Report to:

YALLOURN OPEN CUT
STATE ELECTRICITY COMMISSION OF VICTORIA

YALLOURN OPEN CUT

MINE REHABILITATION
ASSESSMENT OF OPEN CUT STABILITY
PROPOSED FLOODING OPTION

REPORT 1155/2
May 1993

GEO-ENG PTY LTD

YALLOURN OPEN CUT
MINE REHABILITATION
ASSESSMENT OF OPEN CUT STABILITY
PROPOSED FLOODING OPTION

TABLE OF CONTENTS

1 INTRODUCTION

Following a request by Mr D Seymour, Program Manager Yallourn Open Cut (YOC), a study has been undertaken to assess the stability of the Western, Northern and South Eastern batters of YOC subject to proposed open cut flooding as an option for future mine rehabilitation.

It has been assumed in this study that the worked out open cut will be flooded to relative level (RL) 33 metres and the batters will not be subject to rapid drawdown conditions in the future.

In addition as part of the study, it was requested by Mr K Brown, Mine Planning Engineer YOC that the stability of proposed rehabilitation works on the Northern Batters adjacent to the sludge ponds be assessed in both flooded and unflooded conditions.

2 SCOPE OF WORK

The following steps were followed to assess the long term stability of the existing YOC batters under the proposed flood conditions.

- Determine geological and hydrogeological conditions at four key areas (Figure 1) designated by Sections A,B,C & D on the Northern, South Eastern and Western Batters
- Determine appropriate stability analysis methods applicable in each case
- Document assumptions regarding analysis methods, material parameters and groundwater conditions in each case
- Assess overall batter stability conditions at each site for the following three scenarios - existing (no flooding), partial flooding (RL 15 metres) and full flooding (RL 33 metres)
- Assess localised face stability at the Northern Batters site for various planned rehabilitation options
- Discuss and report results of study.

3 STABILITY ANALYSIS

3.1 GENERAL

The stability of Sections A, B and D were assessed using Geo-Eng program BSLIDE. This software models the common and well understood block sliding mechanism which applies to many routine batter stability conditions in the Commissions Brown Coal Open Cuts.

The stability conditions represented by Section C cannot be effectively modelled by BSLIDE and were assessed using computer program GENSAM. This program has been the primary stability assessment tool for design of the Western Batters YOC for a number of years.

Potential for block sliding of the coal batters along the interseam clay at the base of the coal seam is highly dependent on the shear strength of the coal/interseam interface. The stability analyses carried out for this study assumed the residual effective parameters - cohesion (C'r) = 0 kPa and residual friction angle (Ø'r) in the range 12° to14°.

The lower parameter Ø'r = 12° has been used for Sections A & B and is based on the most recent strength testing information of Yallourn East Field Open Cut interseam materials. A design residual friction angle of Ø'r = 14° has been used for the stability assessment of the permanent Western Batters (Section C) and the Northern Batters (Section D). This higher value has been confirmed by extensive laboratory testing of the Western and Township Field batters interseam materials during the last decade.

3.1.1 Analysis Methodology - Sections A, B & D

The stability of the batters at Sections A, B & D is controlled by the simple block sliding mechanism modelled by BSLIDE. For any given batter, the factor of safety against sliding is the calculated ratio of shearing resistance (generated in the relatively weak interseam clay at the base of the coal) to the driving forces comprising both hydrostatic pressures within vertical coal joints and gravity forces resulting from a dipping coal/ interseam interface.

When the coal batters are subject to flooding, the stability conditions can improve or worsen depending on the dip of the coal/ interseam and the critical groundwater levels within the batter. If the coal batters dip towards the open cut, flooding may destabilise the batter. Alternatively if there is no dip or the base of coal dips into the batter (away from the open cut), stability conditions are generally similar or improved compared to the unflooded or existing case.

In cases (Sections A and D) where the toe of the batter is supported by overburden material or sludge dumped inside the open cut, the stability conditions for these batters are improved compared to an unsupported batter.

An acceptable design factor of safety against block movement for a flooded batter would generally exceed 1.2, however, lower values can be observed in the lower regions of the batter face. The results of the analyses and factors of safety obtained in each case are discussed in detail in the following sections.

3.1.2 Analysis Methodology And Assumptions - Section C

The analysis methods relating to the Western Batters have been well documented in previous reports including Report MGD 10 "Yallourn Open Cut, Township Field, Redesign of Permanent Western Batters", August 1991.

It has been assumed in the analysis of this section that overall stability of the batter and Surcharge Dump may be at risk from flooding. These cases were assessed using computer program GENSAM with suitably modified current water level assumptions corresponding to a flood level at RL 33 metres submerging the lower part of the batter and surcharge dump.

