion of these creeks is low.

Table 4.1 Subcatchments, Runoff Coefficients and Contribution to Creek Segment Flow

Subcatchment	Area	Flat Rock	Rock Dump	Pasture (moderate Slope)	Hills (steep slope)	Weighted Runoff Coefficient	Contribution to segment flow
Unit	m^2	%	%	%	%		%
Runoff Coefficient		0.7	0.3	0.025	0.05		
(1) Days Ck south of Peggy Buxton Road	132,000	70	30	0	0	0.580	15%
(2) North East	38,200	0	95	5	0	0.286	2%
(3) Northern Rock Dump	77,600	0	100	0	0	0.300	4%
(4) Lindsay/ Jane Creeks	165,000	100	0	0	0	0.700	22%
(5) Central Rock Dump	64,400	0	100	0	0	0.300	4%
(6) Southern Mine Area	263,000	85	10	5	0	0.626	31%
Subtotal Mine Subcatchments	**740,200 (24%)**						**78%**
Town Catchment*	644,000	5	5	90	0	0.073	9%
Tailings Dam	356,000	0	10	90	0	0.053	4%
Upper Days Creek	1,040,000	0	0	50	50	0.038	7%
Upper Western Creeks (A&B)	356,000	100	0	100	0	0.725	2%
Subtotal Other Catchments	**2,396,000 (76%)**						**22%**
TOTAL	**3,3136,200 (100%)**						**100%**

* Excluding Tailings Dam

In order to provide a preliminary design for the interception detention basin, more detailed runoff calculations were undertaken using a design storm and standard engineering techniques, utilising the catchment areas and runoff coefficients established by the water balance model. These are detailed in Section 6.

5. Possible Diversion

5.1 Alignment Possibilities and Constraints

Dawesley Creek, from Peggy Buxton Road to the downstream gauging station, falls approximately 30 m in approximately 2000 m. This falling gradient would appear to give scope for a suitable diversion alignment to be found. However, there are significant constraints in that the terrain away from the creek does not maintain the creek's relatively even falling gradient. There are flatter sections with wider 'flood plains' and sections with steeper, rocky side slopes. The presence of a large CFS Depot just south west of the township, approaching close to the creek's eastern bank presents an alignment obstacle. There are site roads and tracks and also large trees which must be considered. As indicated previously, Figure 2.1 illustrates the alignment of Dawesley Creek and several of the features referred to above.

5.2 Geological/Ground Conditions

The geological conditions of this region are dominated by the Brukunga formation; interbedded phyllites and greywacke with lenticular pyritic and calc-silicate lenses. Visual inspection has shown that rock is at shallow depth, as evidenced by visible outcrops and steeper hill slopes, over the southern part of the creek alignment as it passes the mine site. On the northern part of the alignment there are flatter slopes and river alluvium is in evidence. We have judged ground conditions with regard to any proposed construction works in accordance with these observations.

It is noted that before a final design for any works could be formulated a geotechnical investigation along the proposed alignment would be required. This would aid in determining rock presence and the ease of excavation.

5.3 Channel v Pipe

The alternatives exist to convey the diversion of Dawesley creek through a pipe, channel or a combination of these. Due to space constraints at the CFS Depot we have determined that the diversion should pass through a culvert-like pipe section to avoid severance of that site. Over other sections we have either the pipe or channel option.

Fundamentally, where gradients and ground conditions are suitable, an open channel will be more economical than a piped conduit, because the excavation for the pipe will be of the same order as for the channel, so the pipe is extra in cost. Where the open channel is to be lined, then the basic comparison is between pipe cost and lining cost.

We would propose the application of stone filled wire mesh mattresses as the lining medium. These have been found to be of successful application in similar channel work in South Australia. The mattresses become silt filled and vegetated over a period of time and form an excellent long term solution to channel lining.

The type of pipe to be considered is required to have good flow characteristics and high abrasion resistance, the latter because the discharge would have the potential to abrade pipe walls due to sediment content. A suitable pipe having high abrasion resistance would be High Density Polyethylene pipe, commonly used in mining applications. Other pipe materials such as steel and reinforced concrete would be of the same order in cost, but not as suitable because of erosion, and in addition for steel, the need for corrosion protection.

It would be expected that over the life of the diversion some degree of maintenance may be required. A channel is the better alternative in this respect due to the ease of inspection and accessibility for repair. A channel also has the advantage in its ability to receive sheet flows from the uphill terrain and any small watercourses intersected. Water would be able to flow directly into the channel without the need for a collection arrangements and pits that would be required for a pipe.

Our basic selection is thus for an open channel for the diversion, lined where necessary for erosion control and with an impervious backing liner where seepage into or out of the channel should be controlled. Piping is to be considered where appropriate, such as through the CFS Site. Where the channel is to be excavated through rock no lining will be required. Sections of pressure pipe will be considered if the terrain suggests that application, but the requirements for air relief and pressure valves and their maintenance would be a disadvantage.

5.4 Alignment Description

The diversion alignment has been divided into four sections for description purposes. These sections are designated A,B,C&D and are illustrated on the Figures 5.1 to 5.3.

5.4.1 Section A

Section A (see Figure 5.1) follows a course between the housing allotments of the township of Brukunga and Dawesley Creek. The surface slopes gradually to the creek over the mainly alluvial ground.

It is proposed to enter this section at an invert elevation of 349 m. An earth channel would approximately parallel the natural creek line, whilst aiming to maximise the horizontal and vertical distance between the channel and the creek. This would remove the potential of seepage either way between the channel and the creek. However, an allowance would be made for a distance of 75 m through softer ground to be protected by rock filled mattresses backed by geotextile and an impervious membrane.

The trapezoidal channel would have a bottom width of 1 m and be approximately 1.0 m in depth. As the likelihood exists that the public will access this section, channel side slopes would not be steeper than 1 vertical to 4 horizontal. Flow velocity would generally be less than approximately 1.25 m/sec.

5.4.2 Section B

The sides of Dawesley Creek steepen as the channel enters Section B (see Figures 5.1 and 5.2) and the development associated with the CFS encroaches upon the creek side. Due to these factors it would not be feasible to construct a channel through this section. It is proposed to cut through the CFS grounds, laying a culvert pipe at depth. An alternative exists to lay a pipe in the creek bed, but during flood this would be prone to damage, hence it is preferred to pipe under the CFS.

An alignment has been chosen and work can be completed efficiently to reduce site disruption. An entry headwall would accept the flow from the channel into the pipe. The pipe will need to be laid at a depth in excess of 2 m underneath the CFS. A junction box would be located along the length of the pipe to accommodate a change in direction. The pipe line would continue, passing under the main access road of the mine to open out into a channel section.

5.4.3 Section C

In Section C (see Figure 5.2) the channel enters a section of low relief. In order to follow a suitable grade line it will be necessary to make some modifications to the site road in the first part of this section. The channel would then follow an alignment to the east of the roadway. Channel side slopes in this section would be 1 vertical to 2 horizontal in earth and 1:1 in rock. Bottom width would be 1.5 m.

There is a localised area in this section which will require fill of less than 1 m in depth to support the channel alignment. Alternatively, the alignment could be diverted slightly to remain in natural ground.

It is proposed that clean water flows from the treatment plant and any local catchment drainage from the east will be collected into the channel over this section.

Due to the alignment of the channel being across a section of lower ground, an impervious geoliner would be used in combination with a rock mattress to prevent seepage either into or out of the channel over a section of approximately 75 m.

5.4.4 Section D

Section D (see Figures 5.2 and 5.3) traverses a ridge and crosses a valley along its length. Rather than take a course down to lower elevations to avoid the ridge, deeper rock cuts across the ridge. Steeper side slopes of 2 vertical to 1 horizontal are proposed in the deeper rock cut areas. Bottom width would be 1.5 m.

Terrain nearer the creek is significantly steeper, which would make civil works there more difficult. Cuts follow the gradient of the land to minimise the depth. Flows are to be collected from the side valley which is intersected in this section.

The channel is to continue along the higher side of the road. It is envisaged that due to the rocky nature of the ground through this section channel lining will not be necessary. The channel however, would need to be fenced to protect stock and any persons having access to the channel alignment.

5.4.5 Section E

Along Section E (see Figure 5.3) it is proposed that the channel pass under a side road to the east through a culvert and that it also collect overland flow in this region. Side slopes would continue as 2 vertical to 1 horizontal.

Beyond this point the channel would follow a suitable gradient along the hillside, dropping in elevation uniformly to enter the creek below the acid seepage collection basin. As for the previous section, it is not expected that lining would be required.

5.4.6 Cross Sections

Cross sections as located on Figure 5.3 are included to illustrate the manner in which the diversion fits into the terrain.

