Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT

TO

SHEDDEN PACIFIC PTY. LTD.

ON

FIELD INVESTIGATION AND GEOTECHNICAL STUDIES

FOR

U.C.G. FEASIBILITY STUDY LEIGH CREEK

MAY 1985

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SUMMARY

Following an initial appraisal of the U.C.G. potential at Leigh Creek, a field investigation has been undertaken to provide quantitative data on the strength and permeability characteristics of the geological profile of the Main Series in Lobe B. The principal concerns for development of a gasified system relate to the potential drawdown of the water table, and resulting groundwater inflow into the burn cavity, and the stability of roof rocks as the cavity expands.

During preparation for the field programme, additional investigation data was obtained from D.M.E. in Adelaide which indicated that a significant fault, with a displacement exceeding 50 metres, passed through the area previously defined for gasification. Following extensive discussion, it was agreed that a redefinition of the area to be gasified in Lobe B was required, if required reserves of some 30 million tonnes were to be obtained. The area selected was updip of the fault, but restricted by the ultimate highwall of the Main Series open cut. The investigation programme was planned for this area.

Investigation Programme

Three partly cored boreholes were drilled to depths of 260.2, 396.8 and 403.7m on two seismic lines crossing the area of study. Two shallow holes were also drilled for installation of near surface piezometers. Permeability testing and geophysical logging were undertaken in the deep holes and sealed piezometers installed for water level measurement. Permeability values were determined for roof and floor rocks and the coal seam. Indentor tests were used to assess rock strengths.

The investigation generally confirmed the thickness and continuity of the Main Series coal seam, established by previous work, with good agreement being achieved between seismic and drillhole data. An average coal thickness of about 14m, with dips varying from 16° to 22° were determined.

Approximate estimates place the reserves in the defined area of study at about 36 million tonnes, significantly in excess of that required. However initial use of these reserves does have significant implications on the development of the complete Lobe B resource.

Geotechnical Evaluation

Computer analyses have been used to simulate the response of groundwater to the progressive burning of a 500m wide cavity, using data obtained from field results. The values for permeability (1 to 5 x 10^{-9} m/s) are significantly lower than those indicated in previous reports and used in the preliminary appraisal in 1983.

Despite the significant assumptions required for the analysis, the results suggest that both groundwater inflow and groundwater drawdown will be acceptable. The estimated inflow suggests that the ratio of average water flow to coal production should be in the range 1:10 to 1:100, which will be readily handled by the gasification process. The groundwater drawdown should maintain a cover of about 100m of water except perhaps near the end of the mine life, depending on the parameters assumed. The long-term situation can only realistically be assessed after obtaining data from the early years of operation.

With respect to roof stability, calculations suggest that complete closure will not occur until the full seam length has been gasified, with the caved zone extending perhaps 25 to 50m above the cavity. Ground settlements long-term in the range 10-13m might be anticipated.

Overview of Lobe B Resource

An initial appraisal has been made of the complete resource in Lobe B, with the purpose of assessing the best technical approach to its development. Total reserves of approximately 200 million tonnes in the Main Series seam, and 80 million tonnes in the Lower Series seam are considered possible, although data below 500m is very limited. While the Main seam appears to maintain excellent thickness, the Lower seam is variable and banded, and although an average of 3m of coal has been assumed, some difficulties may exist in maintaining a continuous burn because of changing coal thickness.

If total reserves of around 250 million tonnes are present, it is reasonable to consider the effect of developing the proposed area on the development of the complete deposit. It is evident that the current proposal would create technical difficulties in developing downdip in the Main Series, and in gaining access to the Lower Series, because of problems of drilling through broken ground.

If development of Lobe B in its entirety is contemplated, it is clear that an initial programme of seismic work and deep drilling would be essential to define reserves and gasification potential below 500m depth.

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1. INTRODUCTION

In April 1983, Golder Associates presented a report entitled "Geotechnical Aspects of U.C.G. Feasibility Study, Leigh Creek". The report collated and reviewed existing data relevant to the development of an underground coal gasification scheme utilizing the Leigh Creek coal measures which are inaccessible to open cut mining.

The report considered a number of alternatives for development including the three main coal seams (Upper, Main and Lower Series) of Lobe B. Lobe C was also considered, but detailed study deferred due to lack of suitable long-term reserves for the required power supply. The most likely area for development of 60 MW of produced power with a plant life of 20 years was considered to involve a high pressure system using Main Series coal from Lobe B. Reserves of about 30 million tonnes were inferred to exist between the upper series outcrop line and the long-term high wall of the Main Series open pit. Coal to the north-west and south-east of this area was considered unsuitable due to likely faulting at depth. Apart from the general geological environment, the report considered three key factors in detail, given the limited data available in the preferred area.

- coal seam characteristics (reserves, thickness and continuity)
- roof stability
- influence of groundwater.

The Main Series seam showed an acceptable average coal thickness of about 13m, without evidence of significant faulting which would affect the continuity of the gasification process. The roof rock was considered to be of sufficient strength to provide controlled caving without suppressing the coal burning process.

An evaluation of groundwater effects on gasification was made using limited rock permeability data provided by D.M.E. The analyses predicted high seepage flows, with desaturation of the roof rock after a number of years of working. Although it was felt that the permeability values quoted were unreasonably high, and the predictions were unduly conservative, it was recommended that a contingency item be included in cost estimates in the event that some recharging of aquifers was required during the mine life.

Following completion of this initial report, it was felt that further progress of the feasibility study required quantitative field data on roof and floor rock strength and permeability, existing water levels, and coal seam permeability and continuity. Various discussions ensued with D.M.E. in Adelaide during 1984 concerning the most efficient use of resources, and the extent to which the Department could assist by providing drilling services. During this period, additional geological information was provided by the Department which indicated that a significant fault passed through the area previously defined for gasification.

A meeting was held in Adelaide on September 7, 1984, to resolve finally the approach to be taken to the execution of a limited geotechnical programme to better define existing uncertainties. The meeting was attended by Prof. I. Stewart and representatives of Golder Associates and D.M.E. It was agreed that the presence of the fault required a redefinition of an area of reserves to supply about 30 million tonnes. A possible area updip of the fault was defined, and the investigation programme set out in detail.

This report describes the field work performed, the rock parameters obtained, and presents the current interpretation of

- coal seam thickness, reserves and continuity
- geotechnical parameters as they affect groundwater pressures and flow, and stability of the roof in the gasified zone.

2. INVESTIGATION PROGRAMME

2.1 Existing Information

The location plan for Lobe B is presented as Figure 1, showing the outcrop of the Main and Upper Series coal seams. Also shown on the plan are locations of previous boreholes and seismic traverses. This data consists of

- a seismic traverse line AA with three correlation boreholes (BHL3027, 3382 and 1576)
- a seismic traverse line BB with two correlation boreholes (BHL914 and BHL3218) plus one borehole entirely in rock (BHL2349)
- one additional borehole (BHL3630)
- available cross-sections within open cut region of Main Series.

Cross-sections along the seismic traverse lines have been drawn up to show the inferred continuity of the Main Series coal seam (Figures 2 and 3). These sections indicate that the coal seam maintains its thickness and continuity to the maximum interpreted depth of about 450m-500m when a major fault is encountered. The throw of the fault is inferred to be 52m on Section AA and 60m on Section BB. Although the seismic traverses picked up minor faults at shallower depths, the coal seam displacements appear to be less than half the seam thickness and should therefore have little effect on the continuity of the gasification process.

Existing drillhole results show a reasonable correlation of the intersected coal seam updip of the fault with that inferred from the traverses. The absence of coal in borehole L2349 on Section BB also confirms the presence of a substantial fault in the area defined by seismic work, although the borehole suggests that the throw of the fault is greater than interpreted. Data from the sections and from coal exposures in outcrop have enabled an inferred zone of influence of the fault to be defined on plan (refer Figure 1). Although positive confirmation of the fault by intersection of the coal seam down-dip of the fault is not available, sufficient certainty of its presence exists to require reconsideration of the originally proposed gasification procedure.

Normal gasification procedure would involve the progress of a burn updip in panels. Collapse of the roof would occur progressively as the panel was burnt out. Obviously the burn would start at the fault, and would require to be restarted if coal at lower levels was to be burnt. There are two main obstacles to the successful restarting of the process - the cost of drilling deep new ignition and recovery holes, and the need to drill through previously caved roof rock. In view of these difficulties it was determined that investigation work should concentrate on coal within an area updip of the fault governed by

- the inferred fault location
- the long-term high wall for the open cut (updip).

Within these boundaries (outlined on Figure 1) it was determined that reserves of approximately 30 million tonnes could be recovered.

2.2 Field Programme

After agreement on the area of investigation, a limited drilling programme was undertaken during the period October-December, 1984. The main purposes of the programme were

- to establish continuity of the Main Series coal seam to give confidence to proposed gasification panel layouts, and to inferred coal reserves

- to establish basic strength and permeability characteristics of the coal seam, and roof and floor rocks, to be used in assessing the consequences of panel development on water flows and rock stability.

The drilling work was undertaken using D.M.E. equipment and personnel, under the direction of Mr. I. Gibson, a senior engineering geologist from Golder Associates. Borehole locations were restricted to existing seismic lines on Sections AA and BB so that calibration of the results could be achieved.

Three partly cored deep boreholes (numbered L3964, L3966 and L3967) were completed, with shallow holes being drilled alongside the first two holes for installation of near-surface piezometers. Borehole L3964 was drilled on Section AA, while L3966 and L3967 were drilled on Section BB to the north-west of the site.

Boreholes L3964 and L3967 were drilled by open hole methods to a predetermined level, and then lined with steel casing prior to commencement of coring. Rising head permeability testing was performed using a wireline pneumatic double packer system. Upon completion of coring, boreholes were geophysically logged for a range of nuclear, electrical and acoustic properties using equipment supplied and operated by S.A.D.M.E.

After geophysical logging, a piezometer was installed within the coal seam interval in these two boreholes. The interval between the upper grout seal and the base of the steel casing may also be regarded as providing a means of measuring piezometric head at this level. Details of the piezometer installations are shown on Figure 4. A supplementary shallow observation bore (L3965) was completed adjacent to L3964.

Borehole L3966 was intended only to correlate with the seismic data and was drilled open-hole into the coal before coring. No in-situ testing was performed, however the upper section of the borehole can be used to monitor groundwater levels. A shallow observation bore (L3968) was completed adjacent to L3966.

Table 1 summarizes the detailed information for each hole - its depth, cored interval, coal intersection, and location of permeability test intervals. Core recovered over the indicated depths was photographed in colour, and then logged in detail for geotechnical purposes, including:

- rock type
- estimated strength
- bedding dip
- joint dip
- fractures per metre.

TABLE 1

SUMMARY OF BOREHOLE DETAILS

Borehole No.	Depth (m)	Cored Interval (m)	Coal Intersection (m)
L3964	403.7	349.1 - 403.7	371.1 - 389.9
L3965		Observation Borehole	
L3966	260.2	241.0 - 260.2	227.0 - 242.9
L3967	396.8	312.4 - 396.8	373.2 - 384.7
L3968		Observation Borehole	

Borehole No.	Permeability Test Interval (m)	Permeability (m/s)	Strata
L3964	350.0 - 368.1	1×10^{-9}	roof
	368.4 - 389.9	2×10^{-9}	coal
	389.7 - 403.7	1×10^{-9}	floor
L3967	315.0 - 335.8		roof
	315.0 - 359.4	4×10^{-9}	roof
	372.0 - 396.8	100×10^{-9}	coal
	384.0 - 396.8	2×10^{-9}	floor

Strength estimates were backed up by a limited field testing programme consisting of Point Load Strength Index testing and Rock Core Hardness Indentor tests. Detailed borelogs and test results are presented in Appendix A to this report. Core photographs are included in Appendix B.