3.2 SECTION A (OLD NORTHERN BATTERS)

3.2.1 General

The section analysed to assess batter stability is shown in Figure 2. This section corresponds to Section 4 Sheet 1 - Yallourn Open Cut Northern Batters Rehabilitation Earthworks Design Ref File No FSO:[310013]F197D014.DGN.

As shown in Figure 2 the toe of the batter is supported by 25 - 30 metres of partially dewatered sludge and ash that improves the overall stability of the batters by providing a stabilising force at the toe. The coal/interseam interface is dipping gently to the north (ie: away from the open cut). The analyses have assumed the presence of the proposed rehabilitation earthworks as shown in Figure 2.

In addition to the above work, localised face stability of planned backfilling associated with open cut rehabilitation and fire protection works on the Northern Batters benches adjacent to the sludge ponds has also been assessed under flood conditions. The two backfilling options are under consideration are detailed below:-

- Placement of constructed clay fill on the upper levels of the batter to provide fire protection and to improve the general long term appearance of the batter and
- Placement of top of coal clean-up material at the base of the batter on a foundation of partially dewatered sludge and ash.

3.2.2 Stability Analyses Results

The results of the analyses are shown in Figure 2. As noted above, due to the presence of the toe support provided by the sludge pond material, the overall batter has an acceptable long term factor of safety for all water level scenarios analysed.

Flooding of the open cut to RL 33 metres in this case will provide an additional hydrostatic resisting force which effectively cancels out the destabilising water forces now present in the batters. In addition, the presence of a coal/ interseam interface dipping away from the open cut improves already favourable stability conditions.

3.2.3 Rehabilitation Works Stability

Analyses of the proposed rehabilitation earthworks have indicated that good quality, well compacted material will be required for placement in the top levels to ensure stability when the open cut is flooded. The analyses indicate that top of coal clean-up material containing large percentages of coal will not be appropriate for use in any upper batter rehabilitation work that would later be fully or partly covered by water. It is recommended that soft, wet clean-up material not be used for fire protection cover or rehabilitation works.

3.3 SECTION B (FLOCCULATION & FIRE SERVICE PONDS)

3.3.1 General

A section between the flocculation and fire service ponds (Figure 3) was chosen for analysis as it represented the highest section of batter unsupported by overburden dumps within the open cut. This batter was therefore considered to be the most potentially unstable part of the eastern and southern batters.

The batter comprises approximately 10 metres of overburden overlying approximately 45 metres of coal. The analyses have taken into account the relatively flat coal/interseam interface and presence of the fire service and flocculation ponds at the toe of the batter and their influence on the initial water levels within the batter. In addition some allowance has been made for the influence of flooding on the Morwell River flood plain during the winter months.

3.3.2 Stability Analyses Results

The results of the stability analyses are shown in Figure 3. It can be seen from the graph of factor of safety versus chainage that the analyses indicate minimum factors of safety of 1.1 for sections of the batter above the water table, increasing with distance from the batter crest. The submerged part of the batter have relatively low factors of safety less that 1.1 approaching 1.0.

It is considered however, that the lower sections of the batter are safe despite having a very low factors of safety. This is because for the submerged portion of batter, no additional net destabilising forces can be applied to the coal blocks as they are already totally submerged and lie on a flat surface (coal/ interseam interface). A factor of safety of 1.01 is acceptable in this situation.

It is therefore considered that the batter may be flooded with little possibility of failure.

3.4 SECTION C (SECTION YWB)

3.4.1 General

The section analysed for overall stability is shown in Figure 4. This section corresponds to Section 6 of the Yallourn Western Batters design as defined in Report MGD 10 "Yallourn Open Cut, Township Field, Redesign of Permanent Western Batters".

As can be seen in Figure 4 the section is located in an area of steeply dipping strata resulting from the adjacent Yallourn Monocline/Fault. The analysis has assumed that all overburden scheduled for excavation at the top of the batters has been removed and that the Surcharge Dump has been fully developed. In addition, the analysis assumes that the internal overburden dump has been placed as planned along the toe of the permanent Western Batters.

3.4.2 Stability Analysis Results

Analyses for overall batter stability were carried out for the three water level scenarios outlined in Section 3.1 of this report and methods outlined in Report MGD 10. When flooded to RL 33 metres and with the internal overburden dump placed against No 4 Cut, the factor of safety against overall batter failure was found to be over 2.0. This figure is well above the required long term factor of safety indicating the overall batter will remain stable if the open cut is flooded.