Cross-section 1 (Figure 5.4) shows the diversion channel located within the flood plain west of the Brukunga township allotments.

Cross-section 2 (Figure 5.5) illustrates the culvert section passing beneath the CFS Depot.

Cross-section 3 (Figure 5.5) is of the channel passing through the section just south of the existing plantation area.

Cross-section 4 (Figure 5.6) shows the deeper rock cut to carry the diversion through the hilly terrain in the southern section of the alignment.

A photograph of a section of channel lined with rock-filled mattresses similar to that proposed through sections of ground subject to significant erosion, is shown in Figure 5.7. Approximately 20% of the channel through earth alignment has been allowed to be protected in this way.

5.5 Upstream Diversion Weir

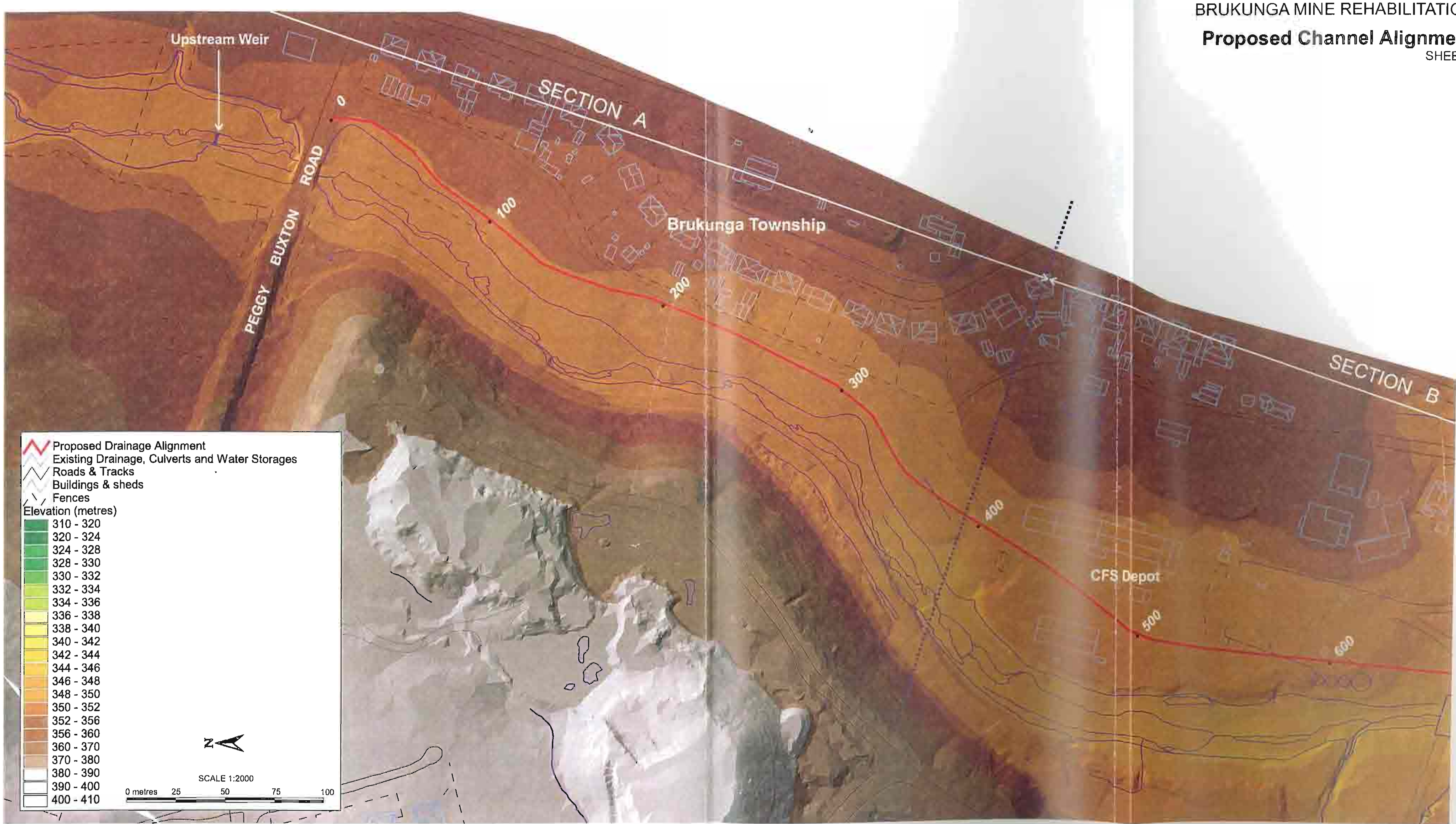
An upstream weir is proposed to divert flow from the Dawesley Creek into the diversion channel. The weir would be sited upstream of Peggy Buxton road. The area upstream of the weir has a limited holding capacity due to topography and nearby development and is considered not to be suitable as a detention basin. However, there will be a small detention capacity as water rises above the level of the diversion channel invert. Figure 5.8 indicates the location of the diversion weir.

The reduced level of the road at the culvert is RL 350 m. The weir spillway may be approximately 1 m above this level without flooding adjacent facilities. Below the spillway level of the weir a channel and pipe would convey the flow to and under Peggy Buxton Road to the commencement of the diversion channel. When flows

BRUKUNGA MINE REHABILITATION

Proposed Channel Alignment

SHEET1



Proposed Vertical Alignment

Exaggeration 10.0 X

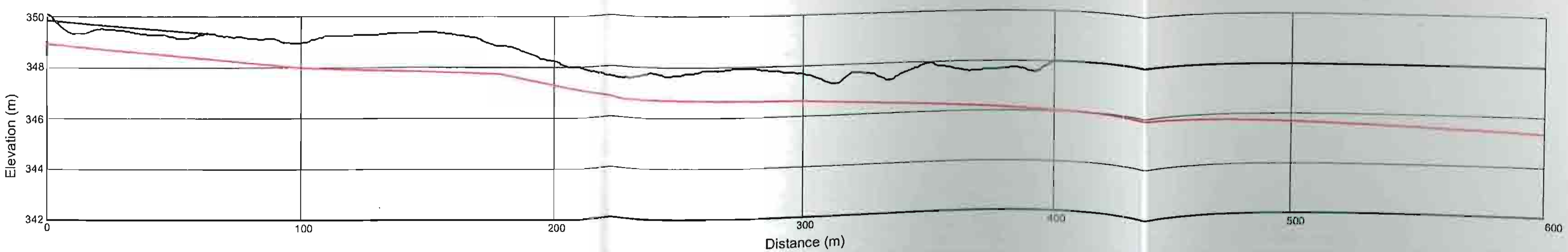
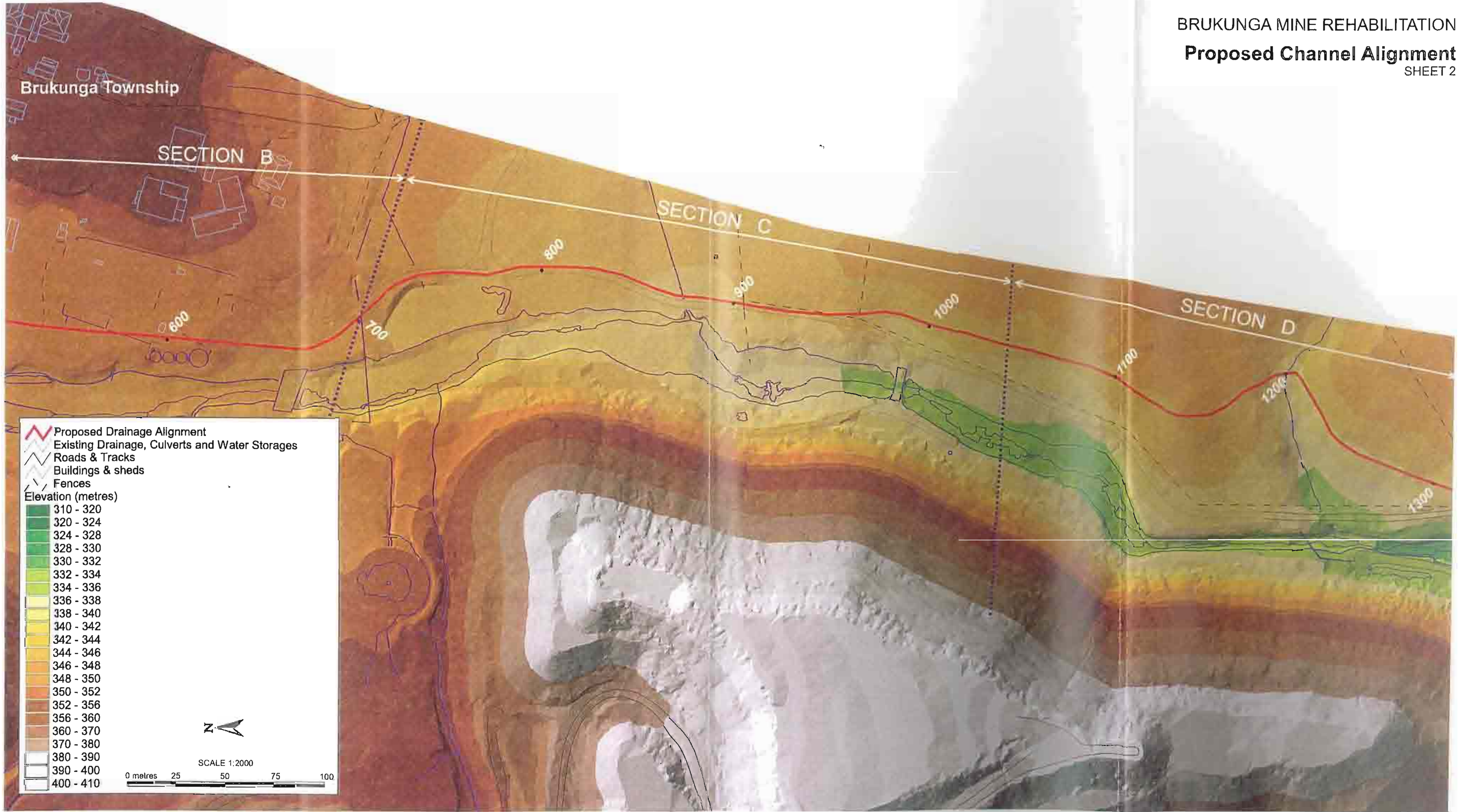