Water levels have been monitored in each of the piezometers/standpipes since the completion of drilling in late December 1984. Table 2 lists all results reported to date, it being noted that the piezometers were flushed out in early February 1985 and have subsequently restabilized.

2.3 Materials Testing

The strength of roof and floor rocks was determined in the field using Point Load Index testing and Rock Hardness Indentor testing. The Point Load Index (I_s) is obtained by testing pieces of core 50mm long, and correlations between unconfined compressive strength (u.c.s.) in MPa and I_s have been established, viz.

$$\text{u.c.s.} \approx 25\ I_s.$$

For low strength rocks, it is often difficult to obtain suitable specimens for laboratory testing, and under these conditions the Indentor, which simulates the loading of a small circular footing, can be used to obtain an estimate of unconfined compressive strength. For low strength rocks ($\phi = 25^0$) a correlation exists between u.c.s. and indentor reading which is linear. As rock strength increases, the relationship becomes non-linear.

The rock strength test data are summarized on Figure 5, which shows

- the correlation curve between Indentor reading and u.c.s.
- the correlation between Point Load Index and u.c.s.
- test data showing Point Load Index strength plotted against Indentor reading. Locations of individual tests are shown on the borelogs in Appendix A.

TABLE 2

LEIGH CREEK
U.C.G. FIELD PROGRAMME
GROUNDWATER MEASUREMENTS

DATE	L3964			L3966		L3967	
	3/4" GAL. COAL	6" STEEL ROOF	L3965 PVC SHALLOW	6" PVC ROOF	L3968 SHALLOW	3/4" GAL. COAL	6" STEEL ROOF
20/12/84	11.28	18.80	DRY	8.84	15.12	11.08	38.83
2/1/85	10.47	18.26	DRY	8.80	15.18	10.72	16.03
4/1/85	10.46	18.00	DRY	8.81	15.19	11.03	15.79
7/1/85	10.47	17.68	DRY	8.81	15.20	11.54	15.60
8/1/85	10.51	17.66	DRY	8.83	5.22	12.36	14.88
10/1/85	10.42	17.62	DRY	8.82	5.25	12.41	15.55
14/1/85	10.41	17.61	DRY	8.82	5.26	12.50	15.60
16/1/85	10.39	17.62	DRY	8.81	5.27	12.59	15.67
18/1/85	10.37	17.61	DRY	8.82	5.27	12.58	15.71
21/1/85	10.37	17.60	DRY	8.81	5.28	12.68	15.76
23/1/85	10.36	17.60	DRY	8.81	5.29	12.79	15.80
24/1/85	10.45	17.61	DRY	8.83	5.31	12.86	14.81
25/1/85	10.48	17.60	DRY	8.82	5.32	12.76	14.75
28/1/85	10.40	17.54	DRY	8.81	5.33	12.79	14.60
30/1/85	10.34	17.52	DRY	8.82	5.35	12.82	14.54
31/1/85	10.35	17.52	DRY	8.81	5.32	12.84	14.52
4/2/85	12.94	17.60	DRY	8.83	5.36	12.88	14.39
6/2/85	12.34	17.57	DRY	8.67	5.37	12.97	14.32
8/2/85	14.41	19.13	DRY	8.78	5.33	12.59	14.30
11/2/85	13.26	18.81	DRY	8.77	5.33	12.81	14.21
13/2/85	13.16	18.69	DRY	8.77	5.36	12.65	14.17
6/3/85	13.68	16.64	DRY	8.71	5.38	13.22	13.89
11/3/85	13.63	16.50	DRY	8.70	5.41	13.07	13.88
13/3/85	13.65	16.44	DRY	8.70	5.40	13.31	13.84
15/3/85	13.68	16.39	DRY	8.69	5.42	13.02	13.86
19/3/85	13.58	16.26	DRY	8.68	5.44	13.11	13.80
22/4/85	13.59	14.81	DRY	8.67	5.51	12.91	13.63

It can be concluded from the results that the Leigh Creek rocks are generally of medium strength (i.e. outside the linear range of the Indentor correlation curve), and are uniform with a relatively small scatter in test data.

2.4 Permeability Test Data

The six rising head permeability tests were undertaken after completion of borehole drilling, and were run for approximately one hour. Water level recoveries over this period varied from 0.06 to 4.5m, with five of the tests producing rises of less than 0.6m due to the relatively low rock permeabilities. While the changes in level for most of these tests are small, a result of time limitations on site, the permeabilities calculated are considered to give a reasonable estimate of the in-situ value for the purposes of the feasibility study. Variations in the static water level, as shown by the measurements reported in Table 2, do not have a significant effect on the calculated permeability. Permeabilities for each of the six tests undertaken are listed on Table 1.

3. COAL SEAM CHARACTERISTICS

3.1 Geology

The general geology of the Main Series coal seam in Lobe B was summarized in the April 1983 report. Previous investigation work, apart from that summarized on Figures 1-3, has been concentrated in areas likely to be mined by open-cut methods, i.e. at maximum depths in the range 150-200m. Detailed examination of geophysical logs resulted in the separation of the seam into upper and lower splits separated by a middle parting of 1-2m thickness comprised of mudstones, often carbonaceous. Some improvement in coal quality down-dip was anticipated.

Average coal thicknesses were assessed in different areas as follows:

N-W area, dip 15°-20°, 13.3m coal in 15.8m seam
E area, dip 10°-15°, 13.4m coal in 15.2m seam
S area, dip 30°-40°, 8.2m coal in 10.7m seam.

An assessment was made of faulting, and it was concluded that only the southern area of the seam was likely to be affected by faulting to an extent which would significantly interrupt the gasification of coal to depths of about 500m.

3.2 Seam Thickness and Continuity

Coal intersections of 15.9m (L3966), 11.5m (L3967) and 18.8m (L3964) were obtained from the three boreholes drilled in this investigation. There was no evidence of intermediate partings over these intervals. These intersections are consistent with the data inferred from previous reports, and from interpretations of the seismic traversing shown on Figures 2 and 3. The results thus give considerable confidence to the maintenance of seam thickness to depths of around 500m.

These intersections have been plotted on Figures 2 and 3 to enable a reassessment of seam continuity to be made. It is evident that good correlation exists between the boreholes and seismic traverse, confirming the good continuity of the seam down to the major inferred fault. The strata dip at an angle of about 16° at borehole 3964 on Section BB, increasing to 22° at 3967 on Section AA.

With respect both to seam thickness and continuity, the additional data obtained for the report gives substantial additional evidence of the suitability of the Main Series coal seam for gasification. The existence of a fault at about 500m depth with a throw greater than 50m does however demand that consideration be given to the best means of utilizing the entire resource in the seam, since gasification updip of the fault has obvious implications if recovery downdip is to be pursued. These broader considerations are discussed further in Section 5.

3.3 Reserves

The principal purpose of the April 1983 report was to confirm reserves sufficient to produce 60 MW actual of power using a high pressure system with a plant life of 20 years. Revised estimates of coal usage gives a calculated requirement for 30 million tonnes of coal. It is obviously important to estimate the reserves existing within the area bounded by the inferred fault and longterm location of the crest of the open cut high wall, assuming a face slope angle of 45^o.

The area for reserve calculation is indicated on Figure 1, while the length of coal seam which can realistically be worked, given geometric constraints, is indicated on the cross-sections (Figures 2 and 3). Approximate calculations of reserves within the bounded area, to an accuracy consistent with the limited field data available, may be summarized as follows.

Plan area within boundaries = $1.9 \times 10^6\ m^2$

Average dip = 18^o, average coal thickness = 14m

.. reserves in-place

$$= \frac{1.9 \times 10^6}{\cos 18^o} \times 14m$$

$$= 28 \times 10^6\ m^3$$

Assuming a density of 1.3 tonne/m^3 gives reserves of about 36 million tonnes, significantly in excess of the required tonnage. However it must be pointed out (refer Section 5) that use of these reserves for initial power production may have detrimental effects on development long-term of the total Lobe B resource.

It is evident that the reserve calculation will be redone when details of a gasification procedure is defined, particularly with respect to detailing of the drilling of deviated holes from the high wall of the open cut. However it is sufficient at this stage of the study to indicate that the required reserves are present to support the feasibility of the proposed plant.

4. TECHNICAL ANALYSIS OF GASIFICATION

4.1 Groundwater Analysis

In the April 1983 report, a simplified analysis of the effects of the gasification process on groundwater levels was made using a finite element groundwater computer package developed by Golder Associates. A computer model was developed to simulate the progressive gasification of a 600m working face at a rate of 100 m/year. This analysis used permeability values provided in a previous report by Coffey and Partners, which were considered at the time to be unrealistically high.

Although permeabilities in the roof and floor rocks obtained in the field programme are relatively uniform, a wide range of values was obtained for the coal. A detailed analysis would thus require a range of permeability values to be used to determine the sensitivity of water inflow and water table drawdown to variations in permeability of the various layers. Other factors to be considered in the analysis are the gas pressure in the cavity and the increased permeability which will result in the caved zone above the cavity. Given the limited scope of this study, a preliminary analysis has been undertaken using the following parameters

. roof permeability	2×10^{-9} m/s
. coal permeability	3×10^{-9} m/s
. floor permeability	1×10^{-9} m/s
. cavity pressure	15 atmospheres
. effect of caving ignored.	

The finite element analysis was used to predict the response of groundwater for the case of a 500m wide burn excavation progressively introduced over a 20 year period. The model was based on the section shown on Figure 6. The coal seam (15m thick) treated in the analysis was restricted to 100m updip of the fault and 200m from the toe of the open cut. The two-dimensional model assumed an extensive burn along strike (i.e. >2000m).

The analysis for the open cut mining phase indicates an average groundwater inflow rate of 23 ML/year for 1 km face length of the pit, with the phreatic surface after 20 years indicated on Figure 7.

The effect of underground coal gasification (years 20 to 40) was simulated by applying a constant mine inflow rate from nodes within the excavated area. The inflow rate was selected by trial and error to be compatible with initial and final pressure states in the cavity, given that progressive mining will occur updip. An average inflow rate of 45 ML/year for a 1 km face length was adopted, and five time increments in the gasification of the seam were adopted.

158 metres head H_2O @ X = 1.00

Figure 7 presents the distribution of water pressure head across the burn section at the completion of the burn. The uniform fluid pressure of about 150m water head in the excavation results from the assumed cavity gas pressure of 15 atmospheres. The water table, which was lowered about 25m at the updip end of the seam during open pit mining, is lowered to 40m after completion of the burn, i.e. about 200m above the seam.

The limited scope of this study has meant that more detailed analyses varying input parameters has not been possible. However inferences have been made from the results obtained as follows.