Stability analyses were also carried out to determine the stability of the Surcharge Dump if the open cut is flooded. These analyses showed the Surcharge Dump will also have an acceptable long term factor of safety of 2.11 when the open cut is flooded.

3.5 SECTION D (TOWNSHIP FIELD NORTHERN BATTER)

3.5.1 General

The section analysed to determine the stability of the Township Field Northern Batter is shown in Figure 5.

The analyses were carried out for the three water level scenarios outlined above. The analyses assume the presence of the internal overburden dump approximately 27 metres high at the toe of the permanent batters. The analyses were carried out using the block failure mechanism with a coal/interseam interface that dips slightly into the Open Cut.

3.5.2 Stability Analyses Results

Results of the analyses are shown in Figure 5. As noted above, this section is supported at the toe by the internal overburden dump which accounts for the high factors of safety throughout the section.

4 CONCLUSIONS & RECOMMENDATIONS

The following conclusions and recemmendations have been drawn from the analyses completed as part of this study:-

- All permanent batters within the existing Yallourn Open Cut are expected to be stable under either proposed partial or full flood conditions

- The results of the stability analyses for the Old Northern Batters (Section A) are shown in Figure 2. Due to the presence of the toe support provided by the sludge pond material the overall batter has an acceptable long term factor of safety for all water level scenarios analysed.

- Assessment of the proposed rehabilitation earthworks has indicated that good quality, well compacted earthfill, material will be required for placement to ensure stability when the open cut is flooded. Material from top of coal clean-up work containing a large percentage of coal is not considered suitable for placement as part of the rehabilitation works.

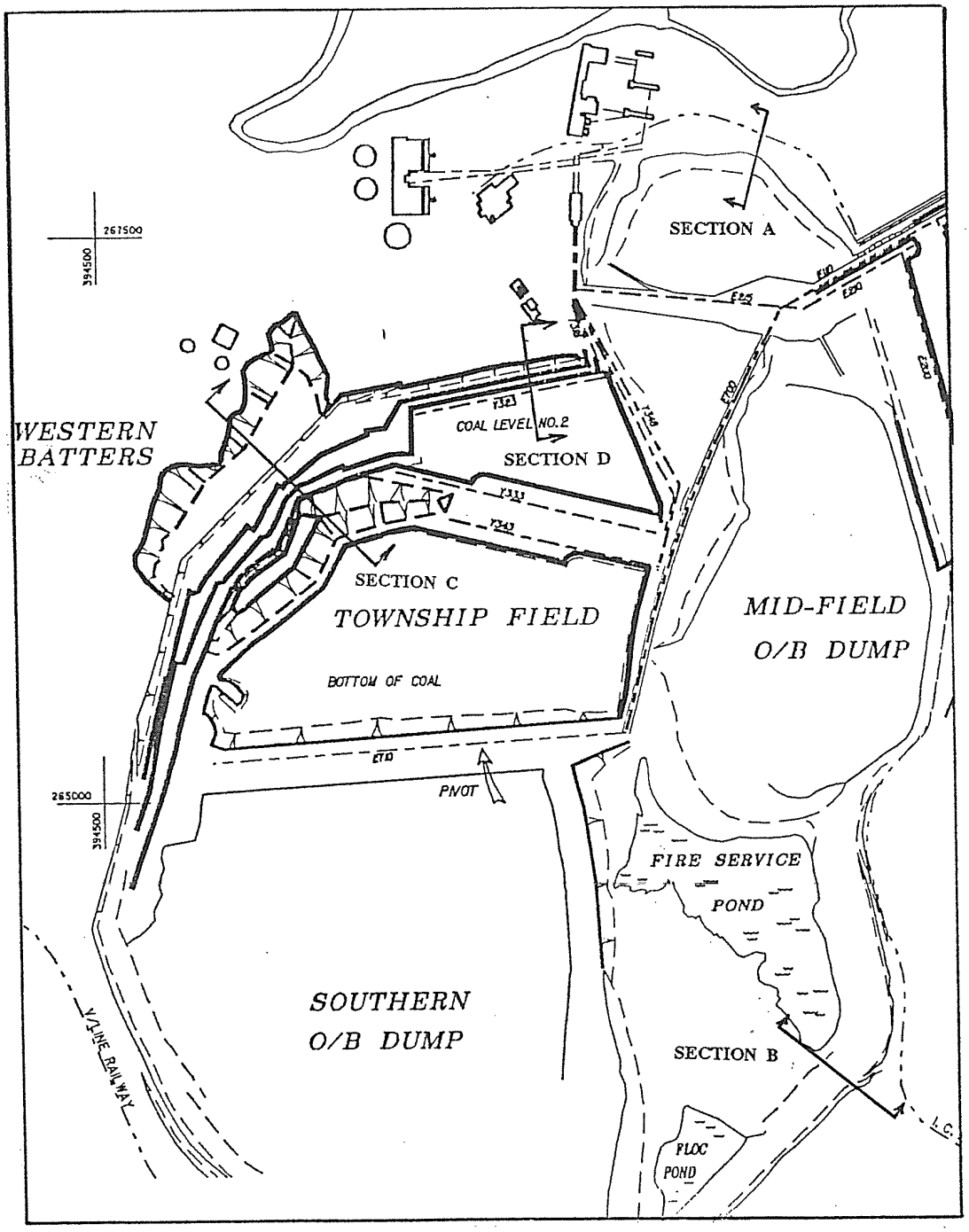
- The results of the stability analyses for the Floc/Fire Service Ponds South Eastern Batters (Section B) are shown in Figure 3. This area has no toe support and analyses of the section shows that the submerged parts of the batter have factors of safety close to 1.0 . However, this is not a serious concern in this case as the stabilising force provided by the flood water balances possible destabilising hydrostatic forces of the water within the batter. With no net destabilising forces able to act on the batter it is therefore considered that the batter may be flooded with little possibility of failure.

