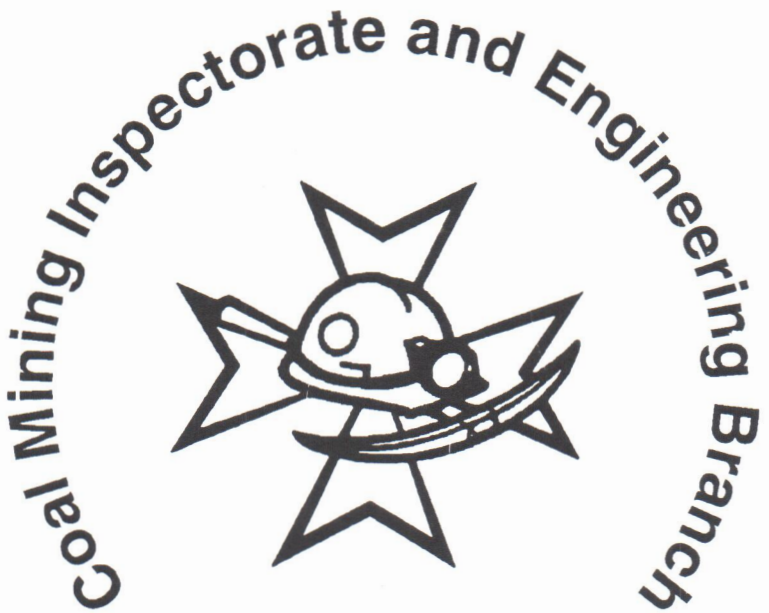
MINERAL RESOURCES

Department of Mineral Resources
New South Wales



EXPLOSION AT ENDEAVOUR COLLIERY
28 JUNE 1995
SUMMARY OF INVESTIGATION

MDG No. 1007

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New South Wales
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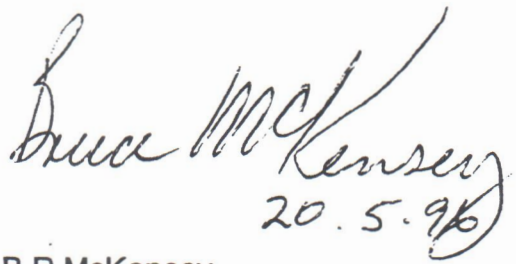
FOREWORD

At approximately 0950 on 28 June 1995 an explosion occurred in the 300 Panel of Endeavour colliery. There were 30 miners underground at the time including 8 in the 300 panel crew who, despite varying injuries and disorientation arising from a lack of visibility, found their way from the panel and the mine. While there were no fatalities resulting from the explosion the event was considered of sufficient gravity to warrant a thorough investigative response from the Coal Mining Inspectorate. This response included the engagement of overseas experts in the fields of mine ventilation and explosion investigation.

From all the information available it appears that the fuel for the explosion was methane gas, an accumulation of which was forced from the 300 Panel goaf by a substantial roof fall in the goaf and associated windblast. A likely area of ignition was identified within a cut-through outbye the working face. Potential initiators for the explosion which were considered include frictional ignition in the goaf, a shuttle car cable anchor and electrical equipment in, or near, the area identified as the likely containing the source of the ignition.

The purposes of this document are to present the issues arising from the Endeavour investigation; to summarise the outcomes of the investigative activities of the various disciplines involved; and, to provide a summary of the event itself.

Many of the issues arising from the Endeavour incident are not considered to be confined to that mine. The presentation of those issues is intended as an opportunity for all in the underground coal mining industry to consider them with a view to preventing future, similar events and, in particular, preventing a future multiple loss of life which, through good fortune, did not result in this instance.



B R McKensey
Chief Inspector of Coal Mines

INVESTIGATION

The investigation into the explosion was conducted as a multi-disciplinary exercise involving a number of groups. Each of these groups produced separate reports covering their particular investigations and examinations. In summary, those taking part in the overall investigation and the nature of their reports are:

- Personnel from the Mine Safety and Health Administration (MSHA) of the US Department of Labor - John E Urosek, Chief Ventilation Division and Clete R Stephan, Principal Mining Engineer. This report covered, in chief, determinations as to the source and location of the explosive methane accumulation and the impact of the mine ventilation system on factors leading to the explosion;
- Inspectors of coal mines from the NSW Department of Mineral Resources - senior inspector Anderson and district inspector Shacklady. This report covered background information to the event, the event itself, recovery of the mine, aspects of the explosion and observations regarding ventilation and stonedusting at the mine; and
- Inspectors of electrical and mechanical engineering of the NSW Department of Mineral Resources - electrical inspector Hodgson and mechanical inspector Koppe. Separate reports were produced covering examination of electrical and mechanical apparatus in relation to the incident.

CONCLUSIONS FROM INVESTIGATION

The individual investigations identified a number of issues which might be taken forward but, in addition, the following summary points regarding failures in systems at the Endeavour mine should also be made:

- There was a failure of panel design, development and review processes to recognise and effectively treat the hazard presented by potential for accumulation of gas in the 300 Panel goaf and the possibility of windblast;
- There was a failure of persons on-shift, and, in particular those in positions of supervision and control, to recognise the potential hazard represented by occurrences of gas and an imminent, large fall of roof in the goaf; and
- There was a failure at the mine to set and/or maintain adequate standards with regard to ventilation (both practice and appliances) and the maintenance of stonedusting and barriers.

ISSUES ARISING FROM THE INVESTIGATION

The following issues have been identified from the various investigation reports as requiring some form of follow-up action. They are presented in terms of identified needs.

PANEL DESIGN/DEVELOPMENT

There is a need to examine panel design practices in terms of the ability to adequately cater for mixture/interaction of mining constraints and hazards and to determine the effect of possible failure in ventilation, roof control and other systems.

There is a need to consider reevaluation and review of panel designs and potential for introduced hazards where initial design intent cannot be met.

OPERATIONAL HAZARD RECOGNITION

There is a need to consider the adequacy of current means used to recognise emerging hazards or combinations of hazards in day-to-day operations of extraction panels.

VENTILATION

Ventilation Practice

There is a need to establish ventilation standards and effective monitoring. Ventilation standards may need to include specified levels of methane which might be considered acceptable under local conditions.

There is a need to consider development of responses to deviation from ventilation standards including unexpected gas occurrences.

There is a need to consider the broader implementation of bleeder returns together with effective management of those returns as a means to maintain goaf and waste areas effectively free of methane gas.

There is a need to evaluate the maintenance of bleeders and other return airways.

Ventilation Appliances

There is a need to consider the specification of design and maintenance criteria for ventilation appliances including regulators, stoppings, doors and overcasts.

There is a need to examine the integrity of ventilation appliances with time and in conjuction with such factors as strata loading or water accumulation.

EXPLOSION SUPPRESSION

Stonedusting

There is a need to review the adequacy of current stonedusting requirements and the level of compliance of mines with those requirements.

Barriers

There is a need to review the adquacy of current barrier requirements and the level of compliance of mines with those requirements.

ESCAPE SUPPORT

Provision of Escape Cues

There is a need to examine means of providing cues to aid escape in conditions of poor visibility/disorientation following explosion or windblast.

Integrity of Personal Equipment

There is a need to consider means to ensure the security (in terms of not being separated from persons) of personal equipment (lamps, rescuers) in the event of windblast/explosion.

Use of Self Rescuers

There is a need to consider the adequacy of current training schemes in light of Endeavour experience (failure to don, difficultly donning, failure to fit nose clip).

There is a need to consider the adequacy of self rescuer maintenance/inspection in view of cannister opening and rescuer removal difficulties experienced at Endeavour.

WINDBLAST

There is a need to reconsider current requirements for management of windblast including reporting requirements, adequacy of current guidance material and conformity to available guidance material.

There is a need to consider and/or develop means of rapidly isolating power to panels subject to windblast.

ELECTRICAL REPAIR/MAINTENANCE

There is a need to review industry maintenance/ repair practices for electrical apparatus in light of condition of the shuttle car trailing cable and back-to-back enclosures in 300 Panel.

There is a need to examine the practicality of in-service protective devices for voltages induced by electrical assymetry in trailing cables in hazardous zones.

SUMMARY OF THE INVESTIGATION

MSHA REPORT

The following summary points are taken directly from the investigation report supplied by MSHA and are reproduced without alteration or addition.