FIGURE 5.1

Proposed Channel Alignment

SHEET 2



Proposed Vertical Alignment

Exaggeration 10.0 X

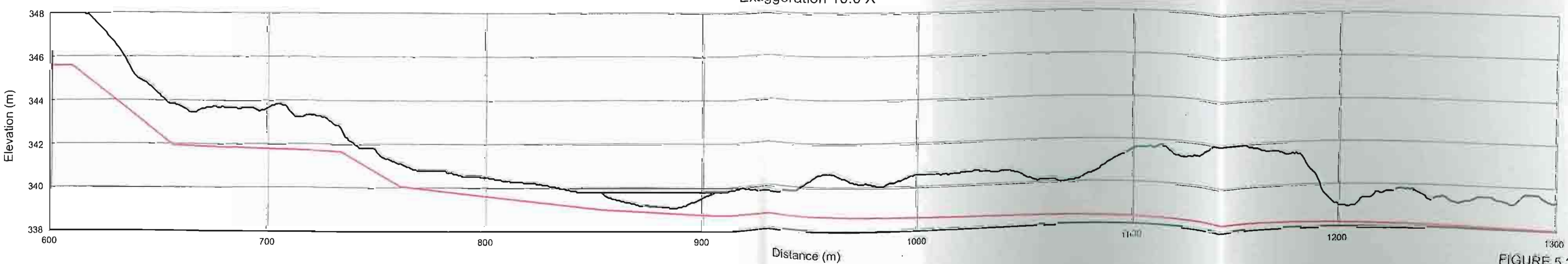
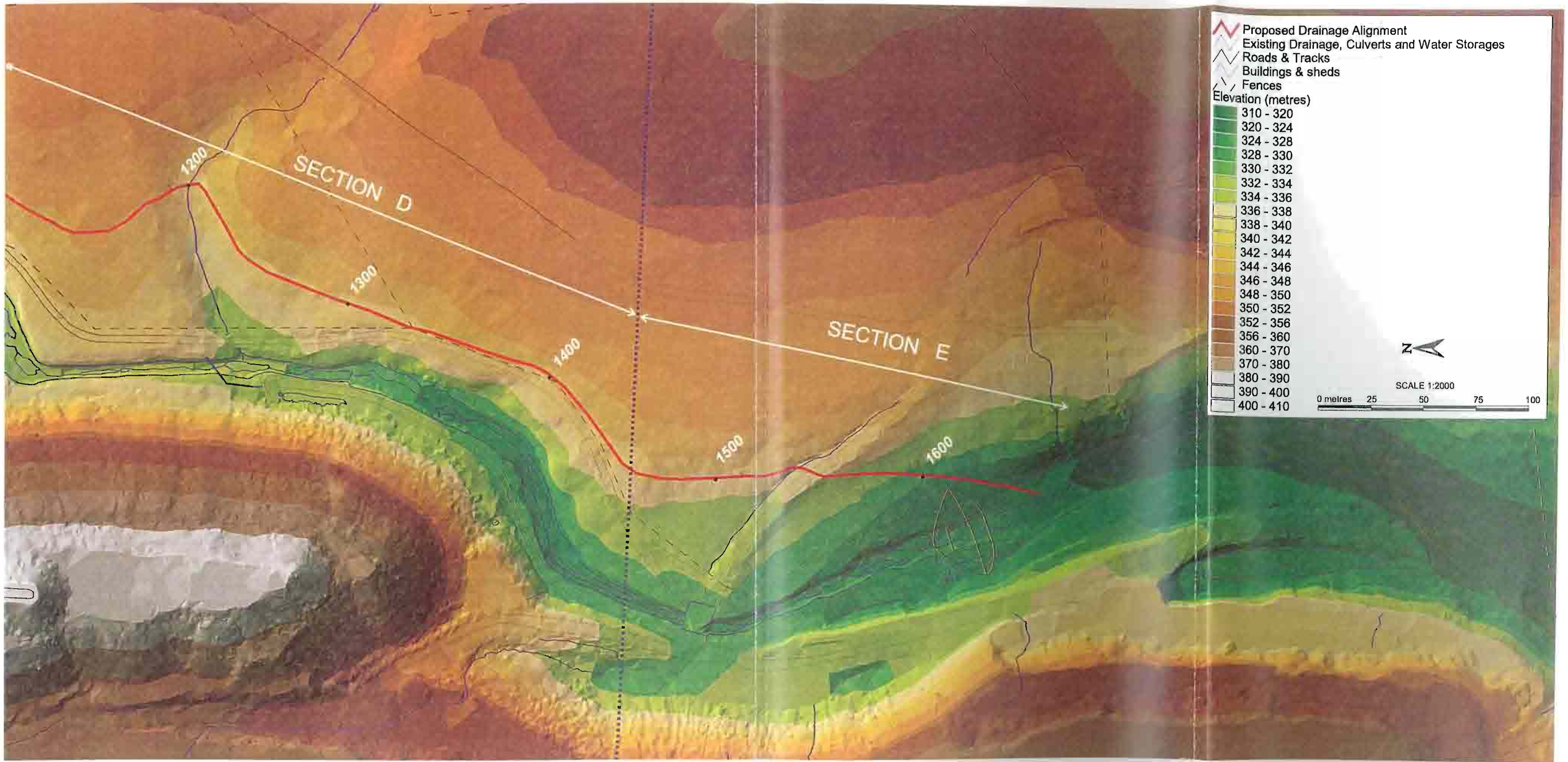
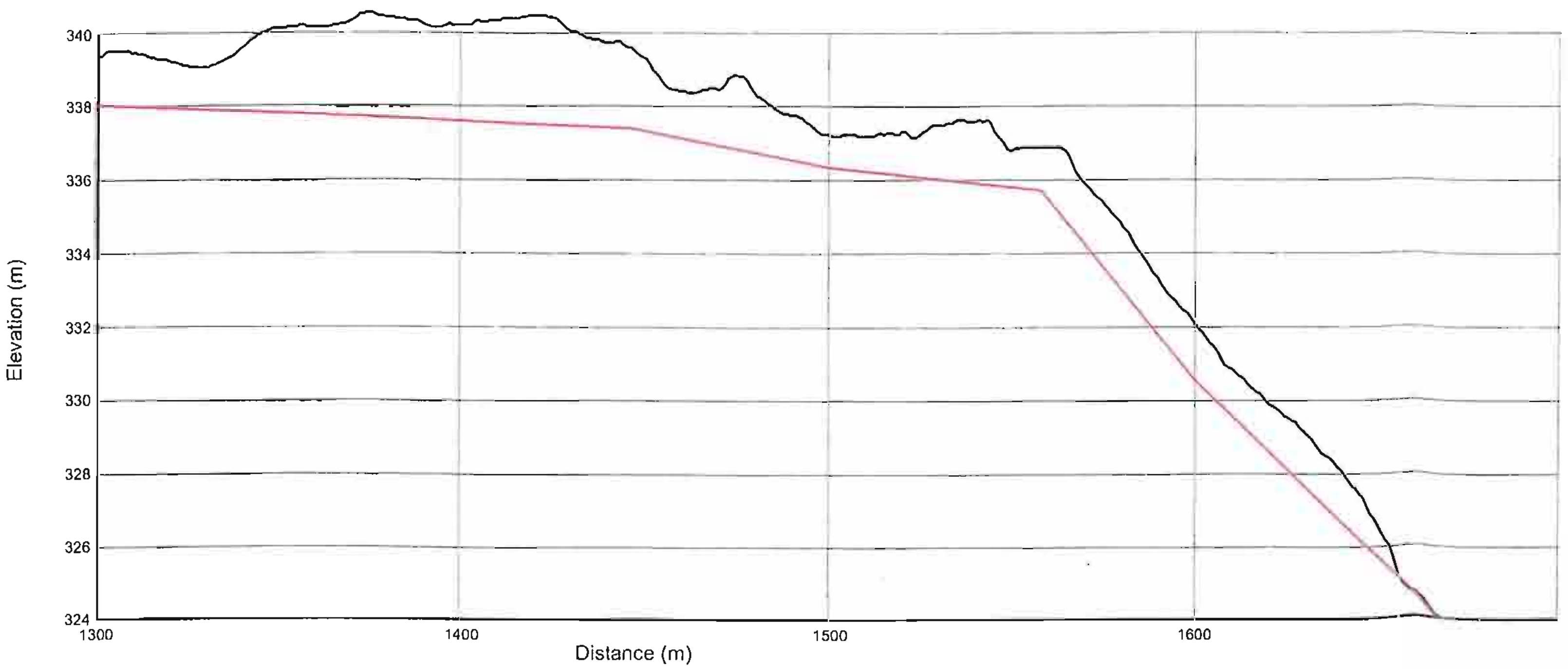