- Township Field Western Batters (Section C) were analysed using the methods outlined in Report MGD 10. When flooded to RL 33 metres and with the internal overburden dump placed against No 4 Cut the factor of safety against overall batter failure was found to be over 2.0. This figure is well above an acceptable long term factor of safety indicating the overall batter will remain stable if the open cut is flooded

- Stability analyses carried out to determine the stability of the Surcharge Dump on Western Batters when the open cut is flooded showed the Surcharge Dump will have an acceptable long term factor of safety of 2.1

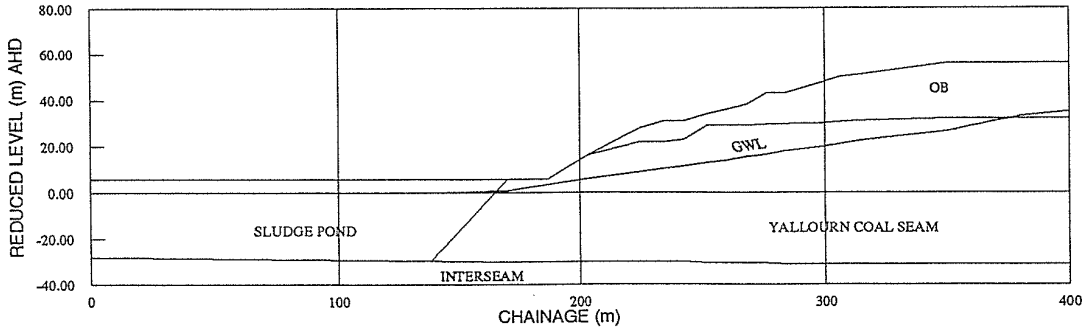
- Results of the analyses for Township Field Northern Batters (Section D) are shown in Figure 5. This area of batter is supported at the toe by the internal overburden dump which accounts for the high factors of safety throughout the section. Flooding of the open cut effectively nullifies the presence of a destabilising water table in the batters and therefore the overall batter has an acceptable long term factor of safety.

- It is recommended that only good quality, well compacted earthfill should be used in the rehabilitation works proposed for the Old Northern Batters area of Yallourn Open Cut.

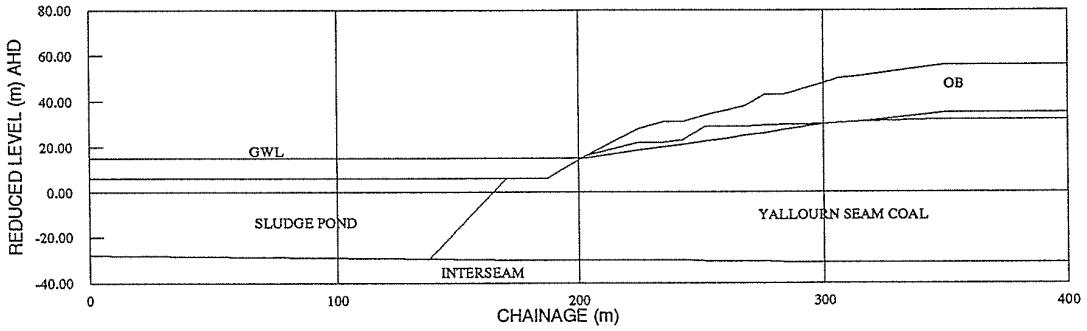


SCALE NTS	GEO-ENG PTY LTD	FIGURE	1
DATE 11/05/93	YOC FLOOD STABILITY STUDY		
DRAWN A.J.	LOCATION OF ANALYSED STABILITY		
APPROVED A.J.	SECTIONS		