1. At approximately 9:50 a.m on June 28, 1995, a methane explosion occurred in the 300 Panel of the Endeavour Colliery. There were thirty miners underground at the time of the explosion, including eight surviving victims in the face area of the 300 Panel who suffered varying degrees of injuries.
2. From June 29 through July 10, personnel did not enter the mine. During this period gas samples of the mine atmosphere were obtained and analyzed. Samples were collected using the multi-point tube bundle monitoring system which gives readings at the surface of CO and methane from six underground stations.
3. Samples were also obtained from boreholes that were drilled into the 300 Panel from the adjacent Munmorah Colliery
4. The New South Wales Department of Mineral Resources contacted the United States Department of Labor's Mine Safety and Health Administration (MSHA) for technical assistance. On July 3, MSHA responded by sending two technical representatives, Messrs John E. Urosek, Chief, Ventilation Division, and Clete R. Stephan, Principal Mining Engineer, Ventilation Division, to New South Wales, Australia. MSHA's representatives assisted in the recovery and investigation of the explosion.
5. On July 10, the atmosphere at the underground monitoring locations and at the boreholes appeared stable with minimal risk of combustion occurring underground. Plans were developed to begin the recovery of the underground workings.
6. The physical examination of the underground areas of the mine began on July 13 with investigative teams entering the mine to examine and record the evidence.
7. A review of the map of the Endeavour Colliery indicates that a bleeder system was generally used in areas where pillars had been recovered. However, a bleeder system was not being used in the 300 Panel.
8. The lack of a bleeder system in the 300 Panel would allow methane, liberated during pillar recovery, to accumulate in the unventilated goaf area adjacent to the working section.
9. The ventilation system used in the 300 panel is dependent on adequate airflow along the fringe of the goaf to remove methane accumulations as they are released from the unventilated portions of the goaf
10. A dual split ventilation system was used in the 300 Panel. The right return heading was open from the mouth of the Panel to the No. 22 cut-through and was unregulated. The left return heading was open from the mouth of the Panel to the No. 18 cut-through. It was regulated by a partial check curtain between the Nos. 4 and 5 cut-through. Air entered the left return from the goaf at the No 18 cut-through. The accessible portion of the goaf between the Nos. 21 and 22 cut-throughs and between the Nos. 18 and 19 cut-throughs was partially filled with stow. The portion between the Nos. 19 and 21 cut-throughs was partially blocked with roof falls.

11. The remanents of all the temporary ventilation controls or brattices, inby the No. 21 cut-through, were discovered during the investigation, except the brattice in the No. 1 heading. The condition of these controls prior to the explosion could not be determined from these remanents. However, all of these temporary ventilation controls were reported by mine officials and check inspectors to be intact and in good condition prior to the explosion.

12. Reportedly, methane was encountered in the 300 Panel on the day of the explosion. The typical concentration encountered was 0 2%. During mining of a split in a pillar, excessive methane concentrations were encountered that de-energized the continuous miner The methane monitor on the continuous miner also indicated that methane concentrations of 1.0% or more were encountered during mining of an extracting lift on more than one occasion. On the preceding nightshift, the miner was withdrawn from the lift to prevent excessive concentrations of methane from de-energizing the machine.

13. After the explosion, statements were obtained from the survivors. George Gain, deputy, stated that he did not detect any methane and that the ventilation was good during the shift. However, he stated that it was possible to get 3% - 4% methane behind the brattice in the left hand goaf.

14. During the recovery efforts, methane concentrations of up to 2.0% were detected throughout the unventilated 300 Panel. In addition, concentrations of methane in excess of 5.0% were detected in the open headings adjacent to the 304 Panel goaf.

15. On July 19, a roof fall in the goaf occurred inby the No. 22 cut-through. Methane was pushed from the goaf into the working places of the 300 Panel. Investigative team personnel in the area encountered methane concentrations approaching 2.0% in the No 21 cut-through.

16. The airflow for the 300 Panel was found to be virtually unregulated. The regulator in the left return headings was constructed of brattice nailed to posts and had a negligible pressure differential across it.

17. The computer analyses indicated that the available pressure differential at the mouth of the 300 Panel was 0.04 kpa (O. 16 inches of water) or less before the explosion. The condition of the ventilation controls in 8 West prior to the explosion would have significant impact on the available pressure differential in the 300 Panel. The pressure differential across the ventilation controls, particularly the check curtains in the No. 1 and 2 headings between the Nos, 21 and 22 cut-throughs, would have been less than that available at the mouth of the panel. The pressure differential and airflow in this area affects the ability of the ventilation system to dilute and render harmless any outflows of contaminants from the unventilated goaf.

18. Survivors working in 8 West at the time of the explosion reported minor effects following the explosion. The overpressures in the 8 West area were not large enough to adversely affect ventilation controls maintained in good condition. Therefore, the very poor condition of the ventilation controls in 8 West prior to the explosion allowed them to be damaged by these small overpressures.

19. In summary, the condition of the controls in 8 West had an effect on the amount of airflow and pressure differential available to the 300 Panel. Prior to the explosion, these controls were generally intact but in very poor condition and leaking.

20. The ventilation controls in the Buff Headings were found intact with the exception of a mandoor in the No. 8 cutthrough between the intake and left return headings. Although this condition appeared to have occurred prior to the explosion, the affect on airflow in the 300 Panel would have been minimal.

21. Methane can accumulate in unventilated areas of underground coal mines. Except for the fringes, the goaf area in the 300 Panel would be unventilated.

22. During a roof fall, methane was pushed from the goaf into the working places of the 300 Panel. The ventilation system did not prevent the inrush of methane onto the section and it was not capable of diluting this methane to below explosive levels.

23. During the roof fall, the restrictions in the left return inby the No. 18 cut-through would have caused a greater amount of displaced gases to flow through the temporary ventilation controls or brattices in the Nos. 1 and 2 headings into the No. 21 cut-through.

24. A drop in the barometric pressure occurred in the hours prior to the explosion. This may have increased the methane liberation and the likelihood of methane migrating from the goaf toward the faces of the 300 Panel.

25. The volatile ratio of the channel sample, taken from the Endeavour Colliery after the explosion, was calculated to be 0.33. This indicates the presence of an explosive, medium-volatile, bituminous coal dust which must be rendered inert.

26. A thorough search of the area affected by the explosion was conducted. No evidence of smoking materials were found.

27. The results of the Alcohol Coke Test, completed on each of the mine dust samples, show that the only large quantity of coke existed in the No . 2 1 cut-through between the Nos. 1 and 3 headings. If the explosion had originated in the goaf, larger quantities of coke would be expected at the inby locations. Therefore, these results indicate that the No. 21 cut-through is a likely point of origin of the explosion.

28. During the underground investigation, 201 mine dust samples were taken throughout areas of the mine affected by the explosion. The incombustible content of many of the 210 samples taken were below 65%.

29. The magnitude of forces that occurred is indicative of a flame speed on the order of 122 meters per second (400 feet per second).

30. Ignition of approximately 200 cubic feet (6 cubic meters) of methane diluted to between 6% and 7% would result in the flame and forces experienced during the explosion.

31. Although the flame can extend up to five times the length of the original methane accumulation, the extent of flame into the goaf could not be determined because of the inaccessibility of this area. Very limited flame extension occurred outby or adjacent to the No. 21 cut-through between the Nos. 1 and 3 headings.

32. During the propagation of the flame, the available methane at the ignition source was readily consumed. Also, several locations near the fringe of the flame zone contained enough incombustible material to prevent the involvement of additional fuel. These two factors prevented further propagation of the explosion.

33. Remanents of the brattice reportedly located in the No. 1 heading near the No. 22 cut-through, was not found. Remanents of the brattice located in the No. 2 heading near the No. 22 cut-through was found inby on the fringe of the goaf. These brattices would have been exposed to two separate forces; one from the windblast after a roof fall in the goaf and the other from an explosion. The windblast clearly originated in the goaf and should have been sufficient to dislodge these brattices. No remanents of this brattice were found in the No. 1 heading. This brattice was reported by mine officials and check inspectors to be in intact and in good condition prior to the explosion. Staples found on the posts in the No 1 heading near the No. 22 cut-through support these reports. An explosion originating in the No. 21 cut-through would have caused forces on the brattices in the Nos. 1 and 2 headings in the inby direction. The remanents of the brattice in the No 2 heading was found in the goaf. However, additional rubble may have fallen in the goaf in the No. 1 heading after the explosion and covered the remanents of the brattice.