FIGURE 5.2





Proposed Vertical Alignment

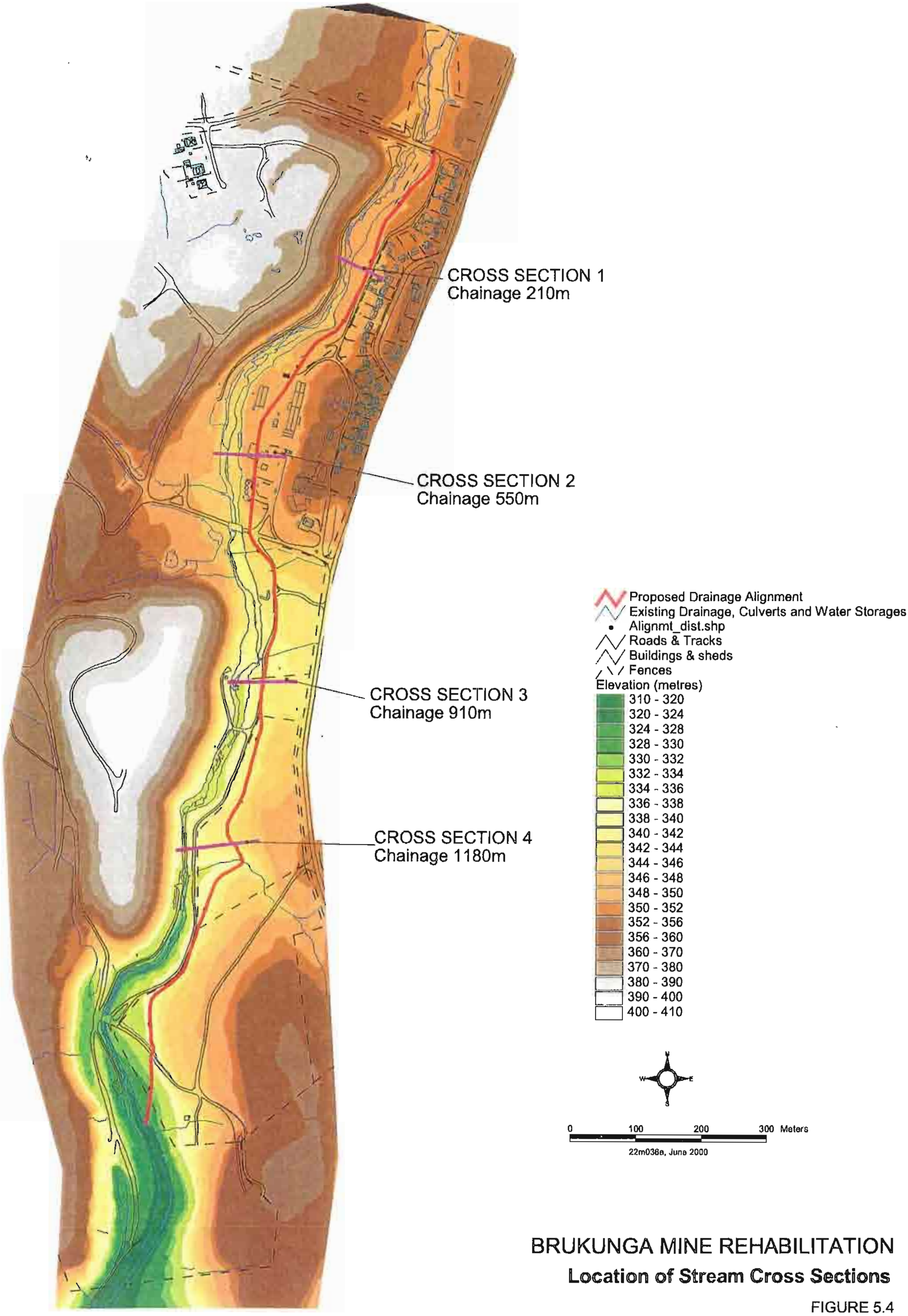
Exaggeration 10.0 X

BRUKUNGA MINE REHABILITATION

Proposed Channel Alignment

SHEET 3

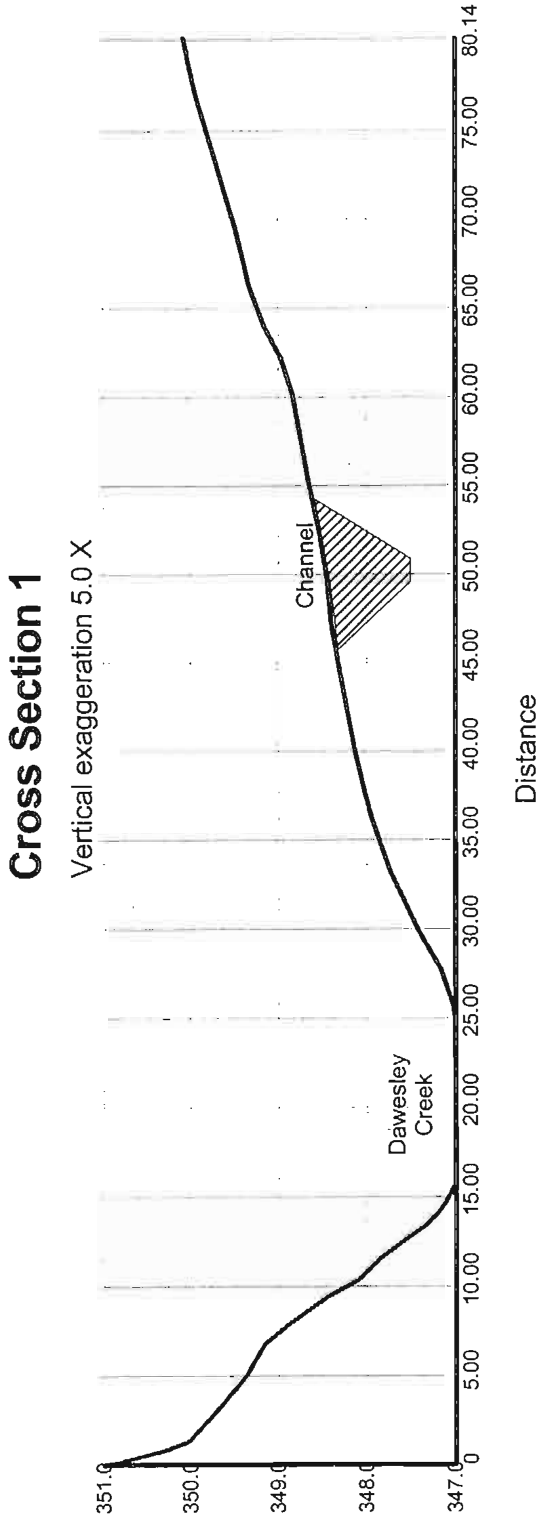
FIGURE 5.3

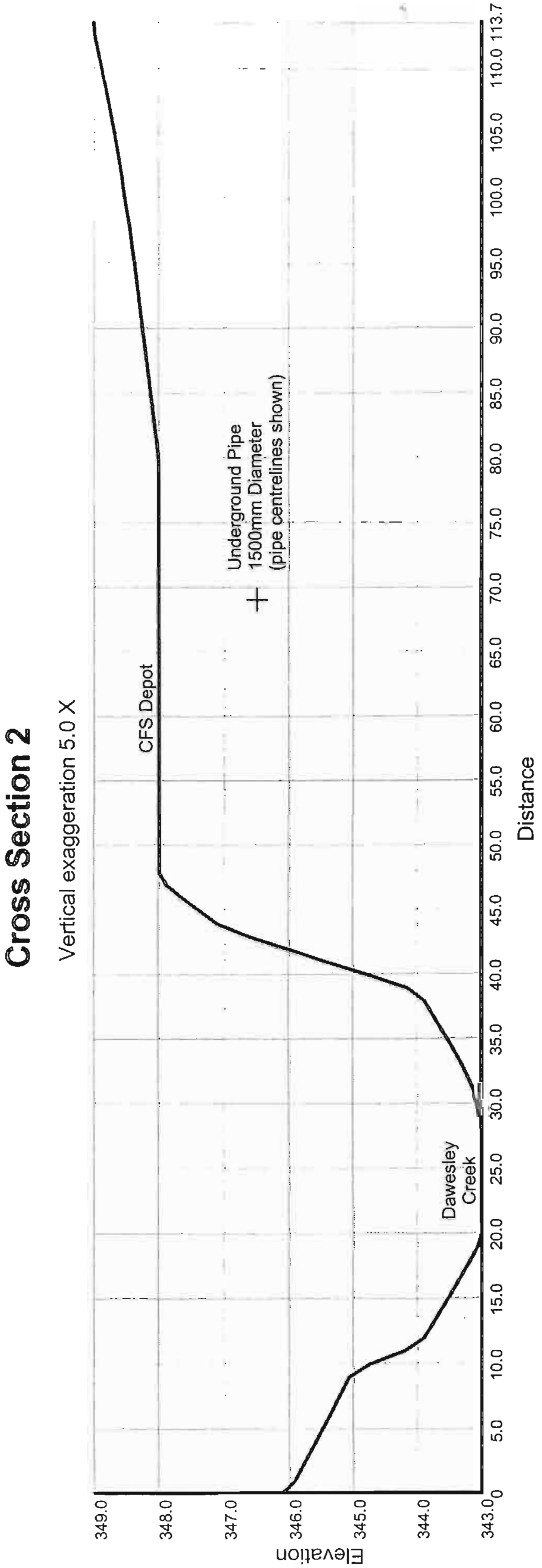


BRUKUNGA MINE REHABILITATION

Location of Stream Cross Sections

FIGURE 5.4



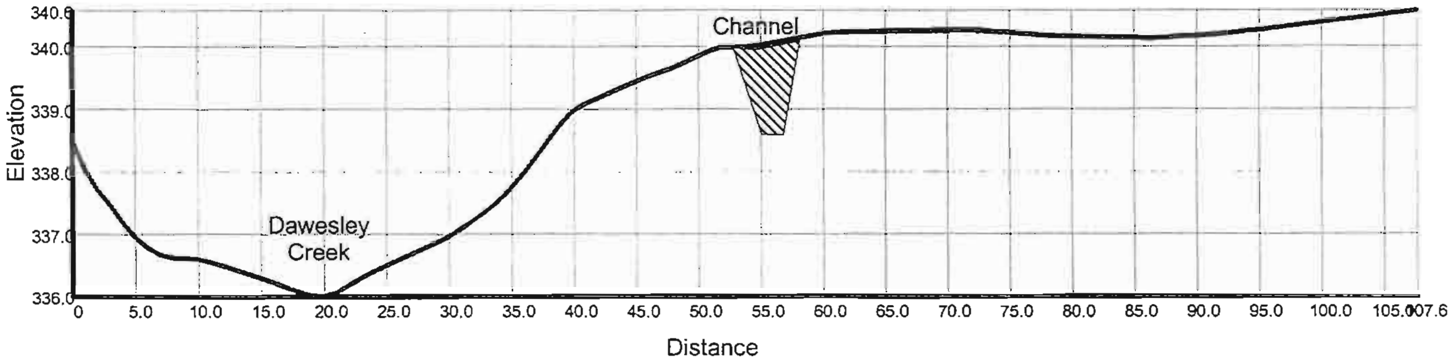


Cross Sections 1 & 2

FIGURE 5.5

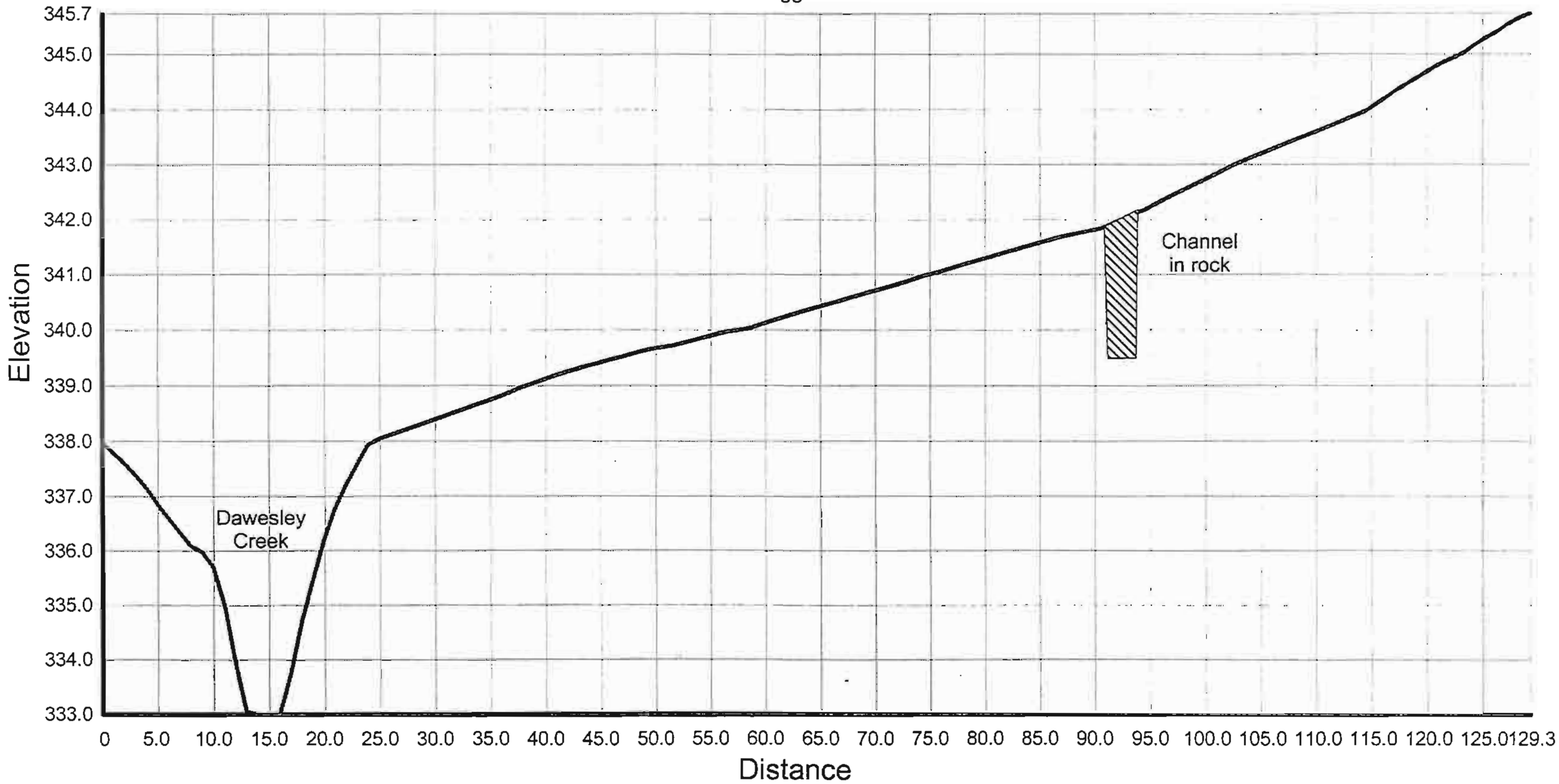
Cross Section 3

Vertical exaggeration 5.0 X



Cross Section 4

Vertical exaggeration 5.0 X



Cross Sections 3 & 4

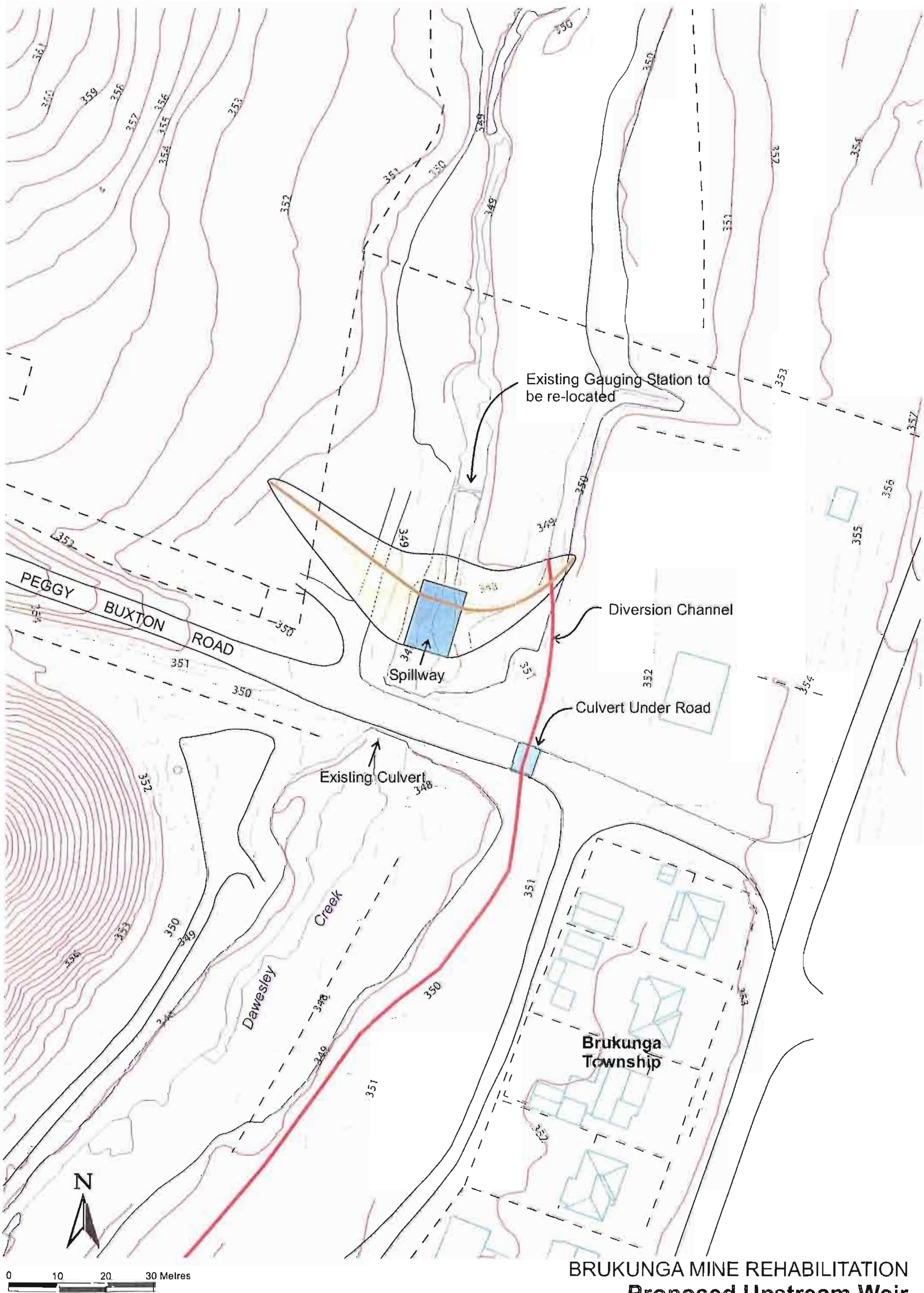
FIGURE 5.6

NOTE: Above channel is of larger dimensions than proposed for Brukunga. Approximately 20% of channel extent in earth materials is to be lined as shown for erosion protection.

BRUKUNGA MINE REHABILITATION

Example of Mattress Lined Channel