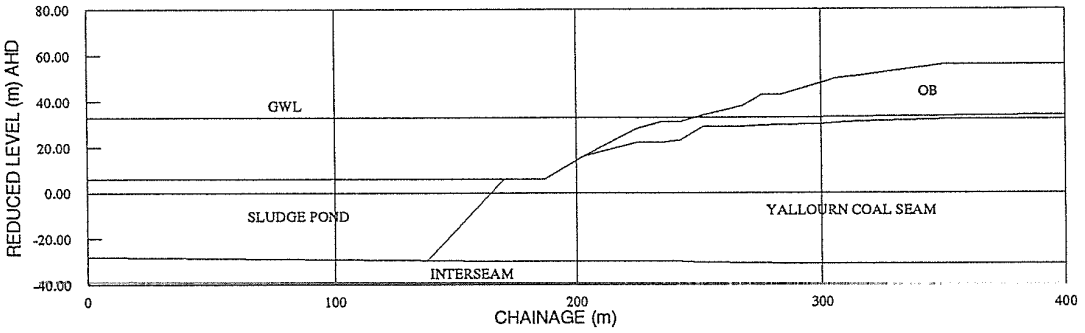
CASE 1:- ORIGINAL ASSUMED WATER LEVELS



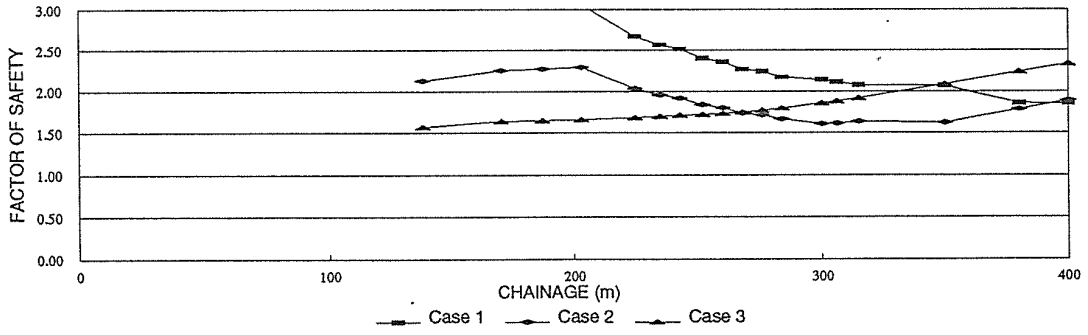
CASE 2:- OPEN CUT PARTIALLY FLOODED TO RL 15 m