A lower cavity gas pressure would increase groundwater inflow rates during excavation. It is estimated that zero fluid pressure at the end of gasification would cause an average inflow of 90 ML/year per 1 km length. Lowering of the water table is estimated to increase from 40m to 100m, which would still leave a minimum groundwater cover of about 140m over the top end of the excavation area.

If a higher permeability dislocation zone was introduced over the burn area in the latter stages of excavation, this would cause a marginal increase in groundwater inflow rates, but a significant increase in groundwater table lowering, particularly for the low fluid pressure case. In the extreme case of zero fluid pressure in the cavity, the groundwater cover at the updip end might be close to zero in the latter part of the gasification period.

The coal seam permeability used in the analysis is at the low end of the range measured. If a significantly higher value was adopted, this would result in slight increases in groundwater inflows and water table lowering during underground mining. In addition, higher groundwater inflows and more extensive depressurization of the coal seam would occur before underground mining commences.

4.2 Roof Stability

A preliminary evaluation of roof stability was made in the April 1983 report, using experience derived from the U.K. involving overburden which was typically well-bedded sedimentary strata. It was estimated that the expected maximum possible settlement might be in the range 0.7 to 0.9 of the seam thickness. For the average coal thickness of 14m used in the ore reserve calculation, this implies a ground settlement in the range 10-13m. The drill core and strength testing showed a mudstone of relatively uniform medium strength, which is consistent with the U.K. rock types from which the data were derived. The projections of maximum ground settlement are therefore considered realistic.

With respect to caving of the coal seam roof, observations of subsidence suggest that the mining width at which closure occurs is about 1.4h (where h is the mining depth below ground surface). For an average mining depth of about 350m, the mining width for closure is thus 490m, i.e. the full width of the burn.

The height of caving above the gasified zone is estimated from experience at about 0.07 to 0.14h, i.e. between 25m and 50m, or about 1.7 to 3.3 times the seam thickness. It should be noted that the height of the caved zone is restricted by the bulking of the caved material. With a bulking factor of between 1.2 and 1.3, the extent of bulking is limited to between 3 and 5 times the seam thickness before roof support is achieved.

Beyond the caving height, a zone of lesser dislocation will exist within which there will be an increase in rock permeability to a height estimated at up to 10 times the mining height. This effect will of course reduce with distance above the cavity.

4.3 Implications on Gasification Process

[illegible]

The field investigation programme has enabled a better definition of rock strength and permeability characteristics, and of groundwater levels. These parameters have enabled more relevant analyses to be made of groundwater response to creation of the gasified cavity, and of roof stability and surface settlement.

Despite the significant assumptions required to be made for the preliminary analysis undertaken, the results suggest that both groundwater inflow and groundwater drawdown will be acceptable. The estimate of water inflow is 45 ML/year per 1 km of face. The rate of gasification indicates that a full face length (along the strike of the seam) of about 4 km will be mined in 20 years, i.e. 200 m/year. The estimated inflow is thus 9 ML/year, or 9000 m^3/year. This compares with a rate of coal production of about 30 million tonnes in 20 years, or about 1 million m^3/year. The ratio of average water flow to coal production is thus about 1:100. This is a relatively low flow, and even with localized higher coal permeabilities the ratio should not exceed say 1:5, which will be readily handled in the gasification process.

With respect to groundwater table drawdown, the analyses suggest that with the most unfavourable assumptions, a groundwater cover should be maintained above the coal seam to prevent gas leakage except perhaps at the end of mine life. Given the limited accuracy of all parameters, it can sensibly be concluded that a significant pressure head over the cavity is likely for most of the mine life, and that the long-term situation can only realistically be assessed after data from the early years of operation are obtained.

Conclusions as to roof stability are not significantly changed from those presented in the April report. The calculations of roof stability suggest that complete closure will not occur until the full seam length updip has been gasified. The caved zone will extend perhaps 25 to 50m above the cavity but should have a limited effect on the gasification process because of its development late in the gasification of a particular panel.

Provided [illegible]?
[illegible]

5. OVERVIEW OF LOBE B RESOURCE

The preliminary studies of underground coal gasification on Lobe B were based on the requirement to provide 70 MW of power over a life of 20 years. Main Series coal was selected as most suitable for this purpose, with a high pressure system forming the basis of the feasibility study.

Following discussions with ETSA on development of Lobe B, it was considered desirable to assess the overall reserves in this deposit, rather than part of one particular seam. Comments below on each of the Lower, Main and Upper Series coal seams are extracted from the April report, modified by limited additional information. The relative positions of the three coal seams are shown on Figure 8. With the relatively shallow depth of the Upper Series, and the possibility of developing the open cut to at least 200m, it is probably realistic to ignore the possibility of recovering coal from these seams by gasification. The obvious possibility involves recovery from the Main and Lower Series over the full seam length.

Both of these seams appear to terminate in the south-west area of the basin, possibly along a major inferred fault structure. The vertical separation between the seams, to the extent that it is defined, appears to be roughly constant at about 150m-200m.

Based on a very preliminary assessment of deep seismic survey data, the Main Series seam downdip of the area proposed for gasification appears to maintain its thickness and continuity. Knowledge of the nature of the seam to a depth of 400m can thus be extrapolated to depth with some modest likelihood of applicability.

The composition of the Lower Series seam is relatively complex, being made up of variably interbedded coal and mudstone according to the limited data available at shallow depth (<200m). The coal bearing interval is comprised typically of an upper and lower split separated by 10m to 20m of mudstone. The overall coal content exhibits considerable range in both splits, as does the thickness of the major coal bands, which range from 2.5m to 8.0m in the north-eastern area and from 1.7m to 3.6m in the southern areas. The upper split contains several coal bands in excess of 3m thickness, but those in the lower split rarely exceed 1.5m.

In attempting to achieve a realistic assessment of total reserves, it would appear reasonable and perhaps conservative to adopt an average seam thickness of at least 10m in the Main Series and a total of 4m in the Lower Series. A rough seam length of 3500m and a width of about 4500m can be obtained from current knowledge of the basin geology. The reserves which result from these dimensions are

Main Series - 160 million m^3 or 200 million tonnes

Lower Series - 60 million m^3 or 80 million tonnes.

The limited accuracy of these estimates should be evident from previous discussion.

If the total gasifiable resources of Lobe B are put at around 250 to 300 million tonnes, i.e. ten times the amount being considered for development in the present study, it is reasonable to consider the impact of the proposed 60 MW scheme on development of the complete deposit.

Two major factors requiring consideration in determining the best method of developing the complete resource are

- the need to define reserves at depth (>500m)
- difficulties in developing the Lower Series seam if the Main Series is gasified first.

The latter point results from the problems of drilling through caved ground within and above the Main Series seam in order to install ignition holes at lower levels.

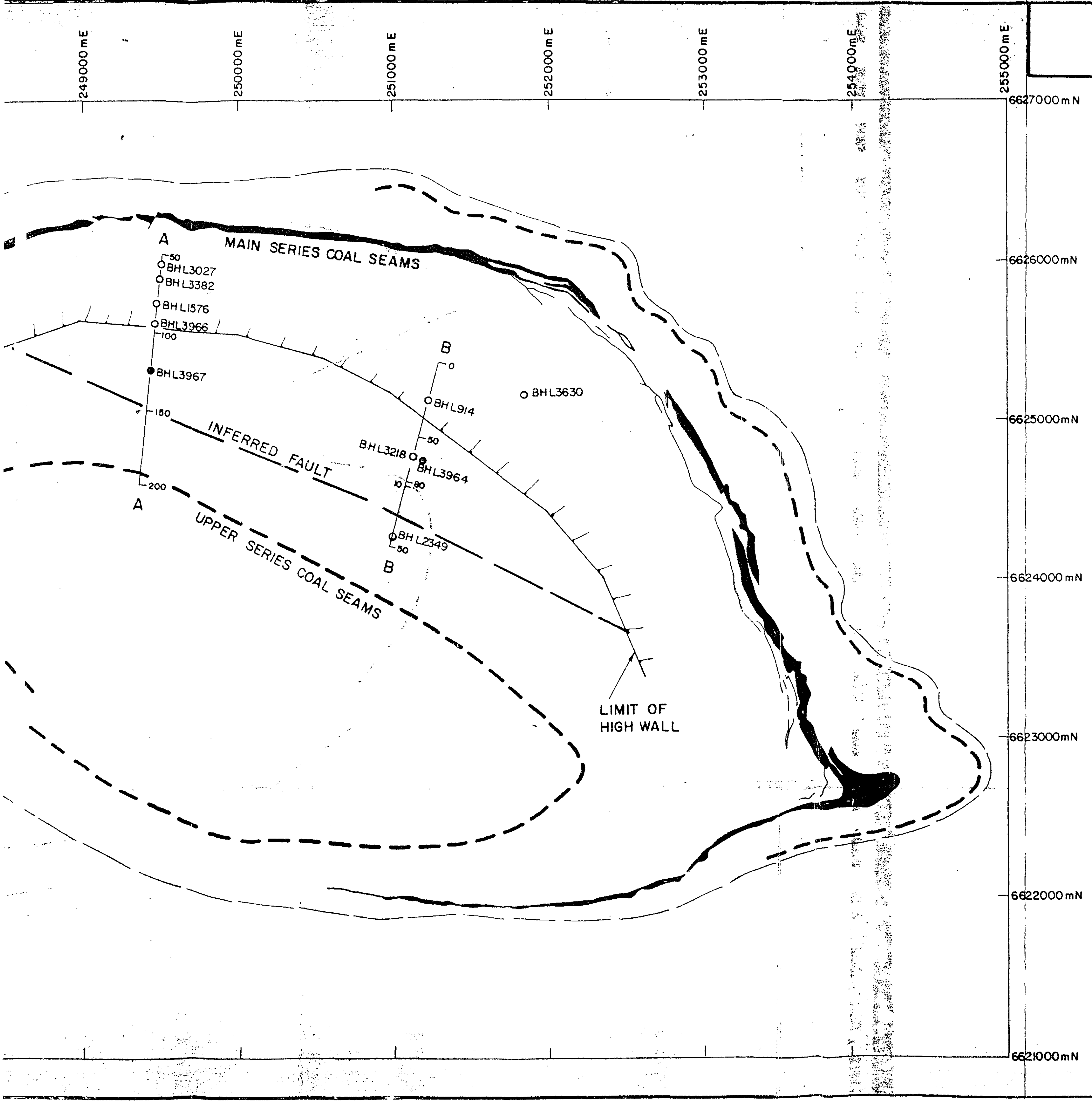
The problem of adequately defining coal seam thickness, reserves, and continuity at depth is obviously of great significance in determining the maximum potential of Lobe B for gasification. This is particularly true for the Lower Series, due to the variable thickness of the seam in the splits.

There is little doubt that an initial programme of seismic investigation and limited deep drilling would be necessary to support any long-term plan to gasify both Main and Lower Series seams to maximum depth.