FIGURE 5.7



BRUKUNGA MINE REHABILITATION

Proposed Upstream Weir

FIGURE 5.8

exceed the channel capacity, the spillway would be overtopped and the additional flow would pass down the existing creek. Such an arrangement avoids any disruption to the existing culvert system under Peggy Buxton Road. The spillway, together with the diversion, would have a total flow capacity of the maximum likely flow. The spillway would have a capacity of approximately 15 m^3/sec.

As a result of the proposed weir it would be necessary to reinstate the present monitoring weir further upstream of the diversion weir. Trees in the vicinity of the weir will need to be protected, as the storage volume behind the weir would cause an area to be engulfed by water for much of the rainy season. It would be proposed that a small island be created surrounding each tree to preserve its viable condition.

5.6 Downstream Basin and Diversion Return

The flow in the diversion would be returned to Dawesley creek downstream of the seepage collection basin as indicated in Figure 5.9. Since the terrain in this location is rocky, the gradient of the channel as it returns to the creek alignment may be steep without flows giving rise to significant erosion.

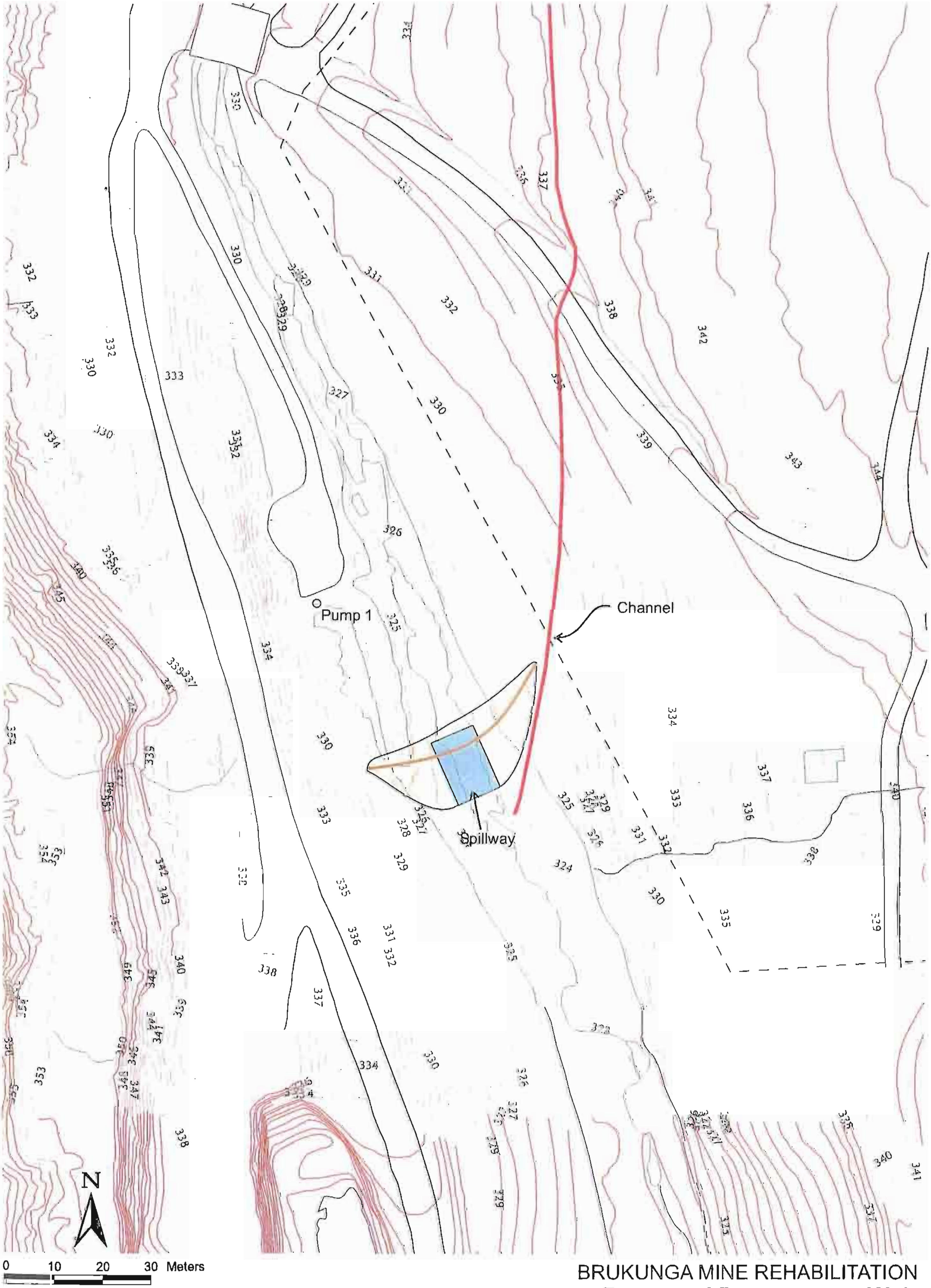
The seepage collection basin is sited some 300 m upstream of the downstream monitoring weir, since below this location there is little observed acid seepage from the rocky mine benches. A simple cut-off drain directed back to the downstream basin could be provided to intercept any run-off from the downstream mine area. The basin is placed well within the property boundary of the mine and its location also has the effect of shortening the overall length of the diversion.