CASE 3:- OPEN CUT FLOODED TO RL 33 m



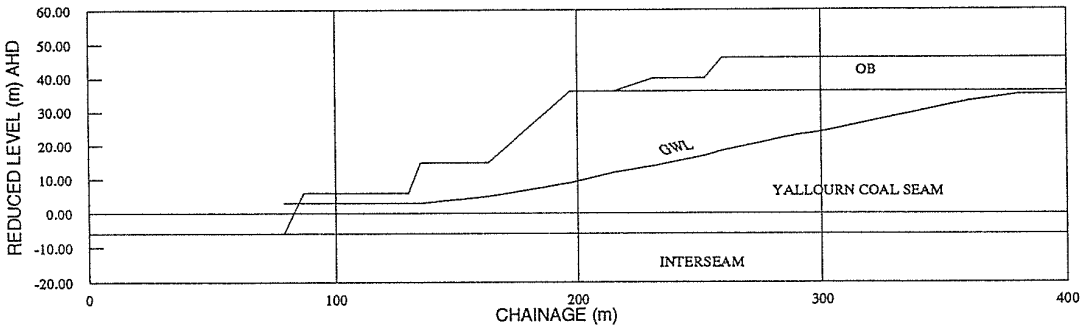
FACTOR OF SAFETY



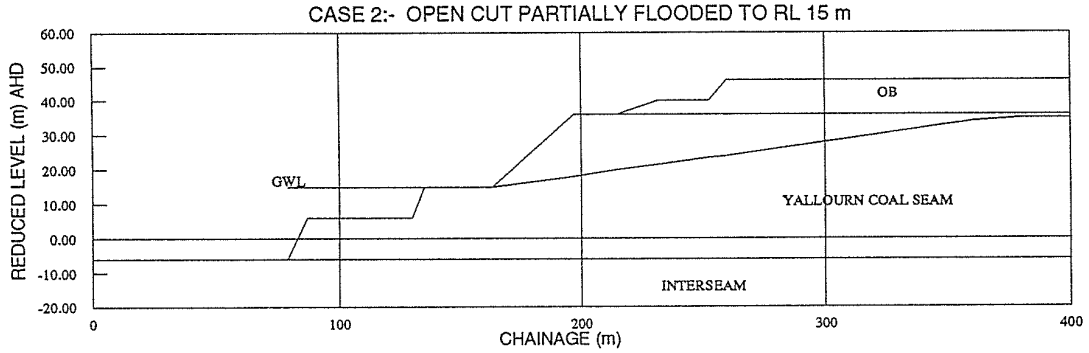
Program BSLIDE 1/6/93

SCALE NTS	GEO-ENG PTY LTD	FIGURE	2
DATE 11/05/93	YOC FLOOD STABILITY STUDY		
DRAWN A.J.	BATTER PROFILE SECTION A		
APPROVED A.J.	OLD NORTHERN BATTERS		

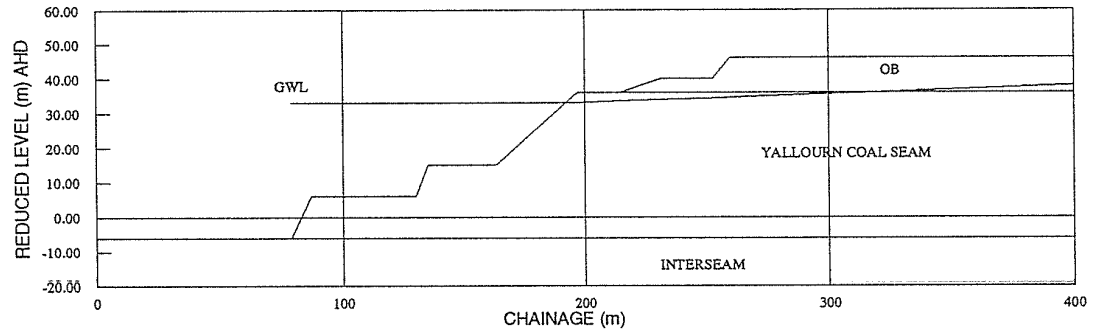
CASE 1:- ORIGINAL ASSUMED WATER LEVELS



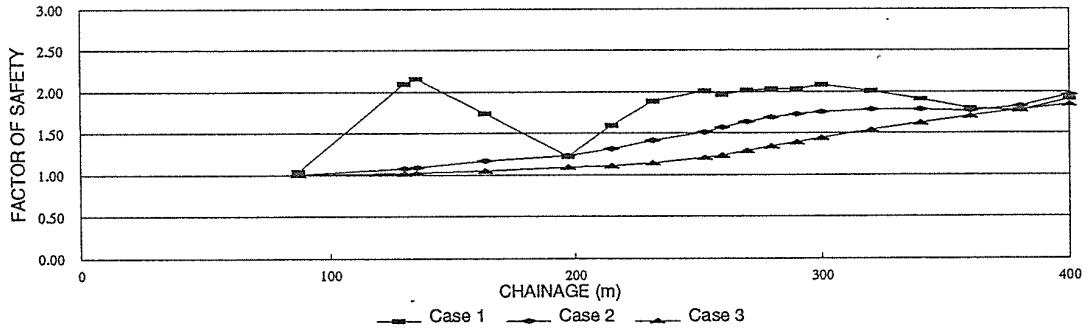
CASE 2:- OPEN CUT PARTIALLY FLOODED TO RL 15 m