34. Evidence indicates that explosion pressures were about 27 kpa (4 psi) in the 300 Panel and about 4 kpa (0.5 psi) in 8 West.

35. Identification of the primary forces was complicated by the occurrence of a large roof fall shortly before the explosion. The evidence of forces produced by these events can be similar. An explosion propagating from the goaf would result in primary forces in the outby direction. However, the evidence indicates primary forces propagating towards the goaf.

36. The evidence from the evaluation of the forces is consistent with the point of origin of the explosion being located in the No. 21 cut-through.

37. The most likely ignition source was located in the No. 21 cut-through approximately between the Nos. 1 and 3 headings. The trailing cable and an associated coupling device from the No. 465 shuttle car were located in this area. This coupling device was located approximately 3 metres from the No. 3 heading in the No. 21 cut-through. The trailing cable and coupling device were taken during the investigation and were subjected to an electrical analysis by the New South Wales Department of Mineral Resources.

38. A large roof fall in the goaf of the 300 Panel occurred prior to the explosion. The men working in the face area reported a windblast from the roof fall. The start switch on the No. 465 shuttle car became engaged causing the pump motor to start. The operator switched "off" the pump motor. He said that a blast came from an outby direction and propagated toward the goaf.

39. The Electrical Investigation Report stated that "... findings are inconclusive as to the cause of the methane ignition ...". Several faults were found on the cable from the No. 465 shuttle car, but these were not in the immediate vicinity of the of the Nos. 2 to 3 headings in the No. 21 cut-through. This included a broken earth conductor in the No. 3 heading. A coupling device in the No. 21 cut-through near the No. 3 heading was found to be in non-flameproof condition. Although testing is incomplete, this appears to be the most likely ignition source.

40. Potential ignition sources in the goaf include spontaneous combustion and roof falls. The mine has no history of spontaneous combustion. There was no evidence discovered to indicate the presence of spontaneous combustion in the 300 Panel.

41. The ignition of a methane accumulation could result from the frictional heating that could occur during a roof fall or from piezoelectric discharges associated with the fracture of crystalline structures during a roof fall. The mine has no history of the ignition of methane from roof falls, however, its potential cannot be eliminated from consideration.

42. After evaluating all of these factors, it was concluded that the most likely point of origin in the No. 21 cut-through is the approximate area between the Nos. 1 and 3 headings.

INSPECTORATE REPORTS

The following points, complementary or additional to those covered in the MSHA investigation report, were made in the Coal Mining Inspectorate reports:

Mining Aspects

OVERALL MINE VENTILATION

As a part of their investigation MSHA conducted a complete pressure/volume survey of the colliery. The principle findings of this survey were that:

- the colliery had a relatively high resistance to ventilation flow;
- the majority of the high resistance areas lay in the outbye (older) half of the colliery;
- major return airways are so restricted that mine air seemed to flow through goaf areas rather than through the design path; and
- the pressure available to ventilate face areas, i.e. 300 and 406 panels was small.
- There was little reserve in the system to cater for abnormal conditions.

A number of less than desirable ventilation practices were also identified, including:

- allowing falls in returns;
- using goaf areas as main returns; and
- allowing goaf areas too close to vital ventilation roadways.

Return airway maintenance was generally considered less than desirable.

The main ventilating fan was noted to not have a continuously recording pressure chart. It was also noted that the last accurate reading of ventilation quanties available in the 300 Panel was taken at least a month prior to the explosion, readings apparently only being taken to satisfy statutory requirements and not at more frequent intervals.

STONEDUSTING PRACTICE

The Endeavour explosion did not progress to a coal dust explosion despite the fact that a dense coal dust cloud had been raised into suspension immediately prior to the gas ignition. The lack of progression to a coal dust explosion was considered due to:

- the relatively low strength of the gas explosion (or initiator); and
- the presence of a large void (the goaf) immediately adjacent to the ignition area, which permitted pressure dissipation rather than confinement.

The prevention of a coal dust explosion was not considered due to the adequacy of the colliery's stonedusting systems. Analysis of samples collected at Endeavour found the average incombustible content of 300 panel to be around 50%. For the area inbye 19 cut-through, to the face, the average was 68% with a standard deviation of 11%. It should be noted however that these results are only indicative since not all of the sampling was in accord with the requirements of New South Wales statute. A combination of sampling techniques was employed in order to provide the MSHA investigators with results against which they could apply benchmarks.

It was noted that during the application of stonedust in 300 panel very little or no effort appeared to have been made to apply stonedust to sections of roadways behind brattice. When the workings advanced and the brattice was removed, one rib line and a portion of the roof and floor were left undusted. Those areas left undusted were normally rich in fine coal dust.

Instances of this practice were noted a number of times. In 300 panel it was found that in 4 heading, 19 consecutive pillars were untreated on one rib line. It was also found that where stonedust was rigourously applied, incombustible levels as high as 90% could be achieved.

Some weeks prior to the explosion a district check inspector had written to the company expressing concern about stonedusting standards. The colliery had commenced a re-dusting program in areas of 300 panel. A series of samples covering these areas produced a mean incombustible content of 64% with a standard deviation of 13%. The same caveat applies to this set of samples as to those described above for the 300 Panel as a whole.

WATER BARRIERS

Under current arrangements water barriers are required to be constructed in conveyor roadways between 60 and 220m from the last line of open cut-throughs and contain certain volumes of water. At Endeavour the conveyor roadway water barrier in 300 area contained an appropriate volume of water but was located some 310m from the last line of cut-throughs.

ISOLATION BARRIERS

No isolation barriers were installed in 300 panel. The closest isolation barriers were some 1.8 km distant. A coal dust explosion initiated in 300 panel had potential to destroy half of the mine before it reached any isolation barriers.

OUTBYE STOPPING DAMAGE

The violence associated with the explosion was largely contained within 300 panel and the few roadways leading to its entry. However, the explosion caused significant damage to stoppings in 8 West, a further outbye area of the colliery some 2 km beyond 300 panel. The overpressure created at 8 West was able to raise some dust but not cause any distress to people and shouldn't have damaged stoppings in adequate condition.

Stoppings at the 8 West area were thought probably weakened prior to the explosion through a number of agencies. There was evidence of long term fractures in these stoppings. In other areas, against which water had accumulated, the stoppings were

so saturated that it was possible to push holes completely through the structure with finger pressure.

The 8 West stoppings were crucial for effective ventilation of inbye areas including 300 panel. Any short circuit of air into the return at 8 West would starve 300 panel. Despite this threat, the stoppings at 8 West were single sheet plasterboard located within the abutment zone of a standing goaf; with consequent high loading.

USE OF SELF-RESCUERS

Following the explosion the donning of self rescuers was not immediate, despite the presence of smoke and heat. One person did not don his rescuer at any time following the explosion. He had removed his belt from his person and his light and rescuer were lost in the explosion event..

Some men were unable to fully remove the rescuer from the canister base and had extreme difficulty in breathing. One man forget to attach his nose clip and another had difficulty keeping his nose clip on. One man prematurely removed his rescuer, felt giddy and then re-donned it. Others reported difficulty in opening the self rescuer latch.

Electrical Aspects

Examination of electrical equipment and flameproof enclosures in the 300 Panel revealed the following:

- the only anomalies detected, and considered of significance, in the electrical equipment examined were a broken earth conductor within the trailing cable of the left hand shuttle car, and a back-to-back cable coupler apparently in a non-flameproof condition;
- the broken earth conductor was detected at an old repair joint where the earth conductor had separated at a repair ferrule;
- the resulting electrical asymmetry of the cable was recognised as potentially generating inductive sparking of sufficient energy to ignite a combustible mixture of methane and air;
- testing of the cable in conjunction with the shuttle car indicated that insufficient static energy could be produced to ignite methane when the hydraulic pump motor (believed to have been accidentally activated just prior to the explosion) was turned on;
- although much of the cable was within the potential zone of initiation of the explosion (identified by MSHA) no evidence was found on examining the cable that an explosion was initiated from the body of the cable;
- a back-to-back cable coupler in 21 cut-through, 3-4 heading (to which the shuttle car cable was connected) was apparently in a non-flameproof condition according to Australian Standard criteria;
- the judgement as to the flameproof condition of the back-to-back coupler was made on a simple flamepath measurement basis and due to inbuilt factors of safety requires back-up testing to confirm, or deny, the true status of the enclosures;

- the back-to-back coupler was within the potential zone of initiation of the explosion;
- evaluation of the full potential for the electrical and flame-proof apparatus examined to have initiated the explosion is dependent on the conduct of further testing;
- the testing required has been requested of the Londonderry Occupational Safety Centre of the Workcover Authority. However, at the time of this report no reply (affirmative or negative) has been received from that quarter. Alternate sources of the required testing are being pursued.