APPENDIX A

LOBE B - LOCATION PLAN

FI



LEGEND

— — LIMIT OF COALFIELD

SUB - OUTCROP OF COAL SEAM

B ⊢—50—⊣ B LINE OF SECTION
GEOPHONE LOCATIONS

● BOREHOLES (GEOTECHNICAL)

○ BOREHOLES - OPEN

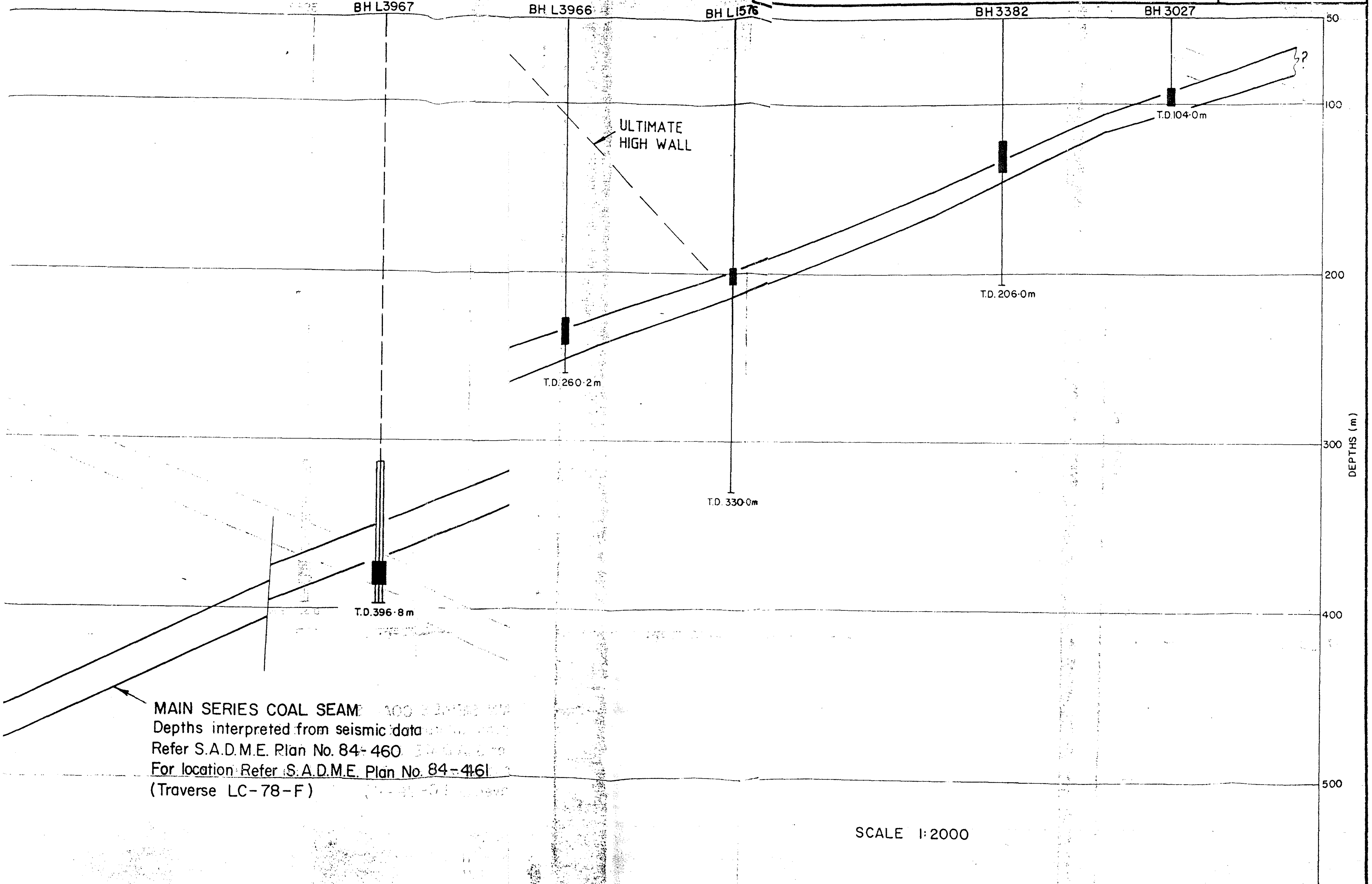
SCALE 1 : 25000

REFERENCE: S.A.D.M.E. PLAN No. 83.86 FEB. 1983

GDL

SECTION A-A

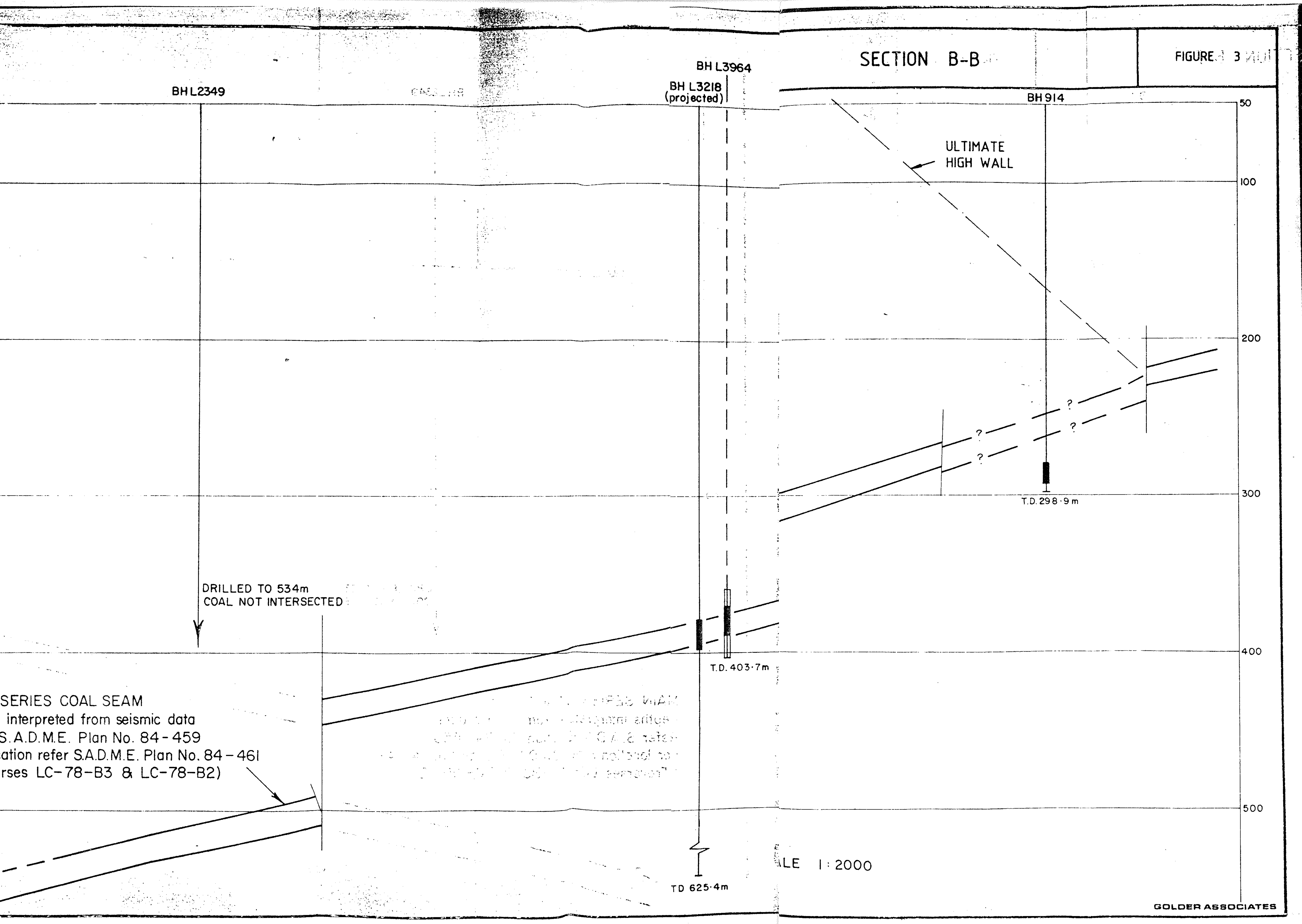
FIGURE 2



MAIN SERIES COAL SEAM
Depths interpreted from seismic data
Refer S.A.D.M.E. Plan No. 84-460
For location Refer S.A.D.M.E. Plan No. 84-461
(Traverse LC-78-F)