CASE 3:- OPEN CUT FLOODED TO RL 33 m

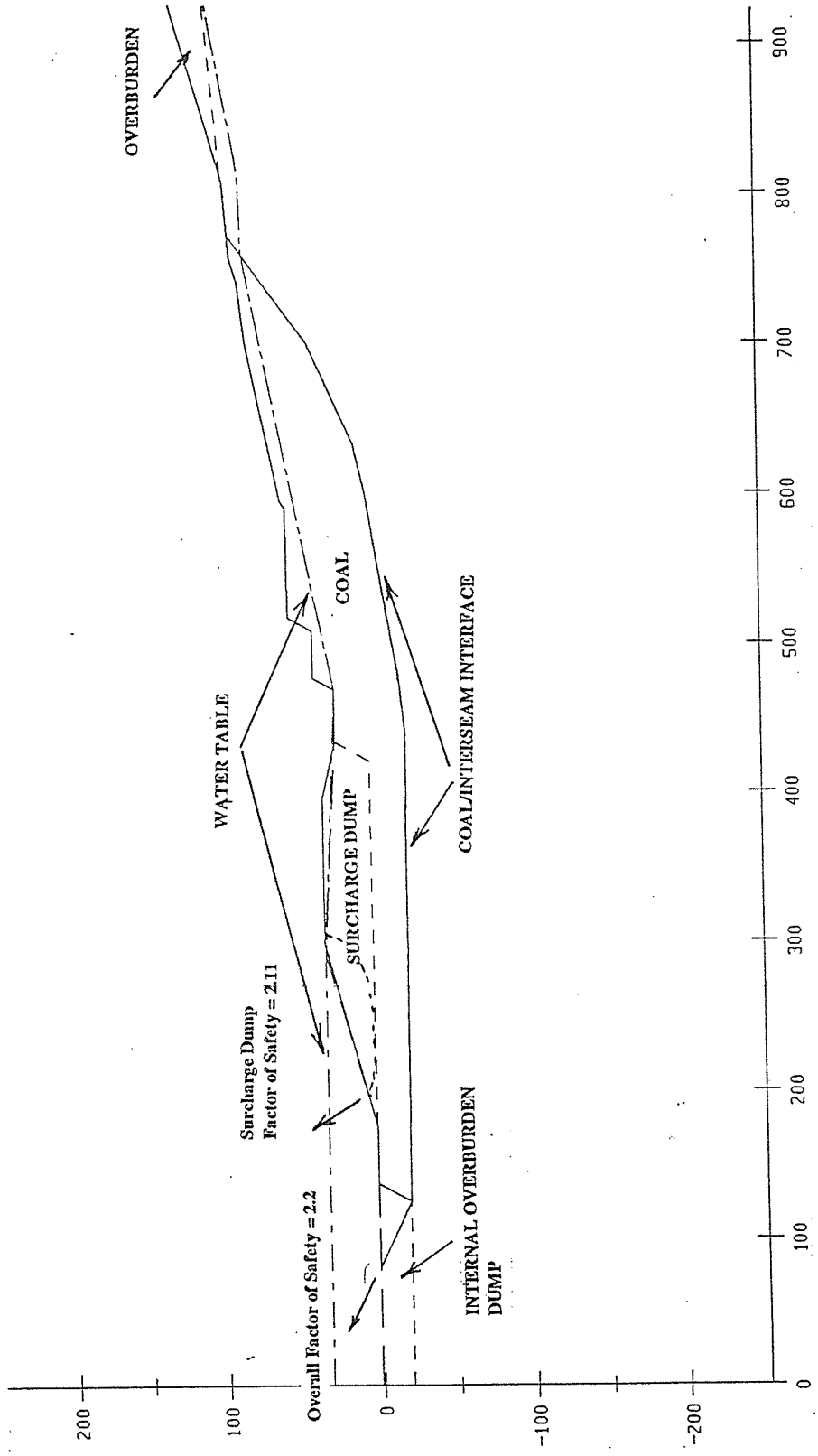


FACTOR OF SAFETY



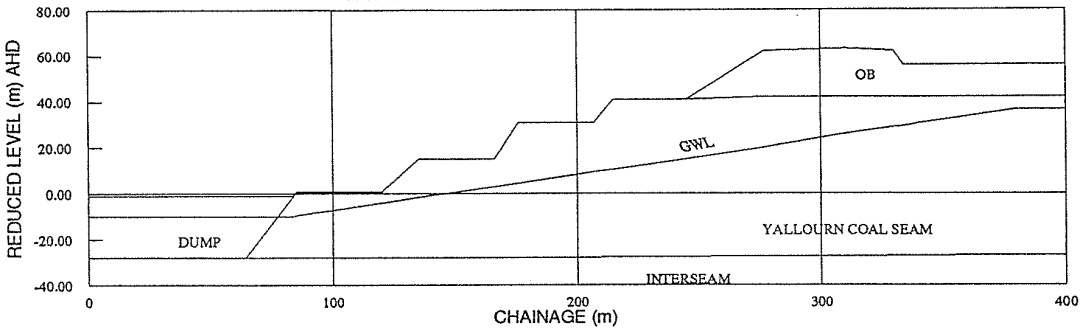
Program BSLIDE 1/6/93

SCALE NTS	GEO-ENG PTY LTD	FIGURE	3
DATE 21/05/93	YOC FLOOD STABILITY STUDY		
DRAWN A.J.	BATTER PROFILE SECTION B		
APPROVED A.J.	FLOC/FIRE SERVICE PONDS		