The dam is in a location where the stream banks are almost parallel and variation to the storage volume could be achieved by locating the dam further upstream or downstream with little change to dam construction. Channel length could be adjusted accordingly. It is noted that the final outlet of the diversion channel could be combined with the dam spillway if final design showed an advantage in locating the spillway at the eastern end of the dam. Dam construction materials would be selected for economy and to achieve the required impervious quality of the wall. The availability of channel excavation material will benefit the construction of the dam.

5.7 Flooding Potential

It can be noted that the provision of a separate creek diversion arrangement, with its additional flow capacity, will have the effect of reducing the overall potential for flooding in the reach of the stream through the mine site.

In an extreme flood there may not be significant additional capacity since the diversion channel itself could become inundated. This would not harm the diversion arrangements but significant reduction in flood level could not be expected.



BRUKUNGA MINE REHABILITATION

Proposed Downstream Weir

FIGURE 5.9

6. Acid Drainage Interception

6.1 Present Conditions

Present arrangements for interception of acid seepage by means of a drainage well and pumping system have been outlined previously in Section 4. Jane, Lindsay and Days Creeks run through the mine site in channels and pipes and at lower flows the former two creeks are collected for pumping to the treatment plant. In the larger storm events these creeks would overtop their channelisation and final ponding and discharge directly into Dawesley Creek.

Days Creek is the largest of the creeks, with its main catchment outside and to the north west of the mine site. Within the site it runs southwards past the western side of the northern rock dump, with at least one section piped. It is understood that the pipe is blocked, and that currently stormwater filters through the porous waste rock. A proportion of the flow is intercepted and pumped to the Assay Pond for treatment. Further discharge is directly to Dawesley Creek. Refer to Figure 4.2.

To the south of the mine site, part of the original Dawesley Creek course has been buried under the southern waste rock dump. The creek line has been reconstructed outside the eastern edge, generally through rock. Seepage through the dump continues to migrate to the creek line beneath the dump, which acts as a collector and accentuates acidification at the two re-entry points to the original channel line.

From the above, it is seen that although a significant proportion of the acid drainage from the mine site is intercepted for treatment, there is a large proportion which escapes to Dawesley Creek. Hence the basic premise of this study, i.e. that if diversion of ordinary flows takes place, then the existing channel could itself become the collection sump and storage for the contaminated flows which now escape to Dawesley Creek.

It is understood that the existing treatment plant together with acid water storage ponds and pumping arrangements from the ponds to the plant have spare capacity of approximately 30%. This is on the basis that any enhanced collection and pumping arrangement would spread the delivery of acid waters for treatment over longer periods of time than at present.

6.2 Optional Strategies for Seepage Collection

The two possible basic strategies to deal with acid seepage interception are as follows, assuming initially that any increased interception volume is within the spare capacity of the present treatment plant:

- Retain all the present arrangements and additionally capture the acidic flows which at present escape down Dawesley Creek; or

- Close down the present interception system and allow all flow from and through the mine site to be collected and disposed of under new collection and pumping arrangements.

Of these two options, the first is clearly desirable, providing the present interception system can remain operational without undue maintenance. The approach recommended is that all the present system remains operational, but that some or all of the existing pumps could be phased out in the future if necessary. The initial installation providing a retention dam and pumping arrangements near the southern end of the mine site could then have its pumping capacity increased as required. It is proposed that all of the existing interception and pumping facilities collecting acid seepage arising east of Dawesley Creek would remain in operation as they are, with the possible exception of Pump 1 which might be incorporated with the retention dam.

6.3 Proposed Interception Arrangement

With the present interception and pumping arrangements in operation as they are, all other western flows would be collected by utilising the present creek channel and a new downstream storage dam in the location previously described. New pumping arrangements would be provided to deliver the acid waters to the existing acid storage ponds for further delivery to the treatment plant.

6.3.1 Capacity of Downstream Storage Dam

It is noted that all flows less than the ARI 1 year flow will have been diverted into the bypass channel. When flows higher than the ARI 1 year flow occur, the portion of the flow which is greater than the 1 year flow will run down the existing channel, being collected at the downstream weir. Only when the spillway of that dam operates will acid waters escape to Dawesley Creek, and these waters would then join the diluting high flow being bypassed by the diversion channel.

To arrive at a recommended storage capacity for the downstream dam, a similar principle is applied to that which established the capacity of the diversion channel, i.e. capacity should be exceeded only for a suitably rare event. We recommend that the storage dam have a capacity equal to the ARI 1 year run-off from the mine site and the western creeks. This is taken to be the full run-off, from the storm of duration requiring maximum storage, neglecting any reduction due to the operation of the present interception facilities during the relatively short period of the storm.

On the assumption that the storage would be partly empty when the ARI 1 year flow from the mine site and western creeks occurred, the bulk of the acid run-off, particularly the first flush of contaminated water, would be retained. If the dam became full and the spillway ran, then this would almost certainly be accompanied by significant flow in the diversion channel with which it would be diluted. More common storm events, yielding less flow, would be less likely to exceed the capacity of the retention dam.

The capacity of the retention dam is relatively large, of the order of 7.5 megalitres, which is approximately a month's average wet season flow in Days Creek. At a pumping rate of say 10 litres/second, which is approximately the capacity of the present pumps on the western collection system, this storage would be evacuated in approximately 8.7 days of continuous pumping, assuming no further inflow occurred. The evacuation of the retention dam could be proceeding at times of low flow in the well interception system.

Table 6.1 sets out an analysis by the Rational Method of the ARI 1 year storm on the western catchment area, based on estimates of the run-off coefficients for the various types of surfaces involved. Approximate calibration was carried out against the hydrological analysis of recorded flows for the relatively short period of record reported in Section 3.3.4. It is believed that the ARI 1 year flows obtained are appropriately conservative. The dam capacity of 7.5 megalitres (Ml) is then established as indicated in the Table. The required capacity can be readily achieved at the proposed site.

Note that high water level of the storage basin would inundate the site of Pump No. 1 of the existing interception system. We would propose that operation of this interception site be discontinued, since the basin would act in its stead. In fact, the electricity supply for the pump, with some adaptation, is likely to be suitable for application to the new basin pumping arrangement.

6.3.2 Pumping Arrangements

It is proposed to provide a submersible corrosion resistant pump, of 10 litres/second capacity, with a delivery line to the existing acid ponds. This rate approximates the combined capacity of the pumps in the existing western interception system.

The existing interception, delivery, acid storage pond and treatment system generally operates to full capacity during the winter periods of higher rainfall, but it is understood to have approximately 30% spare capacity overall. With the retention basin of sufficient buffer storage capacity, it is intended that the delivery of acid waters from the storage dam would be phased with the delivery from the existing interception system, the latter peaking when run-off was actually occurring.

6.4 Alternative Treatment Arrangement

The major advantages of the new diversion and interception facilities are as follows:

- To avoid the uncontrolled release of acid run-off and seepage from the mine site.
- Collect additional acid waters in the existing creek channel and a downstream retention dam.
- To utilise the spare capacity of the existing treatment plant to neutralise the additional acid water pumped from the retention dam.

Table 6.1 Brukunga Mine – ARI 1 Year Flow from West

Use approximate method referenced in Australian Rainfall and Runoff 1987 (AR&R) Chapter 7, using Rational Method run-off coefficients.