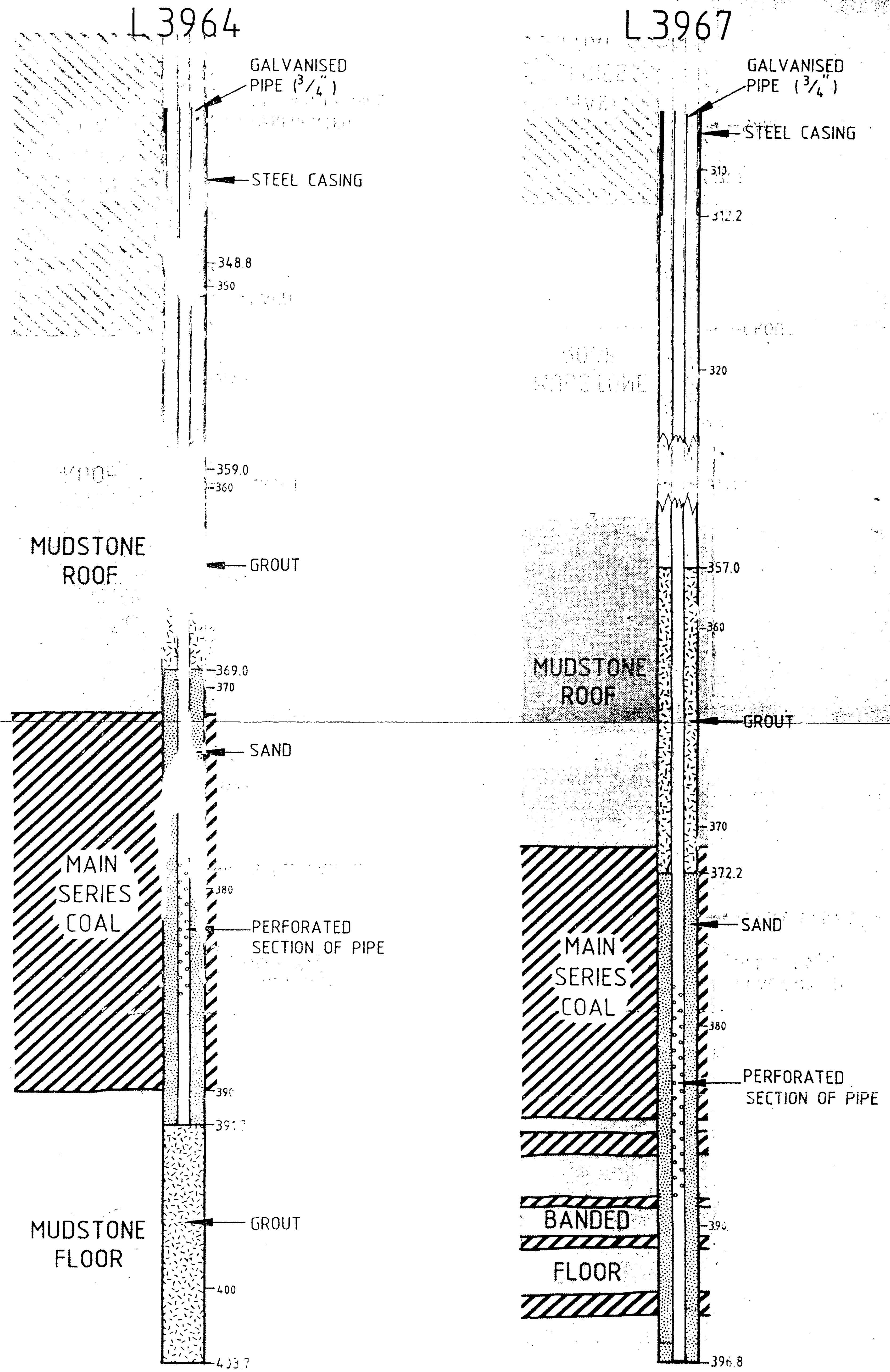
SCALE 1:2000

GOLDER ASSOCIATES



SECTION B-B

FIGURE 3



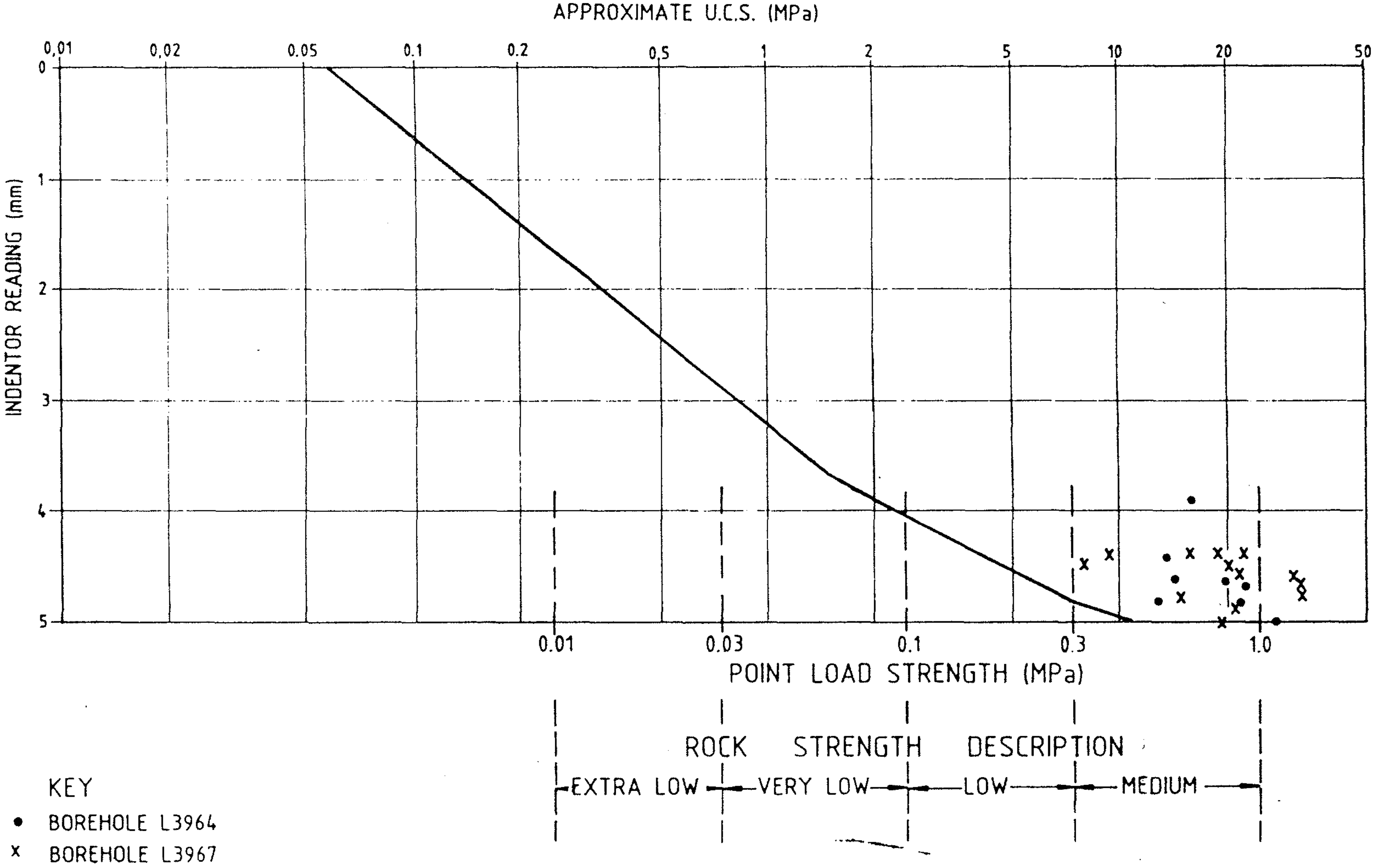
VERTICAL SCALE 1:200

PIEZOMETER INSTALLATIONS
BOREHOLES L3964 AND L3967

FIGURE 4

GOLDER ASSOCIATES

Job No 82612075



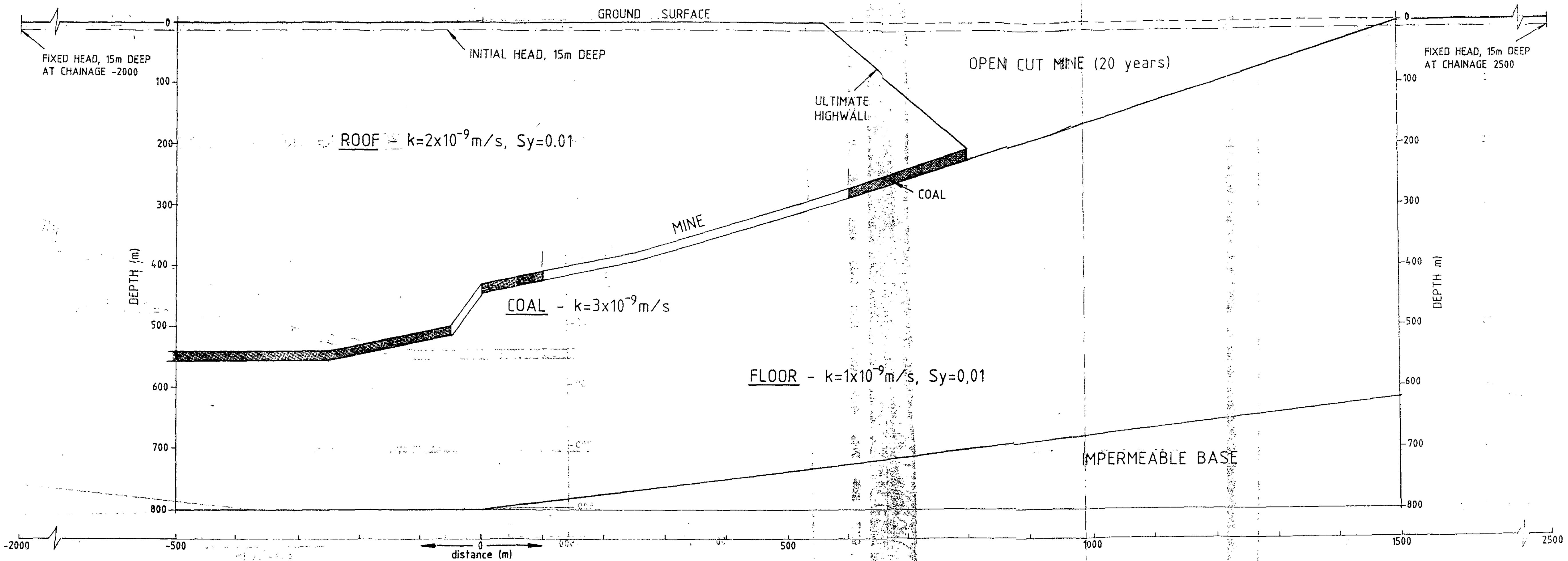
ROCK STRENGTH TEST DATA

FIGURE 5

Golder Associates

GROUNDWATER ANALYSIS
ASSUMED SECTION

FIGURE 6



NOTES

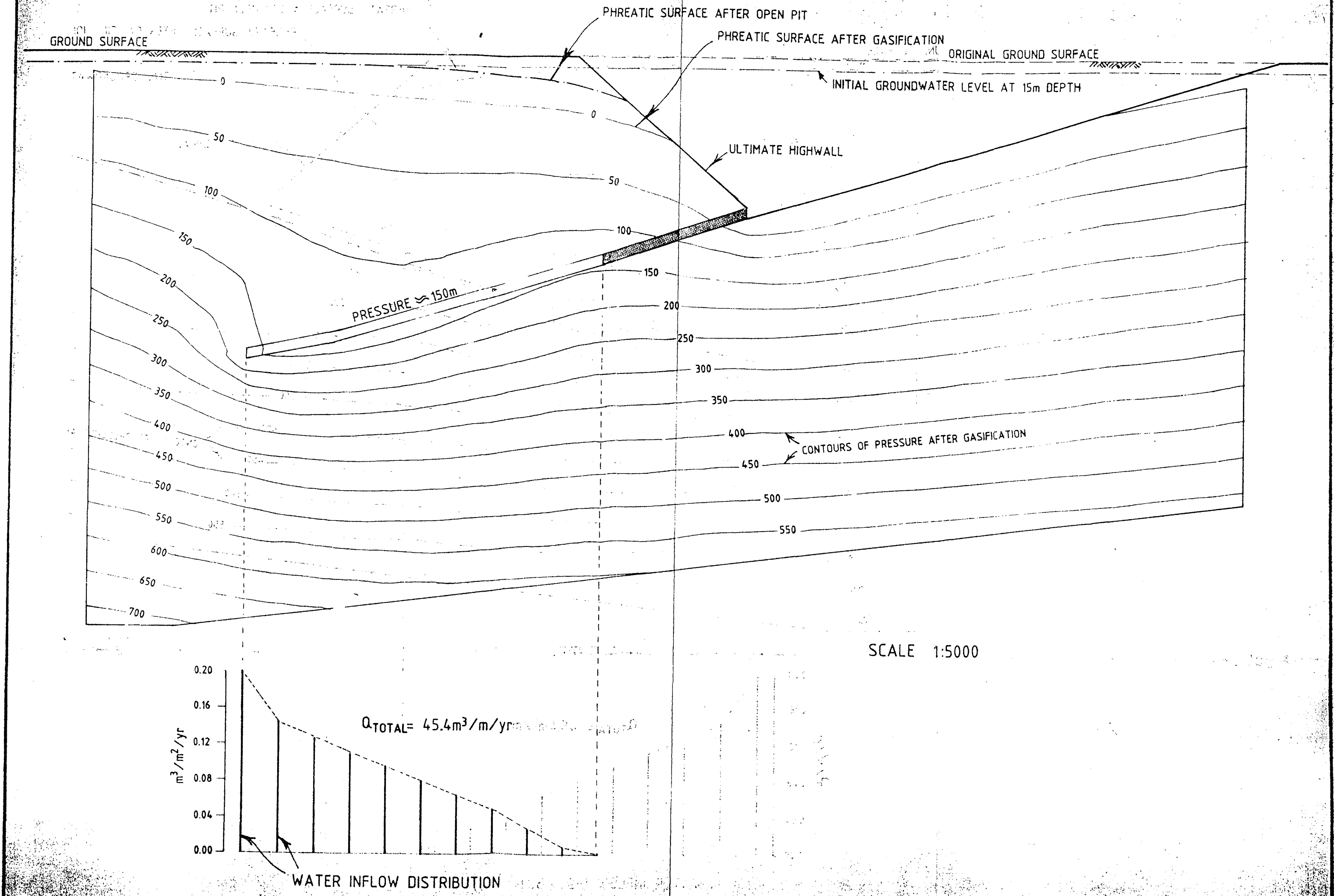
(a) 20 YEARS TO CREATE OPEN CUT MINE $Q = 23m^3/m/year$