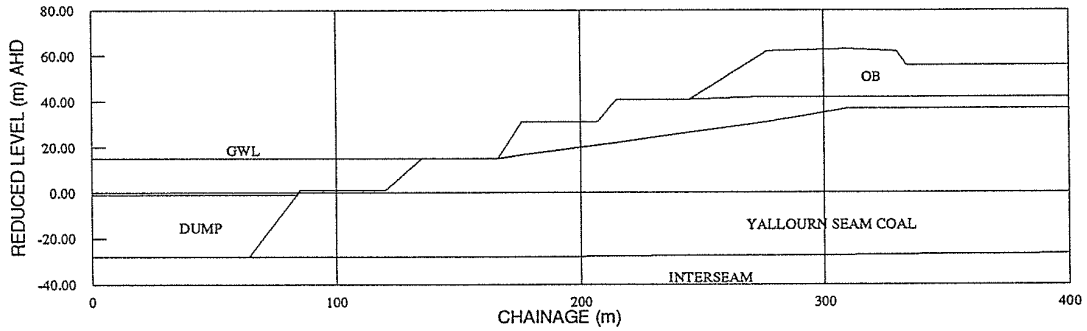


SCALE NTS	GEO-ENG PTY LTD	FIGURE	4
DATE 11/05/93	YOC FLOOD STABILITY STUDY		
DRAWN A.J.	BATTER PROFILE SECTION C		
APPROVED A.J.			

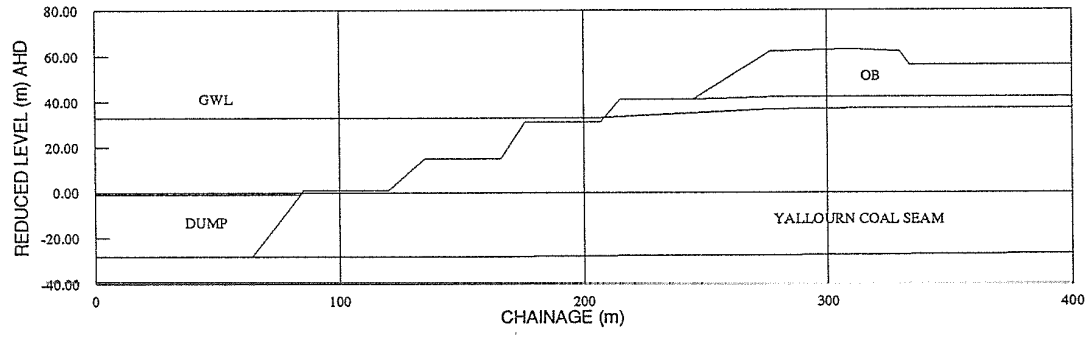
CASE 1:- ORIGINAL ASSUMED WATER LEVELS



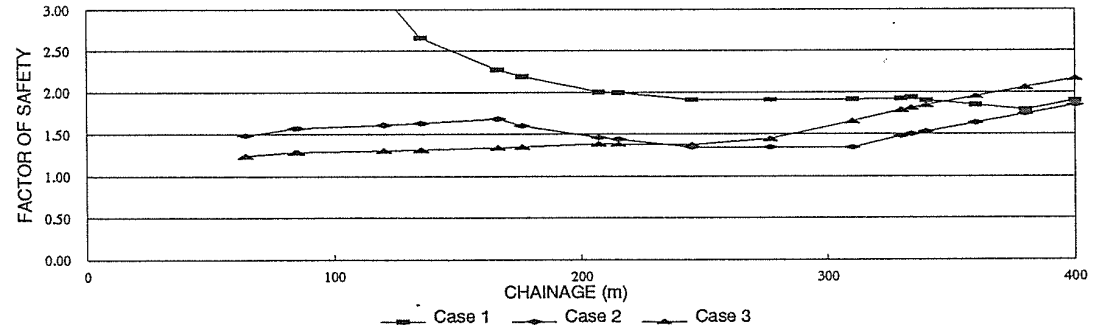
CASE 2:- OPEN CUT PARTIALLY FLOODED TO RL 15 m



CASE 3:- OPEN CUT FLOODED TO RL 33 m



FACTOR OF SAFETY



Program BSLIDE 1/6/93

SCALE NTS	GEO-ENG PTY LTD	FIGURE	5
DATE 21/05/93	YOC FLOOD STABILITY STUDY		
DRAWN A.J.	BATTER PROFILE SECTION D		
APPROVED A.J.	TOWNSHIP FIELD NORTHERN BATTER		