Mechanical Aspects

Examination of mechanical equipment in the 300 Panel revealed the following:

- the only possible source of ignition considered of significance located within the likely zone of ignition (identified by MSHA) were shuttle car cable anchor assemblies associated with the left hand shuttle car;
- the cable anchor assembly was recognised as potentially generating a frictional spark of sufficient energy to ignite a combustible mixture of methane and air;
- testing of a number of similar cable anchor assemblies indicated that insufficient frictional energy was available to produce a spark capable of igniting a combustible mixture of methane and air;
- other possible mechanical sources of ignition within the most likely zone of ignition included frictional effects of roof supporting bolts and w straps, synthetic materials and flying objects from the first windblast;
- although other mechanical sources of ignition in the likely zone of ignition other than the cable anchor assembly are possible, no evidence exists to specifically support any of these sources as the source of ignition for the explosion.
- outside the likely zone of ignition mechanical equipment including a continuous miner, shuttle cars, breaker feeder, diesel powered vehicles and conveyor were examined as possible sources of ignition;
- a diesel powered vehicle was the only item where evidence was found to confirm it as a possible source of ignition. It was found to be in a non - flameproof condition according to Australian Standard flamepath dimension criteria. However the machine was non-operational at the time of the explosion and for some time before the explosion hence is discounted as a source of ignition for this explosion. Evidence is that, with the exception of the operation of a pump motor on a shuttle, car none of the other mobile machinery in the panel was in operation, although power was connected to both shuttle cars and the continuous miner.

ABSENCE OF A BLEEDER RETURN

The following information regarding the use of bleeder returns at Endeavour colliery and the absence of a bleeder return in the 300 Panel was obtained by examination of Department of Mineral Resources' records relating to the approval to remove pillars in the 300 area (Section 138 approval) and from information supplied by senior inspector Anderson:

- although some extraction panels may have been ventilated without bleeders it was the most common practice at Endeavour to ventilate goaf areas with bleeder returns
- the pillar extraction area worked prior to 300 Panel (Buff Headings - Inbye), and in the same region of the mine, was ventilated 'over and through the goaf';
- it appears that the 300 District was intended to be ventilated with air 'over the goaf edge as it is formed'. There is also some indication that it was intended to establish a through the goaf bleeder system 'once the first panel has been driven'. These intentions do not appear to be mutually consistent but in any case a bleeder return was not developed;
- there was, therefore, a change in the most common ventilation practice at the mine from 'through the goaf' to 'goaf edge' ventilation for the period in which pillar extraction occurred in the 300 panel, with a consequent absence of a bleeder return capable of maintaining the goaf free of methane accumulations;
- the approved plan (forming part of the Section 138 approval) indicates the intended formation of bleeder returns by holing into the Buff Headings;
- direct connection to the Buff Headings proved to not be possible due to an accumulation of water in the Buff Headings. This accumulation was a result of using the area as a water storage arising from a need to store water underground pending the installation and approval of surface outlets; and
- an attempt to 'skirt around' the known water accumulation by driving extra roads outbye was prevented by poor roof in 303 sub-Panel.

BACKGROUND INFORMATION

ENDEAVOUR COLLIERY

The Endeavour colliery was developed as Newvale No 2 mine in the early to mid 1960's. During the bulk of its life the colliery's production has been dedicated to thermal power generation. In recent times the colliery has moved to exporting its product. Annual production at the time of the explosion was 600,000 tonnes from a workforce of 118 men.

Access to the workings is gained via an inclined materials drift and two shafts; one being coal winding and the other solely for mine ventilation.

All mining has taken place in the Great Northern seam. Mining has taken place both under land and Lakes Munmorah and Budgewoi. The two operating panels at the time of the explosion, namely 300 and 406, were both under Lake Budgewoi. Both the working panels were at the extremity of the mine, approximately 5.5 km from where ventilating air entered the mine at pit bottom.

The colliery has had no history of spontaneous combustion and while classified Class A (that is a mine with more than 0.1% methane in its return airways) it was not rated as an extremely gassy mine.

The colliery had a six point tube-bundle gas monitoring system installed. This system was capable of analysing for methane and carbon monoxide. Outputs from the analyser were available by computer screen display in the undermanager's office. The nearest sampling point to the 300 Panel was located some 5 km outbye.

300 PANEL

300 Panel was developed to partially extract coal under Lake Budgewoi using the panel and pillar method.. The workings were at a depth of some 170 metres. Access was gained by driving a set of 5 headings until the barrier with Munmorah Colliery was reached. The extent of the panel's workings together with the sequence of goaf formation are shown on an attached plan.

VENTILATION ARRANGEMENTS

The mine is ventilated by a centrifugal exhausting fan producing approximately 180 m^3/second of air at 100 mm water gauge. The airflow in 300 panel was measured at 25.2 m^3/second in May 1995 with a general body methane content of 0.4% in the return airway.

Ventilation into the panel was via 3 central intakes and two flanking returns, on 304 sub-panel side (Left Hand Return - LHR) and on the other side of the 300 area development (Right Hand Return - RHR).

When 303 and 304 sub-panels were being mined the RHR was used as the main return with a small bleed of air maintained in the LHR. This approach was subsequently altered.

It was known that methane had accumulated in 304 goaves. In order to keep this gas away from the face, the LHR was activated as the main return. Once the gas at the 304 panel goaf edge had been bled and a required airway established,

ventilating air was split equally between both returns. In the weeks prior to the explosion the air balance was again altered so that the RHR carried most of the districts air and the LHR became a bleed. Indicative air quantities, provided by the Ventilation Officer were 17 m^3/second for the RHR and 5m^3/second for the LHR.

The principal means for controlling the district airflows was a panel regulator in the LHR. The RHR, the most resistive split, was unregulated.

Stoppings, separating intake and return air, from the panel entrance to 21 cut-through line were of a single plasterboard sheet construction, attached to props and cross batons or in some instances nailed directly to square sawn vertical timber posts. In all cases the stoppings had their clean faces on the intake side.

Other ventilation controls at the face and goaf edge were of brattice sheeting.

Ventilation stoppings on the RHR and at the face were viewed and inspected during the shift on the day of the explosion, as adjacent roads were used for travelling purposes into the panel and as wheeling roads from the face. Mining officials and the local check inspector were adamant that, despite being on the non-operational side of the panel, the LHR stoppings were in place and intact on the morning of 28 June.

Access to the return airways in the panel was via belt door flaps. This style of door differed from the Buff access headings at 8 cut-through and between 303 goaves where a substantial, latched steel door was used.

The controlling regulator in the LHR consisted of brattice sheeting nailed to timber props. There was no secure manner of attaching the brattice to the ribs. There is no facility to lock the regulator into a fixed position. It is questionable whether this structure would retain it's integrity under normal operating conditions, let alone in the event of an explosion. This single structure, some 750m from the face, was the most important ventilation control in 300 panel. Any change in its performance would not only alter panel air quantities but also the distribution of air within the panel.

Panel Ventilation Path

On the day of the incident the airflow path considered mostly likely was as shown in one of the attached plans. Once ventilating air had passed over the continuous miner into the goaf, pressure differentials caused the air to split and flow to both returns. With this particular type of layout, that is two flanking returns, an area of pressure equalisation exists in the goaf. At this point (the neutral point) pressure differentials between the two return paths are zero and ventilation ceases. The location of the neutral point may be altered by manipulating pressure differentials but it cannot be eliminated. Methane, if present, would tend to accumulate at the neutral point.