(b) DEPRESSURIZATION OF 500m WIDE MINING STRIP OVER 20 YEARS OF MINING $Q = 45.4m^3/m/year$

GOLDER ASSOCIAT

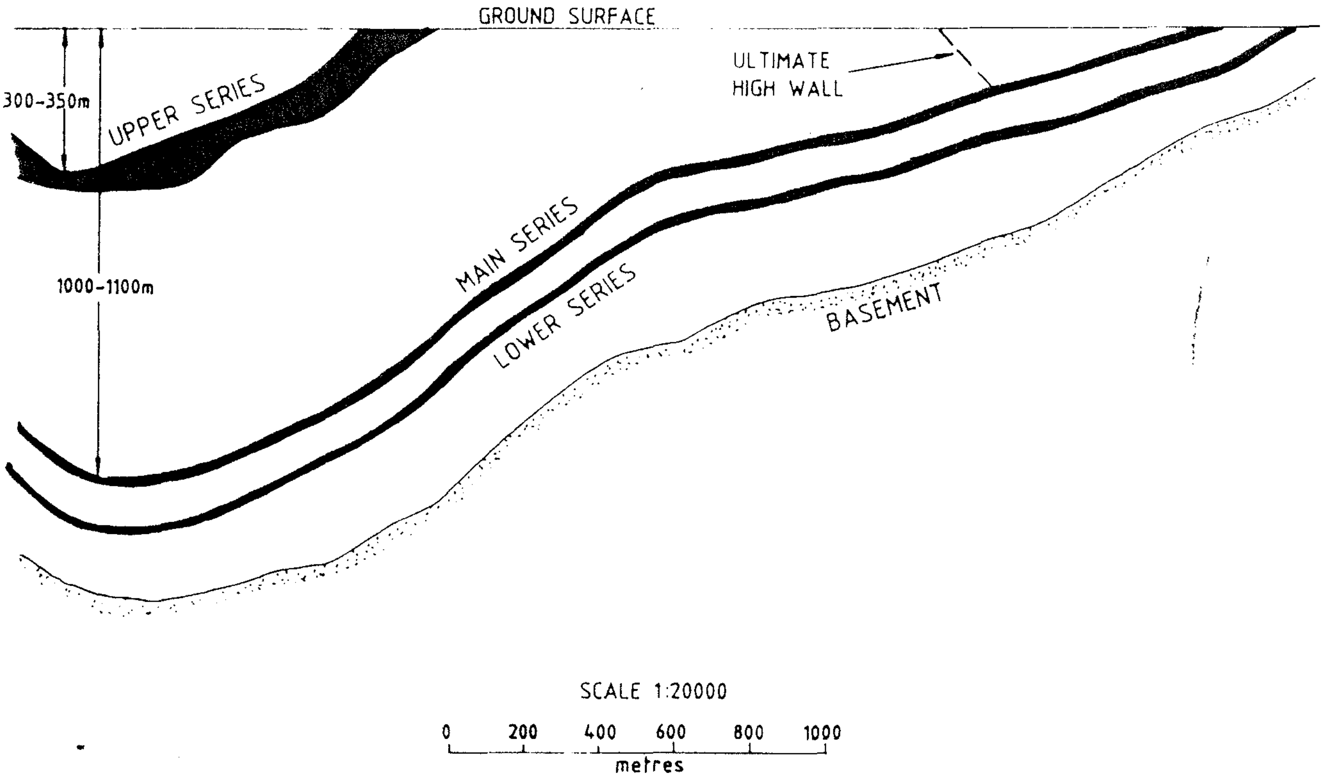
PREDICTED DRAWDOWN AFTER GASIFICATION

FIGURE 7



GOLDER ASSOCIATES

LOBE B - INFERRED BASIN PROFILE	FIGURE 8



Golder Associates

LOCATION

SURFACE ELEVATION (R.L.) DATUM

INCLINATION VERTICAL AZIMUTH

DRILL TYPE / METHOD HOTT DATE

BORE HOLE L 3964

FIGURE A1

SHEET 1 OF 7

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. / DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm) 1 4 16 64	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
	OPEN HOLE Surf. - 349.09								
			349						
MUDSTONE F	dark brey, moderately weak, massive, some banding evident, low angle dip 6° to 8°						1	349.09 bedding dip 6°clean,rough,planar	
				460			1	349.38 bedding dip 8°clean,rough,planar	
				390				349.56 bedding dip 8°clean,rough,planar	
				420		100	0		
							1	349.95 drilling 10°,irregular,stepped, rough	

LOCATION

SURFACE ELEVATION (R.L.) DATUM

INCLINATION VERTICAL AZIMUTH

DRILL TYPE / METHOD HQTT DATE

BORE HOLE L 3964

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A1

SHEET 2 OF 7

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (I_s=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak, massive, low bedding angle to 10°		350				1	350.23 bedding dip 10°, slight curve, smooth, clean	460
							1	350.36 bedding dip 4°, clean smooth planar	470 450
							0		470
							1	350.84 bedding dip 10°, clean, smooth, planar	460
			351			100	1	351.10 bedding dip 4°, clean, smooth, planar	
							0		470 485
							0		440
							2	351.91 bedding dip 10°, clean, rough, planar	440
			352 352	10			0	352.02 bedding dip 10°, clean, rough, planar	
							0	352.50 to 352.58 hard bar	500 520
						100	0		460
							1	353.00 bedding dip 10°, clean, rough, planar	460
			353				0	353.37 drilling B3 10°, clean, rough, planar	(I_s = 1.10 MPa)
							1		500 500
							0		510
							1	353.72 bedding dip 10°, clean, rough, planar	500
			354				2	354.23 B3 dip 10°, clean, rough, planar 354.30 B3 dip 9°, clean, rough, planar	510
							0		460 460
			345	34			0		
							1	354.84 bedding dip 6°, discoloured, rough, planar	460
			355				0	355.29 bedding dip 9°, discoloured, rough, planar	460
							1	355.57 to 355.60 hard bar, irregular, small, slickensides developed on bedding planes 12° to 16°	460
	minor bedding plane trace, SILTY horizons (?)					100	2		
							1	355.80 bedding dip 9°, discoloured, rough, planar	460 460 (I_s = 0.81 MPa)
			356				0	356.04 drilling - bedding dip 9°	460
							0		510
							0		460
							1	356.98 bedding dip 9°, discoloured, rough, planar	470
			357 357.	26			2	357.06 bedding dip 8°, discoloured, rough, planar	(I_s = 0.56 MPa)
							1	357.13 bedding dip 9°, discoloured, rough, planar	460
							1	357.40 drilling 9°, clean, rough, planar 357.54 drilling 9°, clean, rough, planar 357.65 hard bar 25mm, bedding 10° at 120° to other faces	460
							0		460
			358				0		460
							0		460
							1	358.72 bedding dip 5°, discoloured, rough, planar, iron-stained	440
						100	0		480
			359				1	359.22 bedding dip 8°, discoloured, rough, planar	470
							1	359.31 bedding dip 7°, clean, rough, planar	480 (I_s = 0.86 MPa)
									470
			359. 360	90					

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD HQTT DATE

BORE HOLE L3964

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A1
SHEET 3 OF 7

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (I_s= POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak, massive, uniform well developed banding throughout, often several cycles of upwards filling		360 361 362 362.06 363 364 365 365.14 366 367 368 368.14 368.64 369 370			100 100	0 0 1 1 1 0 1 1 0 3 0 0 3 3 1 1 1 0 1 0 2 7 4 2 1 0 0 1 0 3 4 1 5 4 1 0 0 1 2 1	360.51 drilling 8°,clean,smooth,planar, minor leaf impression 360.95 drilling 10°,clean,rough,planar 361.04 drilling 9°,clean,rough,planar 361.60 drilling 10°,clean,rough,planar 361.90 bedding 12° minor slicks, smooth planar 361.91 to 362.10 hard bar 361.92 bedding 16°,slicks,smooth,planar 363.21 drilling 10°,clean,smooth,planar 363.80 drilling 11°,clean,rough,planar 364.04 drilling 6°,clean,rough,slightly curved 364.18 drilling 8°,clean,smooth,planar 365.03 to 365.04 driling breaks from catcher 365.23 bedding 6°,clean,smooth,planar 365.48 bedding 7°,clean,smooth,planar 365.49 bedding 7°,slickensides down dip polished planar 365.30 to 365.80 many bedding planes with 9° dip,minor slickensides very smooth, planar, slicks often small striations sub-parallel to bedding direction. 356.70 irregular slicked fragments 365.79 to 365.86 hard bar 366.05 366.92 bedding dip 6°,clean,rough,planar 367.29 bedding dip 6°,minor slicks, rough, planar 267.44 bedding dip 5°,very small crush zone paralled bedding 367.47 several sub-parallel sub-vertical discontinuous fractures 367.62 bedding 8°,clean,rough,planar 367.86 bedding 10°,clean,rough,planar 368.13 joint dip 65°,clean,rough,planar passes downhole into zone of sub-vertical sub-parallel fractures 369.06 to 369.83 several sub-vertical drilling induced fractures due to re-drilling	450 440 450 460 470 450 440 440 500 460 470 460 430 470 (I_s = 0.88 MPa) 470 470 460 450 460 460 460 430 420 500 355 430 440 420 440 (I_s = 0.63 MPa) 380 50 430 460

JOB NO. 0461002 04 2/5/2/7

3864

LOCATION	
SURFACE ELEVATION (R.L.)	DATUM
INCLINATION VERTICAL	AZIMUTH
DRILL TYPE / METHOD HOTT	DATE

BORE HOLE L3~~69~~4

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A1

SHEET 4 OF 7

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES
MUDSTONE F	grey and dark grey, moderately weak		370				0	370.37 drilling very minor grinding	430
							1		465
						100	1		450 390
							0	370.74 drilling	460
			371						
COAL F	black, vertical		371.07						
			371.69						
			372						
			373			NA			
			374						
	MAIN SERIES COAL SEAM 371.07-389.87		374.72						
			375				NA		
			376			NA			
			377						
			377.77						
			378						
			379			NA			
			380						

JOB NO. 1280278 26/2015

LOCATION

SURFACE ELEVATION (R.L.)