	Runoff Coeff.	Flat rock	Rock dump	Pasture (gentle)	Hills	
		0.7	0.3	0.025	0.05	
Catchment						
Mine Area	Area m^2	Flat rock %	Rock dump %	Pasture %	Hills %	Weighted Runoff Coeff.
1. Days Creek	132,000	70	30	0	0	0.580
2. North east	38,200	0	95	5	0	0.286
3. Northern rock dump	77,600	0	100	0	0	0.300
4. Lindsay/Jane Creeks	165,000	100	0	0	0	0.700
5. Central rock dump	64,400	0	100	0	0	0.300
6. Southern mine area	263,000	85	10	5	0	0.626
External Area						
Upper Days Creek	1,040,000	0	0	50	50	0.038
Upper Western Creeks	356,000	0	0	100	0	0.025
Total Area of Catchment	2,136,200					
Equivalent Impervious Area	458,199					

Inflow Hydrograph

Assume triangular hydrograph

Average Recurrence Interva	1 year/s	
Storm Duration	6.00 hours	(Time interval is 0.60 hours)
Average Rainfall Intensity	2.70 mm/hour	(estimate average 1.5 mm/hour continuing loss)
Then Peak Inflow Rate	0.687 cumecs	(Double average)
Total Storm Volume	7,423 cu m	

These advantages would accrue fully from the proposed system during the 5 or 6 drier months of the year and during extended dry periods in the winter months. However, in continuously wet periods, when the existing interception system and treatment plant were working to full capacity, the retention dam may fill. Its 7.5 Ml capacity could be exceeded by the combined continuous run-off from the mine site and western creeks, less the quantity intercepted and pumped by the existing system.

In a typical winter month, the combined run-off could be 16 Ml with 9 Ml being intercepted by the existing system. Hence, 7 Ml could flow to the retention basin, approaching its capacity. Because of the random nature of rainfall events, it is not possible, other than by extended simulation studies, to predict the frequency of spillway overtopping.

It has been a basic premise of the study that Dawesley Creek flow would exceed the diversion capacity and run through the existing stream bed on the average once per year, flushing through the system. It is possible that the retention dam spillway could overtop from effects more local to the mine site on say two or three more occasions per year. These events would most likely occur when significant diluting flow was running in the diversion, which would join the spillway flow immediately downstream of the dam.

Future experience might show that overtopping of the downstream spillway occurs in winter more frequently than desirable, taking into account that it would be overtopped on the average at least once per year due to excess Dawesley Creek flow. Then, an alternative to pumping to the existing acid ponds would be to establish additional treatment facilities at the downstream basin. Space would be available for a modern plant to be installed of the capacity required to meet any new water quality requirement.

Our estimates (Section 7) show a significant cost to providing a pipeline to the existing acid ponds as the disposal method from the downstream retention basin. It may be considered more cost effective to invest this capital in an additional downstream treatment facility as part of the diversion/interception project.

7. Estimated Costs

Estimates of the cost of implementation of the stream diversion and acid drainage interception scheme as reported have been carried out.

The scheme as presented in this preliminary feasibility study is based on hydrological studies which have established the quantum of flow to be diverted and investigations regarding the diversion alignment and type of conduit.

Supported by these investigations and studies as set out in the report, we present the estimates below as representing a budget cost for the work, which may be used for comparison with the cost of other strategies for improving the quality of Dawesley Creek waters.

The estimate, Table 7.1, is broken down into the two main components of the work – stream diversion and seepage collection and pumping. In the stream diversion estimates a break down has been shown for the five alignment sections (A to E) and for other elements of the diversion works.

Table 7.1 Estimated Costs

Description	Qty	Unit	Rate	Cost	Total Cost
			$	$	$
Diversion Works					
Preliminaries					100,000
Section A					
Ch. 00m to 400m					
Channel earthworks	2400	m3	60	144,000	
Mattress lining for 75 m (including geotextile and geomembrane)	750	m2	150	112,500	
					256,500
Section B					
Ch. 400m to 680m					
Excavation	1600	m3	60	96,000	
Pipe (1500mm)	280	m	750	210,000	
Headwall	2	Item	2,000	4,000	
Junction box	1	Item		3,000	
Re-instate surface works		Item		80,000	
					393,000
Section C					
Ch. 680m to 1050m					
Earthworks: in earth	1500	m3	60	90,000	
in rock	600	m3	150	90,000	
Fencing: where side slopes 1:1 in rock	300	m	50	15,000	
Mattress lining for 75 m (including geotextile and geomembrane)	520	m2	150	78,000	
Adjust existing road alignment		Item		50,000	
					323,000
Section D					
Ch. 1050m to 1450m					
Earthworks: in rock	2400	m3	150	360,000	
Fencing	800	m	50	40,000	
					400,000
Section E					
Ch. 1450m to 1680m					
Earthworks: in rock	780	m3	150	117,000	
Culvert under road		Item		6,000	
Fencing	200	m	50	10,000	
					133,000
Carried Forward					1,605,500

Description	Qty	Unit	Rate	Cost	Total Cost
			$	$	$
Brought Forward					1,605,500
Upstream Dam					
Earthworks	1800	m3	30	54,000	
Diversion channel to Peggy Buxton Road		Item		10,000	
Culvert (600mm x 1200mm) under Peggy Buxton Road	3	Item	6,000	18,000	
Mattress lining to spillway (including geotextile)	300	m2	180	54,000	
					136,000
Sub-Total					1,741,500
Seepage Collection Works					
Downstream Dam					
Earthworks	2500	m3	30	75,000	
Rock pitching to spillway (including geotextile)	300	m2	100	30,000	
Cut-off drain from south		Item		10,000	
					115,000
Mechanical Works					
Pump arrangement		Item		50,000	
Electricity supply		Item		10,000	
Pipeline to Acid Ponds 90 mm dia	1000	m	80	84,000	
					139,000
Sub-Total					254,000
Total Capital Works					**1,995,500**
Project Management, Investigation and Engineering (+12%)					239,460
Contingencies (+10%)					199,550
Total Estimate					**2,434,510**

8. Conclusions and Recommendations

A pre-feasibility study has been carried out, showing that it is technically feasible to divert Dawesley Creek past the former Brukunga mine site, to isolate the creek from acid seepage. By building a dam across the creek downstream of the mine site, acid seepage would be temporarily detained in the creek bed prior to pumping it out to water treatment facilities.

Hydrological studies have defined the ARI 1 year flow in Dawesley Creek, which has been taken as the required capacity of the diversion. This flow is estimated to be 4.5 m^3/sec. Similarly, hydrological analyses of the flows into Dawesley Creek from the west, via the mine site, have assisted in defining the required capacity of the detention basin, taken as the run-off from the critical ARI one year storm and estimated as 7.5 Ml.

The stream diversion arrangement comprises an upstream dam to provide the required water level for diversion off-take, sections of open channel and a section of pipework under the existing CFS Depot. Much of the channel would be in rock cutting, and sections of the open earth channel would be lined with rock-filled mattresses where flow velocity and/or bed material gave potential for erosion.

Under conditions of flow greater than ARI one year, the upstream weir would overtop and flow in excess of the ARI 1 year value would then pass down the existing stream bed, flushing through the system. Contaminated water would join the diverted, clean flow downstream of the site and be significantly diluted.

Acid drainage water from the mine site, in excess of the capacity of the existing well and pump interception system to divert to treatment, would accumulate in the detention basin behind the downstream dam. From there it would be pumped to the existing acid ponds and thence to the treatment plant.

It is expected that, because the treatment plant has only approximately 30% spare capacity, on occasion under local storm conditions, capacity of the detention basin would be exceeded and its weir would overflow. This could be expected on two or three occasions per year, occurring when there would most likely be significant diluting flow in the diversion channel. Generally, escape of contaminated water to downstream Dawesley Creek would be greatly reduced during normal creek flow.

The estimated implementation cost of the diversion scheme as reported is approximately $2.5 million, including allowances for engineering design and contingencies.

It is recommended that, if implementation of the Dawesley Creek diversion project were to be considered, a comprehensive geotechnical investigation should be carried out to more closely define rock excavation and earth channel construction conditions. Also, detailed investigation of conditions on the CFS site would be required.

Because of the limited additional capacity in the existing treatment plant, it is recommended that a review be carried out of the potential for upgrading the plant to cope with the additional acid waters captured in the detention basin. The alternative of installing new plant in the proximity of the downstream basin should also be investigated.

Appendix A

Statement of Limitations

PPK
Environment & Infrastructure

PPK Environment & Infrastructure Pty Ltd
ABN 80 078 004 798
STATEMENT OF LIMITATIONS

Scope of Services

This report has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and PPK ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access, survey and/or geotechnical constraints.

Reliance on Data

In preparing the report, PPK has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, PPK has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. PPK will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to PPK.

Conclusions

In accordance with the scope of services, PPK has relied upon the data and has not conducted any monitoring or testing in the preparation of the report. The conclusions are based upon the data and visual observations and are therefore merely indicative of conditions at the time of preparing the report.

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. PPK assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of PPK or for any loss or damage suffered by any other party in relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

PPK will not be liable to update or revise the report to take into account any events, emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to nor ownership of the properties, and facilities referred to in the report, nor the application or interpretation of laws in the jurisdiction in which those properties, and facilities are located.