The ventilation layout might be described as a goaf edge bleed return system. This system relies upon the fact that the goaf edge is sufficiently open to allow reasonable quantities of air to pass. Given the massive strata conditions at Endeavour this was probably a realistic expectation.

While such a system may be effective in controlling methane levels at or near the goaf edge it probably has very limited, if any, impact on methane that may be accumulating in the main body of the goaf. It is foreseeable that if accumulated

methane were to be forced suddenly from the body of the goaf then it could overwhelm the ventilation system, resulting in excessive, and possibly explosive, mixtures of methane in or adjacent to the face area.

Face Ventilation

Readings taken by the mine Ventilation Officer from September 1994 to May 1995 for the 300 district are as follows:

Date	Panel Quantity	Face Ouantity	Comments
	(m^3/see)	(m^3/sec)	
Sep 94	20.7	9.3	
Oct 94	16.7	7.5	30m on brattice
Nov 94	21.2	14.0	At Breakaway
Dec 94	16.9	4.5	
Jan 95	20.6	9.3	
Feb 95	13.4	5.3	
Mar 95	17.1	9.1	Lifting Off
Apr 95	19.7	12.3	Split Holed. Lifting off
May 95	25.2	20.5	Lifting off

These quantities show a marked variation in total air to the panel and also in the actual value available at the face. Deputies reports examined, when referring to face air quantities, were notably subjective with comments such as "good, adequate, poor, sufficient". It must be said however, that although required to make such entries officials are generally not provided with either measurement equipment nor benchmarks to refer to.

On the day of the explosion the view of those in the panel was that the airflow at the face was the best enjoyed for some period of time. No quantitative estimate could be placed on the volume flowing. None of the mining officials interviewed were able to state where the ventilation flowed once it passed over the miner.

METHANE OCCURRENCE

Methane had been detected by colliery officials in 300 panel prior to the explosion. Methane had been found:

- in both the LHR and RHR airways, ranging from 0.2 - 0.6%. The last reading entered by the Ventilation Officer (for May 1995) was 0.4%;
- emanating from 304 goaf with the goaf edge bleed air. This ranged from 0.4 to 1.0%;
- at numerous working places. Typical in-shift values were 0.2%. The methane monitor on the continuous miner had tripped power whilst driving a split in the pillar immediately adjacent to that being extracted on the day of the explosion. On that occasion extra ventilating air was coursed to the face and the gas level dissipated. The gas source was believed to be a roof feeder. No further problems were encountered whilst extracting that pillar; and
- at the face, by the continuous miner monitor, on the day of the explosion. Whilst the monitor did not trip, it did flash a warning light indicating 1% methane. This level of methane was unusual for an extracting lift where flood ventilation was being practiced. Similar problems had been experienced by the preceding nightshift, where it had become necessary to keep withdrawing the miner from the lift thus preventing the monitor from tripping power. It was noted that the offending gas was general body (not layered) and was present only when cutting. This suggests a body of methane was present in 300 goaf, in the 12 hour period prior to the explosion, and that ventilation flow was not adequate to completely disperse this gas.

THE 300 AREA GOAF

An intention of the mining method being practiced in 300 panel (the panel and pillar method) was to minimise strata movement and hence strains at the rocked under Lake Budgewoi. This approach is both well known and appropriate when the risk of inundation is to be avoided. A series of goafs, 90m in width were being developed. 33 x 40m abutment pillars separated these goafs and acted as strata stabilisers. This process, akin to abutments on a long bridge construction, was aided by the competency of the conglomerate and sandstone roof.

Within formed goaf areas the immediate roof strata had collapsed. However, these collapses had been often noted as irregular and shallow. This type of goaf formation was not unexpected given panel geometry and strata conditions. Prior to the explosion the goaf had collapsed in most areas but was standing (or open) in areas adjacent to the face. In other areas the goaf had shallow falls only and the main goaf had not yet been formed.

Windblast potential from goaf falls, with this system of mining and with competent roof, must always be considered a possibility. With relatively large areas standing (30 x 30m or greater) massive and sudden air displacements are probable. Such displacements may be associated with significant overpressures which are capable of destroying ventilation structures and raising dust into suspension (reducing visibility and creating an explosion hazard). Large falls may propel goaf gases into working areas in overwhelming volumes.

CONDITIONS PRIOR TO THE EXPLOSION

On the shift during which the explosion occurred pillar extraction was taking place as indicated in an attached plan. Mining commenced at 0645 and by around 0930 a position shown had been reached where a further two lifts were required to complete a fender.

It was noted that a water fitting on the continuous miner needed repairing and the machine was withdrawn and was turned off to allow repair work to commence. At this time the disposition of crew members was:

At the continuous miner:	Deputy	G Gain
	Miner	P White (local check inspector)
	Miner	G Smith (miner driver)
	Fitter	D Hines
On shuttle cars:	Miner	K Wolfenden
	Miner	D Wrixon
Outbye:	Miner	O Peters (at crib table
	Electrician	P Hadden (working on shuttlecar)

Both shuttlecars were parked with power on, but no motors running. This lack of machinery noise allowed those present at the face to listen closely to strata "talk".

The crew were aware that a sizeable area of goaf was standing and that coal had been popping from the ribs as they mined, indicating strata pressures were increasing. A fall was expected. Crew members at the continuous miner heard some roof cracking and observed minor roof dribbling. This was followed by a tearing noise high up in the roof. All recognised that a large goaf fall was imminent. Gain, White and Hines ran outbye to escape the coming fall whilst Smith crouched down behind the back of the miner (adjacent to the boom) to protect himself from the expected windblast.

Wolfenden and Wrixon heard the large tearing noise, and recognised that a large fall was only seconds away. Wrixon stayed on his car whilst Wolfenden made an attempt to get off his vehicle. Hadden and Peters were unaware of the events occurring at the face although Peters, who had only recently been relieved as miner driver by Smith, felt that a fall was likely. Peters had observed goaf props cracking and general signs of increasing weight during the earlier part of the shift. Hadden was aware that the goaf was standing and a fall was likely.

THE GOAF FALL/WINDBLAST

As the men at the face ran outbye a large goaf fall occurred and a windblast followed. Gain and Hines had made the intersection of 22 cut-through and 3 heading near the shuttle cars when the blast struck them. White had reached a shuttlecar and was part way along its length on the right hand rib (when looking outbye). Wolfenden and Wrixon were on their shuttlecars.

The violence of the windblast knocked Gain, Hines and White to the ground. White had the radio control unit he was carrying, a reasonably heavy object, torn from his hands. Gain reported being peppered by coal particles from the goaf. Smith, who was protected by the bulk of the continuous miner, reported hearing the windblast pass over him but was not adversely affected by its passing.

Wrixon, on one of the shuttlecars, felt a powerful windblast which hit his face and peppered him with coal particles. His helmet was blown away and the bracket holding his cap lamp to the helmet was torn off. He described the windblast as the largest he had ever felt.

Wolfenden reported feeling a slight blast hitting his face followed immediately by a huge blast which knocked him off his car and into the rib. He reported the air thick with dust due to the second blast. As he was blown off his shuttlecar power suddenly came on and the pump motor started. Wolfenden had not knowingly started the vehicle and believes either his knee or flying debris accidentally hit a control lever on the instrument panel, thus activating the pump motor.

Meanwhile White, who was on the ground on the opposite side of the shuttlecar, became alarmed by the noise of the pump motor starting. The windblast had blown his helmet and light away and forced him near the shuttle car wheels. He feared Wolfenden was trying to move the shuttlecar and that he would be run over and killed. White screamed to Wolfenden not to move the car. White could distinguish his cap lamp near him but could not see for the dust raised by the blast.

Hadden who had been working on another shuttle car was walking back towards the crib room in 20 cut-through between 3 and 4 heading when he heard a goaf fall and felt a gush of air on his face. He then called out to Peters, sitting at the crib room table that "that was a little one", referring to the size of the goaf fall.

Peters did not feel the windblast but heard a 'rumble'.

THE EXPLOSION

After the large windblast occurred all members of the crew were hit by a further blast. The time was approximately 0950.