DATUM

INCLINATION VERTICAL

AZIMUTH

DRILL TYPE / METHOD HQTT

DATE

BORE HOLE L3964

FIGURE A1

SHEET 5 OF 7

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
COAL F	black, very weak to weak		380						
			380.82						
			381						
			382			NA			
	MAIN SERIES COAL SEAM 371.07 - 389.87		383						
			383.87						
			384				NA		
			385			NA			
			386						
			386.84						
			387						
			388			NA			
			389						
			389.87						
			390						

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD HQTT DATE

BORE HOLE L3964

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A1
SHEET 6 OF 7

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.
MUDSTONE F	grey and dark grey, moderatley weak
near CLAYSTONE	

DEPTH metres	CORE RUN AND TYPE	R.Q.D. (%)
390 – 392.66	392.66	100
392.66 – 394.72	394.72	100
394.72 – 397.72	397.72	100
397.72 – 400		100

DEPTH metres	FRACTURE LOG (PER 250mm)
390	0, 0, 0, 0
391	0, 1, 0, 0
392	0, 0, 1, 0
393	0, 0, 0, 0
394	0, 0, 0, 0
395	2, 0, 1, 1
396	0, 0, 0, 0
397	0, 1, 0, 0
398	0, 1, 0, 2
399	1, 1, 0, 0

DISCONTINUITIES (JOINTS, BEDDING, SEAMS, FAULTS) **DESCRIPTION** (SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE)

391.03 very thin hard bar 5mm
391.31 bedding dip 6°,clean,rough,plan planar

No breaks

392.66 bedding dip 6°, slicked crush zone 3mm intact

393.5 to 394.4 irregular fracture at about 15° Increased dip between two crush zones 392.66 and 395.08

395.08 to 395.10 bedding dip flat, irregular, high slicked,very smooth slightly curved

395.74 bedding dip 4°,clean,rough, planar
395.95 bedding dip 6°,clean,rough, planar

396.43 bedding dip 4°,clean,rough, planar

396.96 to 397.11 hard bar

397.55 bedding 4°, possibly crush zone, very thin

398.46 bedding (?) dip 2-3° clean, rough, planar

398.77 bedding 7°,clean,rough,planar

398.96 to 399.08 hard bar
398.96 contact to hard bar dip 3°, highly polished, smooth, planar

399.12 bedding 4°, clean,very rough, planar
399.36 bedding 6°,clean very rough, planar

ROCK INDENTOR VALUES (I_s=POINT LOAD STRENGTH)

430
440
430
460
420
460-500
450
480 (I_s = 0.50 MPa)
440
440
470
410
460
430
430
450 (I_s = 0.53 MPa)
460
440
450
450
450
460
500
520
450
500
460
475
460
440
450
460
430
440
420
500
460
460
460
460

Job no. [illegible]

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD HQTT DATE

BORE HOLE L3964

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A1
SHEET 7 OF 7

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. / DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES
MUDSTONE F	dark grey, massive		400				0		460
							0		460
			400.72				0		430
							0		460
			401				1	401.0 minor grinding 401.07 bedding dip 3°, very rough, clean, planar	500
							0		430
							0		460
							0		450
			402			100	0	slickensides, msooth, slightly curved, hard bar at 402.65 15mm thick, slickensides, smooth, planar	450
							2		430
							0		470
			403				0		480
							0		450
							1	403.50 bedding dip 4°, clean,rough, planar	480
							0		460

END OF BOREHOLE
@
403.72M

LOCATION			
SURFACE ELEVATION (R.L.)		DATUM	
INCLINATION	VERTICAL	AZIMUTH	
DRILL TYPE / METHOD	PORTADRILL -H Q T T	DATE	14.12.84
PROJECT	SHEDDEN/ U.C.G./LEIGH CREEK		

BORE HOLE L3966

FIGURE A2

SHEET 1 OF 2

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm) 1 4 16 64	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
	OPEN HOLE (SURF - 241m)		240						
COAL F	black, very weak		241 242					bedding contact angle 10°	
SILTSTONE F SANDY	grey, moderately weak, rare coal bands and blebs		242.95				0 1 2	at coal base very fine grained silty sandstone 15mm 243.4 sub-vertical in fill structure	
SANDSTONE F	light grey-brown, very fine grained		243.80 244				4 0 2	244.3 bedding dip 8°, clean, rough, planar	
GRADING VERY SILTY	?		244.61 245				1 3		
GRADING SANDY	light brown and grey						5 2 3		
COAL			245.78 246				1 2 3		
MUDSTONE F WITH COAL BANDS	dark grey, weak		246.65				2 3		
MUDSTONE F	grey, moderately weak, massive minor banding evident		247.00 248				1 3 3 7 4 8 5	247.10 bedding dip 2°, clean, rough planar 247.18 bedding dip 7°, clean, rough planar 247.25 bedding dip 4°, clean, rough planar 247.33 bedding dip 5°, clean, rough planar 247.5 to 248 many bedding planes dip 4° to 16°, clean, rough, planar 247.95 hard bar 26mm intact bedding dip 6° clean, rough, planar	
(?CLAYSTONE)	light grey, moderately high strength		249 250				8 5 4 5 6	248.95 hard bar 10mm 249.82 and 249.88 bedding dip 8° clean, rough, planar	

LOCATION

SURFACE ELEVATION (R.L.) DATUM

INCLINATION VERTICAL AZIMUTH

DRILL TYPE / METHOD PORTADRILL -H Q T T DATE 14.12.84

BORE HOLE L3966

FIGURE A2

SHEET 2 OF 2

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
MUDSTONE F	grey and dark grey, moderately weak, massive		250 251 252 253 254 255 256 257 258 259 260				1 1 2 2 4 2 2 3 3 3 5 4 2 3 2 1 3 3 4 3 4 5 3 3 3 5 3 2 3 3 3 4 5 3 2 2 4 5 6 7 3	250.80 bedding dip 8° clean,rough,planar 250.95 bedding dip 5°clean, rough,planar 251.14 hard bar intact 251.48 SLTST band, yellow-brown, moderately weak Bedding disrupted at top and bottom, no slickenside 251.92 bedding dip 11°clean,rough,planar 252.48 hard nodule, parallel bedding 252.80 bedding dip 8°clean,rough, irregular, planar 253.50 to 253.60 hard bar intact 253.96 bedding dip 8° clean,rough,planar fossil trace 254.22 bedding dip 4° clean,rough, irregular, planar 254.37 bedding dip 5°clean,rough,planar 254.73 joint dip 20°grooved down dip, smooth,planar,dip normal to bedding dip 254.83 hard bar, thin, weak 255.06 to 255.21 development of several thin hard bars- sandy bedding dip 8° clean, rough, planar 256.00 bedding dip 8°clean,rough,planar 256.20 bedding dip 4°clean,rough,planar 256.26 bedding dip 15°clean,rough,planar 256.43 to 256.46 hard bar, thin, weak bedding dip 8°, clean, rough, planar 257.19 to 257.26 sandy siltstone, bedding dip 8°, clean, rough, planar 258.0 to 258.38 several bedding planes dip 4° to 15°, clean, rough, planar 258.68 to 260.0 many bedding planes dip 6° to 10° clean, rough, planar	
CLAYSTONE (?)	banded light grey and grey							259.30 to 259.46 hard bar, high strength	

END OF BOREHOLE
@
260.20M

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3
SHEET 1 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING APERTURE	ROCK INDENTOR VALUES (Is= POINT LOAD STRENGTH)
	OPEN HOLE SURFACE - 313.60M		310						
			311						
			312						
			313						
MUDSTONE F	dark grey, moderately weak, rock, massive low angle bedding						X		
			314				0		460 470
							1	314.52 joint dip 12°, very smooth, clean, planar, horizontal to bedding direction	490
			314.44				2		480
			315				0		470
							0		490
							1	315.45 bedding dip 15°,clean,rough, planar	480
							1		
			316				0		490
							2	316.02 bedding dip 10°, clean,rough, planar	
			316.40				3		480
							2		
			317				3		490 480
							0		480
							1		520
							1		(Is = 0.6 MPa)
			317.85				0		450
			318				0		470
							2		430 420
							0		
			319				1		460
							1		
							1		470
							1		480
			319.70				1		
			320						

LOCATION			
SURFACE ELEVATION (R.L.)		DATUM	
INCLINATION	VERTICAL	AZIMUTH	
DRILL TYPE / METHOD	Portadrill - HQTT	DATE	

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3

SHEET 2 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm) 1 4 16 64	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (Is=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak rock massive, low angle bedding		320				0 1 1 0		480 470 500 480
			321			100	1 1 1 1		460 490 490 440 (Is = .86 MPa) 450
			322	322.05			0 1 0 0		440 500 460 470 520 560
			323			100	0 1 1 0		(Is = .78 MPa) 460
			324	324.58			0 1 1 2	324.25 bedding dip 22°, pyrite (?), rough, planar 324.58 joint dip 17°, slickensided, highly polished, very smooth, planar	480 500 470 520
			325				1 2 3 2	325.47 tp 325.76 several joints dip 8° to 15° normal to bedding direction, Each highly polished, very smooth, planar, slicks generally parallel to bedding dip direction	490 400 480 460
			326			45	2 3 4 8	326.75 to 327.10 numerous flat dipping joints and bedding. all approx paralled to bedding, each highly polished, very smooth, planar to slightly curved	480 490 470
			327	327.70			6 0 1 0		480 470 470 490
			328				1 2 1 2		480 480
			329			100	0 0 3 1		460 470 (Is = 1.32 MPa) 470
			330						

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3
SHEET 3 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. / DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (I_s=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak rock massive, low angle bedding		330 – 340						

Core runs and R.Q.D.:

DEPTH	CORE RUN	R.Q.D. (%)
330.48		
		98
332.69		
		98
335.76		
		65
338.08		
		90
340		

Fracture log (per 250 mm), 330 to 340 m:

0, 2, 2, 1, 1, 1, 2, 0, 2, 0, 1, 0, 2, 1, 1, 1, 2, 2, 2, 2, 1, 2, 2, 1, 2, 2, 2, 3, 3, 4, 1, 3, 4, 0, 1, 1, 1, 1, 0, 2

Discontinuities:

333.83 to 333.89 hard bar

335.15 to 335.32 hard bar, irregular nodules

337.32 joint dip 25° to 30°, discontinuous, polished, very smooth, curved
337.22 joint dip 50° normal to bedding, polished, very smooth, planar
337.60 joint dip 60° normal to bedding, polished, very smooth, planar
338.0 joint dip 65°, curved and polished, very smooth, planar

Rock indentor values:

460
440
480
450
450
420
450
440
450
450
490
480
460
460 (I_s = .82 MPa)
480
480
510
480
480
440
470
460
490
470
450
460 (I_s = .88 MPa)
470
440
440
420
500
460
460
460
460
470
I_s = .33 MPa
450
450
430
460

LOCATION

SURFACE ELEVATION (R.L.) DATUM

INCLINATION VERTICAL AZIMUTH

DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3

SHEET 4 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (I_s=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak rock, massive, low angle bedding		340				0 0 2 3	339.90 two parallel joints dip 60°, highly polished, very smooth, planar, normal to bedding	460 470 470 480 (I_s = 1.30 MPa)
	DEPTH CHECK REVEALED ERROR IN DRILLING DEPTH. BASE OF BOREHOLE ACTUALLY AT 339.84M DEPTH ERROR 1.24M TOO DEEP		341				1		

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3
SHEET 5 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm) 1 4 16 64	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
			330						
			331						
			332						
			333						
			334						
			335						
			336						
			337						
			338						
			339						
	REPORT NOTE - SHEET 4 DEPTH CHECK ETC.								
			340						

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

FIGURE A3
SHEET 6 OF 11

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (I_s=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderatley weak rock, massive, low angle bedding		340			30	1 4 5 5	340.4 to 341.2 several flat dipping joints, normal to bedding, highly polished, very smooth,slightly curved surface,normal to bedding dip 340.64 joint dip 65°,highly polished, very smooth,slightly curved surface, normal to bedding dip 340.8 joint dip sub-vertical curved, highly polished and slickensided,very smooth,normal to bedding dip	440 450 470 490
			341				3 4 4 2	341.75 joint dip 55°,highly polished and slickensided,very smooth,planar	470 440 470 470
			342				3 5 5 3	342.0 to 342.4 several slightly curved joints dipping in same directions as bedding. Each highly polished,slickensided,very smooth 342.84 two parallel joints dip 60°, highly polished, slickensided,planar, normal to bedding	480 460 430 480 470
			342.84						
			343				0 3 2 2		470 440 460 (I_s = .38 MPa)
			344			50	2 2 2 5	344.24 joint dip 60°,polished, very smooth,planar, dip same direction as bedding 344.55 joint dip 65°,polished,smooth, planar, normal to bedding	360 380 480 470 450
			345				5 2 4 1	345.30 to 345.90 several bedding planes, dip 12° to 15°, clean, rough,planar, often trace pyrite	460 460 470
			345.90						
			346				2 2 0 2		460 440 440 460 (I_s = .59 MPa) 460
			347			75	1 3 3 1		470 460 470
			348				3 2 3 1	348.45 several sub-parallel joints,dip 55° to 65°,highly polished,very smooth, slightly curved 348.75 bedding dip 16°,clean,rough, planar, joint dip 35° to 40°,slickensides,very smooth,slightly curved, normal to bedding	440 460 440 470
			348.90						
			349				1 1 0 3	349.75 joint dip 65° normal to bedding, closed slickensided,very smooth,planar	480 470 460 480
			350						

LOCATION		BORE HOLE L3967	FIGURE A3
SURFACE ELEVATION (R.L.)	DATUM		SHEET 7 OF 11
INCLINATION VERTICAL	AZIMUTH		
DRILL TYPE / METHOD Portadrill - HQTT	DATE	PROJECT SHEDDEN/U.C.G./LEIGH CREEK	

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	ROCK INDENTOR VALUES (Is=POINT LOAD STRENGTH)
MUDSTONE F	dark grey, moderately weak rock, massive, low angle bedding		350			30	3 X 4 2 5	350.7 to 351.0 several flat-dipping joints highly polished, very smooth, planar	460 529
			351			45	3 4 2 2 2 3 3 5 2	351.3 intersecting joints dip 50° and 60°, polished smooth, planar, normal to one another, onwards bedding decreases from 15° to approximately 6° to 8° 352.25 joints dip 60°, normal to bedding, polished, smooth, planar	470 440 450 460 460 470 460 470 450 440
			352						
			353						
			353.5			65	1 1 1 2 2 2 1 1 2 2 4 2	355.7 joint dips 35°, polished, very smooth, dip parallel to direction of bedding	470 460 (Is = .92 MPa) 440 470 420 430 450 450 440 440 420 440 430
			354						
			355						
			356						
			356.5			20	3 2 2 3 4 3 5 2 3 2 5	357.0 bedding dip 5°, clean, trace pyrite, rough, planar 357.12 bedding dip 5°, clean, trace pyrite, rough, planar 357.30 bedding dip 4°, clean, rough, planar 357.98 bedding dip 3°, clean, rough, planar 358.10 bedding dip 3°, clean, rough, planar	460 430 460 450 470 470 440 440 440 440 (Is = .78 MPa)
			357						
			358						
			359						
			359.4				2 0 1		465 440
			360						

LOCATION

SURFACE ELEVATION (R.L.) DATUM

INCLINATION VERTICAL AZIMUTH

DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3

SHEET 8 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
MUDSTONE F	dark grey, moderatley weak rock, massive, low angle bedding		360				360.13 and 360.20 Bedding dip 2°, clean, rough, planar 360.4 Shattered band above thin hard bar, minor grinding at base	
			361			80	361.22 Bedding dip 4°, clean, very rough, planar 361.31 Bedding dip 4°, clean, rough, planar 361.55 Bedding dip 4°, clean, rough, planar, light grey claystone/mudstone bar 75mm thick	
			362 362.10	10		100		
minor silty banding evident			363 363.13	13		45	363.0 Bedding dip 4°, clean, rough, planar 363.13 Shattered hard bar, minor slickensides on some surfaces 363.66 Joint dip 80°, partly open, discontinuous 363.72 Joint dip 60°, fault contains 8mm thickness of healed fragment, joint surface is highly polished, very smooth, planar 363.98 Intersecting, discontinuous joints normal to each other, 50°, highly polished, slickensided, very smooth, planar	
			364				364.26 Joint dip 50°, discontinuous highly polished, very smooth, planar. Also three joints sub-parallel to bedding dip 10°, 15° and 25° to 35° Each slickensided, highly polished, down dip, very smooth, slightly curved to curved 364.36 Similar zone, two joints sub-parallel to bedding. Slickensided across dip, highly polished, very smooth, planar 364.36 to 366.00 Extensive disruption evident across thin hard bands 364.60 Hard bar with several open joints dip 55° normal to bedding, calcite in fill, also dark crystal growth 364.80 Joint dip 20°, dips normal to bedding direction, slickensided, highly polished, very smooth, slightly curved 364.82 Joint dip 75°, normal to bedding direction Striated, slickensided, smooth, planar	
			365				365.40 Joint dip 60°, parallels bed dip direction, slickensided, highly polished, some healed fragments, very smooth, planar	
			366 366.13	13				
			367			95	367.1 this light grey baning,dip 12°	
			368				368.05 joint dip 65°,clean,rough,planar 368.80 bedding planes dip 6°,polished, very smooth,several intact closed curved planes	
			369 369.11	11				
	thin brown mudstone bands		370					

FRACTURE LOG (PER 250mm): 3, 5, 0, 1, 2, 3, 2, 1, 2, 1, 1, 1, 1, 2, 1, 2, 0, 6, 2, 1, 1, 1, 3, 2, 2, 1, 1, 1, 1, 3, 0, 2, 1, 1, 0, 4, 0, 0, 0, 0

LOCATION
SURFACE ELEVATION (R.L.) DATUM
INCLINATION VERTICAL AZIMUTH
DRILL TYPE / METHOD Portadrill - HQTT DATE

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3
SHEET 9 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. DEPTH metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
MINOR SANDSTONE BAND, TO 5MM			370				0	370.22 joint dip 55°,clean,rough, slightly curved	
							2	370.3 joint dip 60°,closed,irregular, curved	
							1	370.52,370.63,370.85 bedding dip 8°, clean, rough, planar	
						90	1		
			371				15	371.04 bedding dip 8° 371.04 to 371.31 10 parallel joints,sub-parallel to bedding,each discontinuous, slickensides,polished,planar,bounded by two stepped joints,dip normal to bedding at 70° and 55°	
							2		
							1		
							1	371.31 joint dip 15°,clean, very smooth, planar	
			372				1	371.50 two intersecting joints dip 40° and 35°,discontinuous, slickensides, polished,smooth,planar	
							1		
							0	371.71 joint dip 30°, normal to bedding clean,smooth,planar	
							2	371.80 joint dip 40°,clean, smooth, planar	
			373 373.14				2		
COAL F	weak, black and brown, irregular banding		373.20				4		
							2		
							1		
			374				2	374.0 to 374.7 several sub-parallel, discontinuous near vertical joints	
							5		
							1		
							1		
			375				1	375.4 to 375.75 three sub-parallel, discontinuous near vertical joints 375.85 joint dip 70° to 90° curved at top, extended to 376.4, joint has strike normal to bedding dip direction, i.e. parallel of strike of bedding	
							2		
							3		
							3		
			376 376.09				1		
							2		
							2		
							2		
			377 377.14				3		
							2		
							2		
							1		
			378				4	378.08 joint dip 70° to 90° curved at top	
							2		
							1	378.85 joint dip 60° to 90° curve at top	
							6		
			379				3		
							5		
							1		
							1		
			380						

LOCATION			
SURFACE ELEVATION (R.L.)		DATUM	
INCLINATION	VERTICAL	AZIMUTH	
DRILL TYPE / METHOD	Portadrill - HQTT	DATE	

BORE HOLE L3967

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

FIGURE A3

SHEET 10 OF 11

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm)	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
COAL F	weak banded, irregularly black and brown		380 381 382 383 383.14 384	383.14		NA	2 1 1 2 1 1 0 0 0 0 10 0 0 0 10 0 1 1	dip of all banding in the range 25° to 30° 381.61 stone band, hard SLTST 381.87 stone band, hard SLTST 382.30 stone band, hard SLTST 382.39 stone band, hard SLTST 384.66 sharp contact SLTST/COAL	
SILTSTONE F F	grey, moderately high strength, moisture, irregular coal blebs throughout		385			NA	2 5 4	384.89 joint dip 55°, clean, rough planar 384.95 to 385.13 several sub-horizontal blebs 385.00 small fault zone, minor shearing on joint with 60° dip	
COAL F	black and brown, weak		385.38 386	385.38		NA	2 1 0 1 1	386.7 to 388.6 Each fracture is irregular, near planar, sub-parallel to bedding	
SILTSTONE F MINOR COAL BANDS	grey, moderately weak,massive, minor coal blebs throughout		386.46 387 388	386.46		98	2 1 0 0 4 1 3 1	387.35 to 387.92 Minor thin COAL 388.48 to 388.80 COAL transitional at base	
COAL F	black, weak		388.48	388.48			3		
MUDSTONE F CARBONACEOUS IN PART	dark grey, moderatley weak		388.90	388.90			0 0		
SILTSTONE F	grey and dark grey, moderately weak		389.29 390	389.29		100	1 0 1	389.91 to 389.96 COAL band	

LOCATION			
SURFACE ELEVATION (R.L.)		DATUM	
INCLINATION	VERTICAL	AZIMUTH	
DRILL TYPE / METHOD	Portadrill - HQTT	DATE	

BORE HOLE L3967

FIGURE A3

SHEET 11 OF 11

PROJECT SHEDDEN/U.C.G./LEIGH CREEK

ROCK TYPE AND DEGREE OF WEATHERING	DESCRIPTION COLOUR, HARDNESS, etc.	GRAPHIC LOG	R.L. ▼ DEPTH ▲ metres	CORE RUN AND TYPE	CORE LOST	R.Q.D. (%)	FRACTURE LOG (PER 250mm) 1 4 16 64	DISCONTINUITIES JOINTS, BEDDING, SEAMS, FAULTS DESCRIPTION SPACING, ATTITUDE, SMOOTHNESS, FILLING, COATING, APERTURE	REMARKS
SILTSTONE F	grey and moderately weak		390				0 0	Bedding dip 15 - 20°	
COAL F	black and brown banded		390.55				3		
COAL AND CARB MUDSTONE F	dark grey - black, weak		390.85 391			100	1 1		
MUDSTONE F	dark grey, moderately weak		391 392 393	62			0 3 0 0 1 0 0	391.45 - 391.52 Coal Bright conchoidal fractures	
CARB AND MUDSTONE F			393.26				0		
COAL F	black, weak		393.32 394			100	0 0 0 0 0		
SILTSTONE F	grey (blue) moderately high strength, massive		394.45 394 395 396	60		100	2 0 1 0 1 1 1 1 1		
	END OF BOREHOLE AT 396.75M								