The explosion, which apparently travelled from outbye towards the face, hit Gain as he was sitting in the intersection of 22 cut-through and 3 heading. He was again knocked to the ground. He reported the explosion's violence to be of an order of magnitude greater than the windblast. He felt intense heat. Visibility was virtually nil.

Smith crouching behind the miner described how the explosion hit him from outbye and peppered him severely with coal particles. He thought the violence would never stop. It went on much longer than the windblast. White was standing (after hurriedly moving away from the shuttle car wheels when the explosion knocked him to the ground again. He became aware of smoke (by smell) and heat. There was no visibility.

Wolfenden was blasted by the explosion which sounded like a 'screaming jet engine' to him and he felt intense heat. At some stage Wolfenden believed he saw an orange glow.

At no time did any person at the face or on the shuttlecars report seeing flame.

Hadden was entering the crib room when he felt the goaf windblast and within a few seconds was hit by a concussion coming along 20 cut-through from the belt heading. The blast hit him in the face. He was blown 2 - 3m backwards and knocked to the ground injuring a knee. His helmet was blown off. Hadden felt intense heat but saw no flame. Even with his cap lamp he could not see Peters only metres away because of the intense dust cloud.

Peters did not feel the goaf fall. He was sitting with his back to the belt facing a shuttlecar and could see Hadden walking towards him. Peters then heard a second ' rumble and grunt' followed by a blast which hit him from behind and propelled him towards Hadden and the shuttlecar in the 4 heading travelling road. Peters felt intense heat, he reportedly saw a fire ball come along the floor and run up his body. He believed that the flames came from the travelling road. Everything was coloured red. Peters felt he was being cooked, as if he was in an incinerator. He smothered the burning on his face and arms using his reflective safety vest.

ESCAPE FROM THE PANEL

After the explosion the survivors made their escape in three groups:

- White, Wrixon, Smith and Hines;
- Gain and Wolfenden; and
- Hadden and Peters

WHITE, WRIXON. SMITH AND HINES

White believed that the atmosphere near the right hand shuttlecar was clearer than near the right hand car shuttlecar, so he called for people to follow him along the rib line of the cut-through until they reached the intersection of 22 cut-through and 4 heading (the travelling road). This was done in close to nil visibility by groping along

the rib or by holding the adjacent man's belt. When they reached the travelling road the heat being felt intensified significantly. Fearing a fire and having smelt smoke they donned their self-rescuers and began to feel their way out along the rib.

This party made their way outbye, passing the DCB's and not realising so, due to the dust and smoke. By the time they were in the vicinity of 19 cut-through they were disorientated. Fortunately the party ran into a materials machine parked by Smith some time earlier. They then noticed a reflective toilet sign. Once re-orientated they proceeded along the transport road, to the belt underpass. Visibility was slightly better here and the group split into two as they walked outbye with Hines and Smith going ahead. The air began to clear as they walked outbye and unpolluted air was found around 9 cut-through.

GAIN AND WOLFENDEN

Gain heard Wolfenden calling for assistance and came to his aid in close to nil visibility. They then also made their way along 22 cut-through to 4 heading but somewhat behind White's group. They too felt intense heat at the intersection. The pair then progressed outbye with Gain wearing his rescuer. Wolfenden felt he did not need to wear his. They became completely disorientated due to the smoke and dust and were lost.

Fortunately, both heard a telephone ring and then immediately ran into a table. This placed them in the crib room. Wolfenden donned his self rescuer here. Gain then found the belt and the pair proceeded outbye along the belt using the structure as a guide. Gain reported that the heat dissipated outbye 18 cut-through but visibility there was only 0.5m.

MADDEN AND PETERS

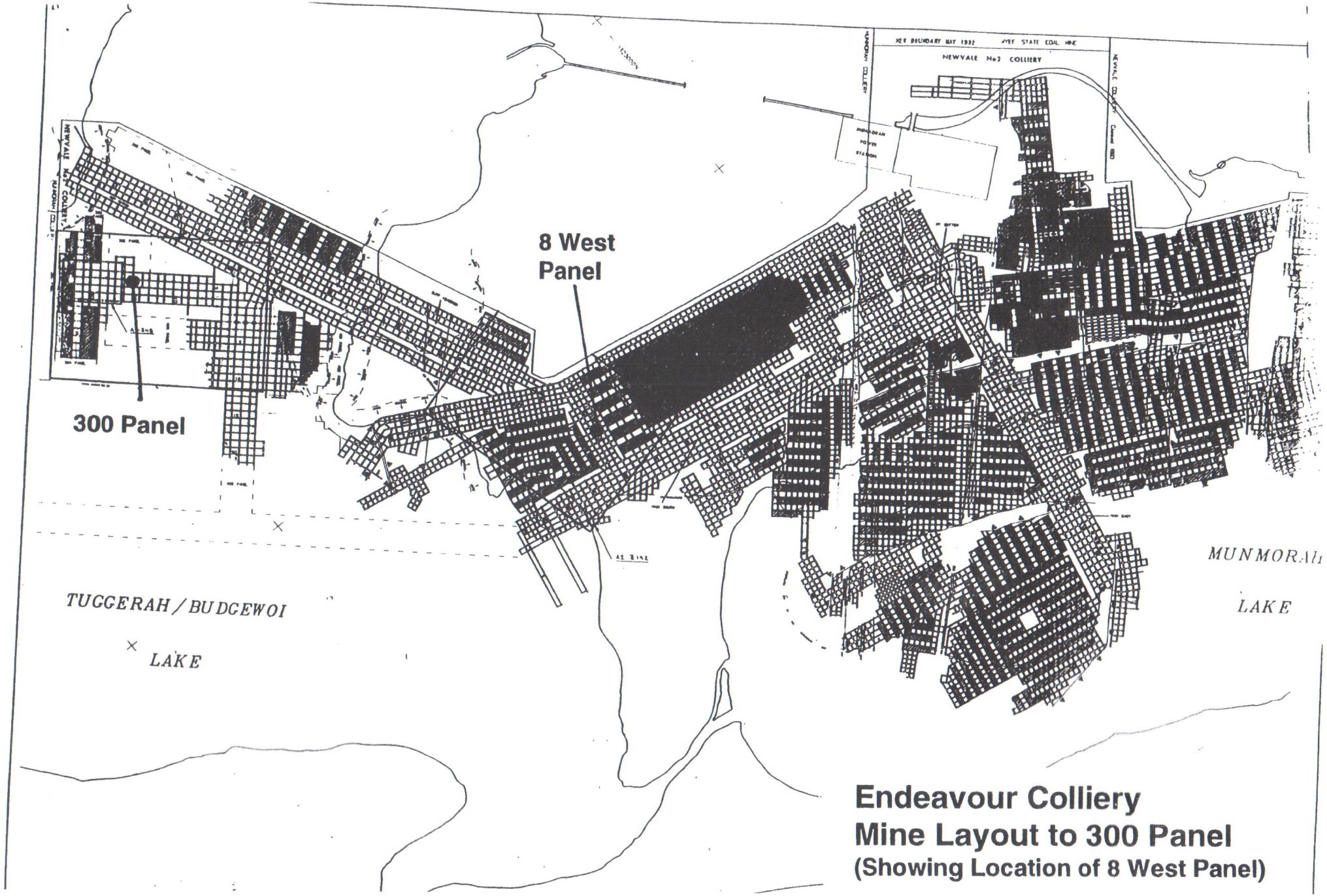
By calling out to each other, these two men began to move out along the transport road in nil visibility. Hadden recalled walking into an MPV (mobile machine) without seeing it. This machine had been parked there earlier by Smith. It was the same machine that White's group were later to encounter. Hadden's self rescuer became very hot whilst making his way out. Peters felt that their escape was aided by his facial burns, claiming his face was ultra sensitive to air temperature and he could feel intake air by simply turning his head and assessing the sensations on his face.

The two men headed towards 2 heading 18 cut-through, where electrician Hadden knew they could follow the high tension cable outbye. By the time they reached 2 heading 18 cut-through and found the cable, visibility had increased to 1 m. They made their way out following the cable.

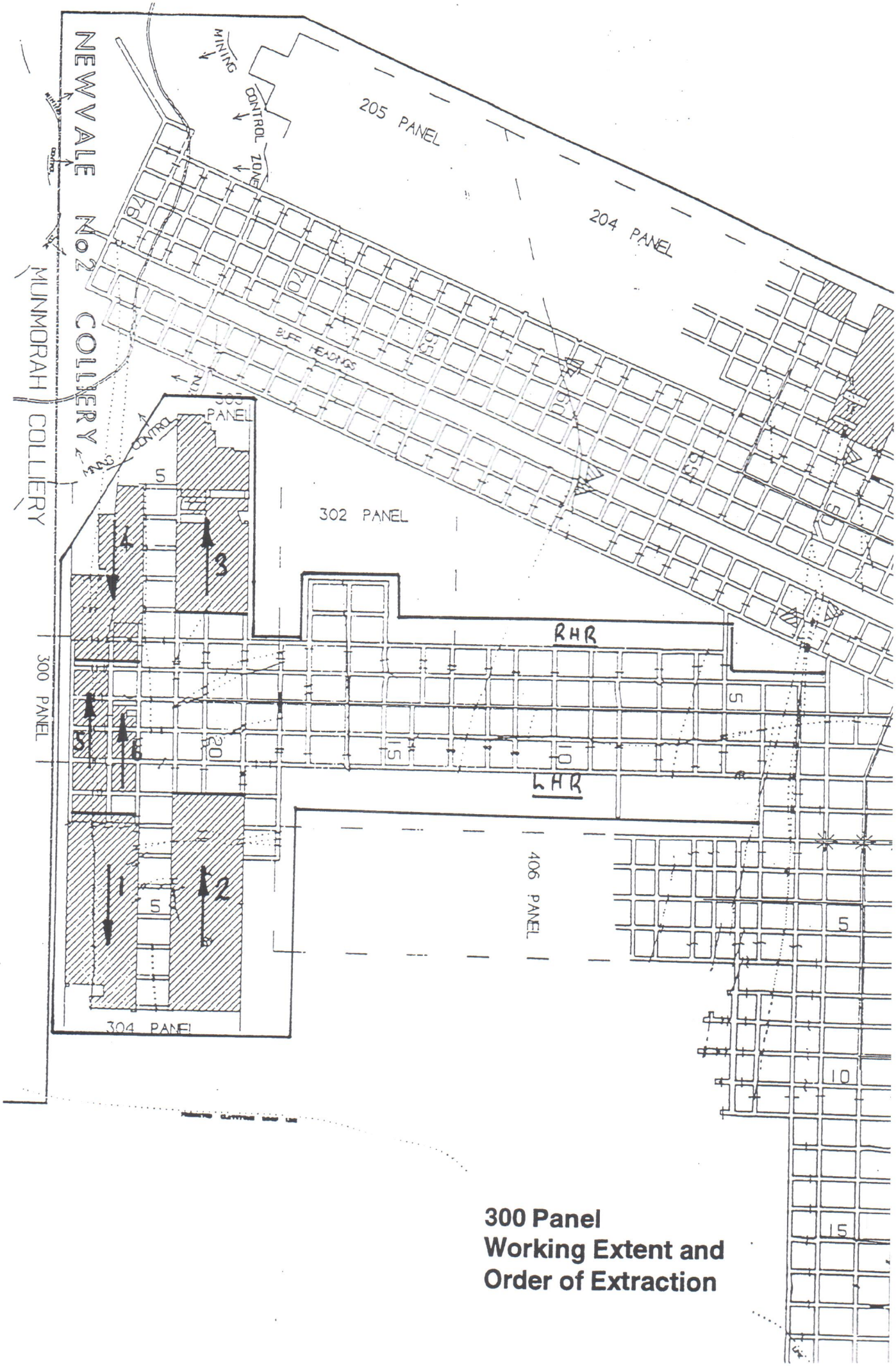
At 9 cut-through they encountered the transformer, noting power was still connected. Peters told Hadden to trip the power, which he did. Both noticed that visibility had improved markedly and that heat was no longer being felt. Peters claimed visibility improved significantly at 8 cut-through.

Peters had the presence of mind to telephone from 5 cut-through using the emergency number to advise the surface of the explosion. Once in fresh air all 3 groups made their way to the end of the tracks, some 5 minutes walk outbye of the panel entry at 1 cut-through, to await help.

This document was prepared by Chris Ellicott, Training & Development Officer
Coal Mining Inspectorate & Engineering Branch

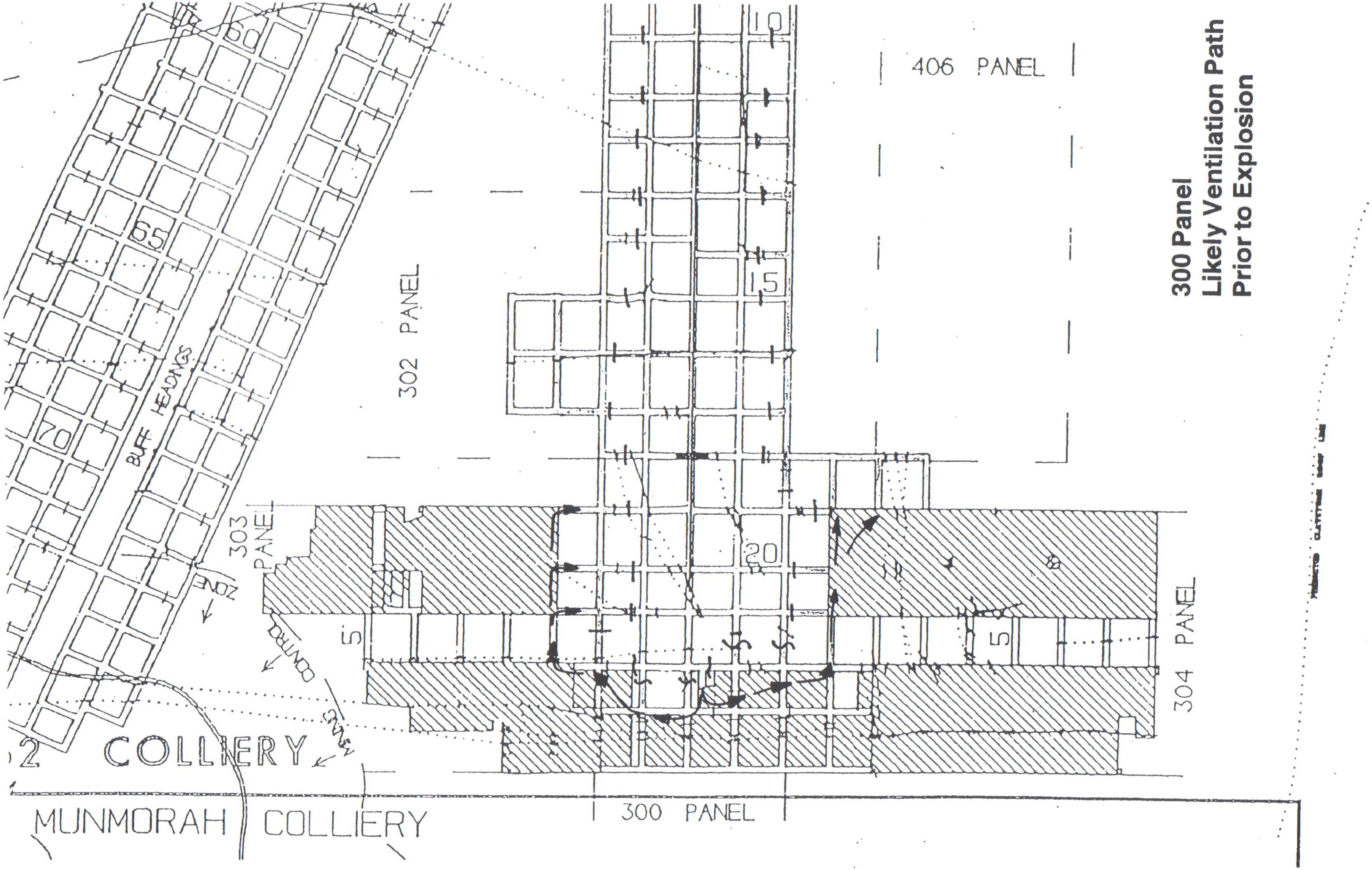


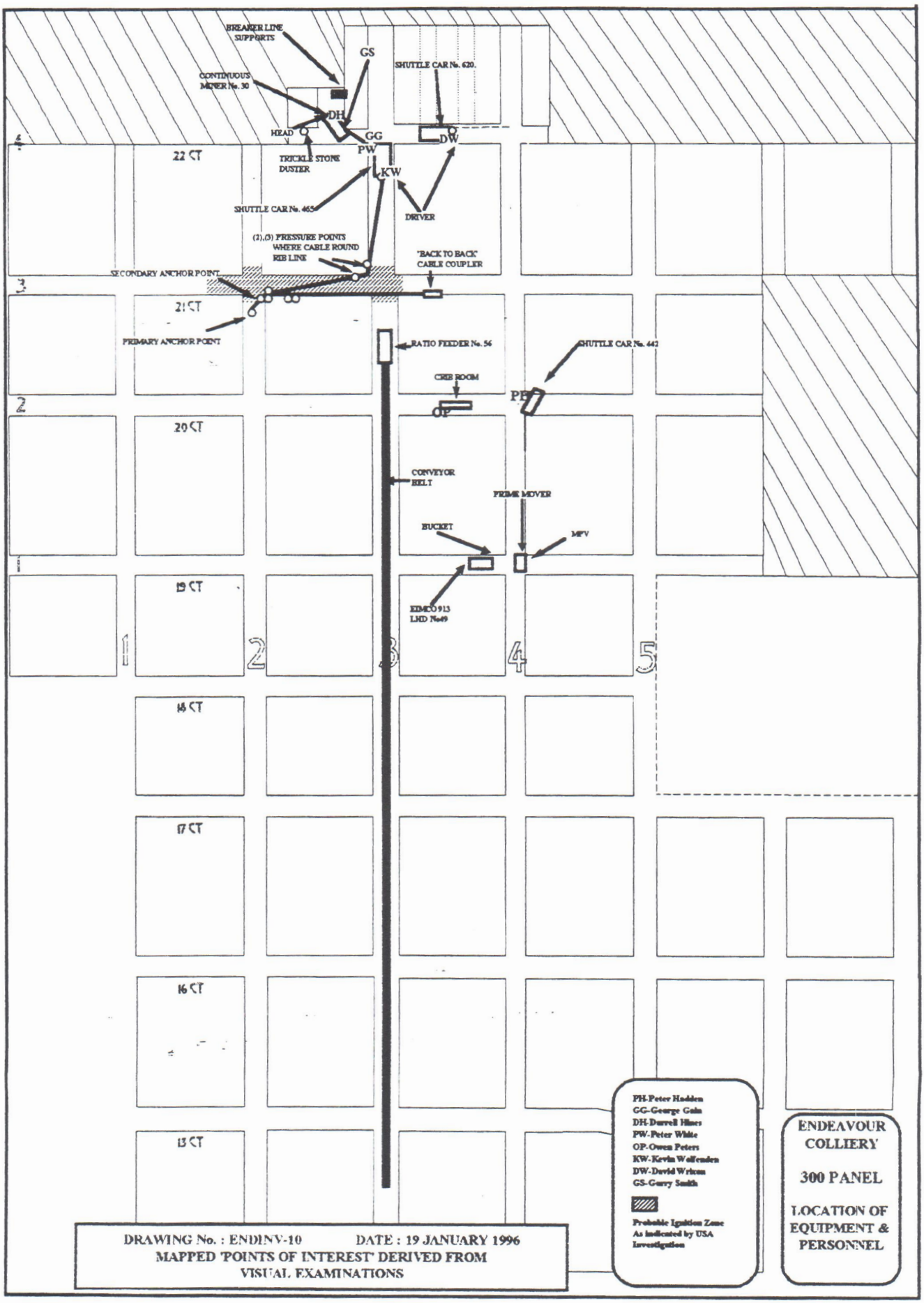
Endeavour Colliery
Mine Layout to 300 Panel
(Showing Location of 8 West Panel)

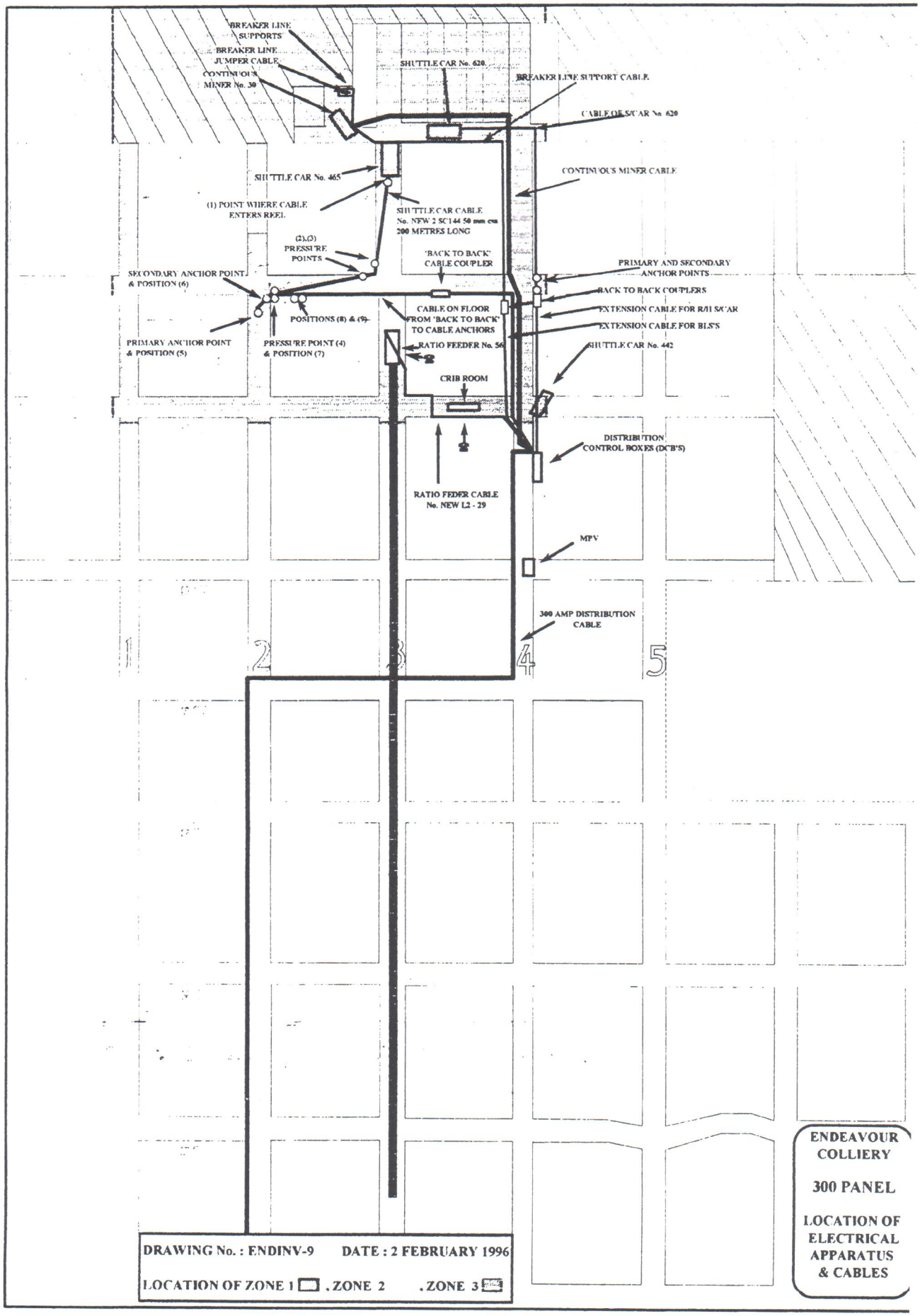


300 Panel
Working Extent and
Order of Extraction

300 Panel
Likely Ventilation Path
Prior to Explosion




BREAKER LINE SUPPORTS
GS
SHUTTLE CAR No. 620.
CONTINUOUS MINER No. 30
DH
HEAD
GG
DW
PW
TRICKLE STONE DUSTER
KW
SHUTTLE CAR No. 465
DRIVER
(2),(3) PRESSURE POINTS WHERE CABLE ROUND RIB LINE
'BACK TO BACK' CABLE COUPLER
SECONDARY ANCHOR POINT
PRIMARY ANCHOR POINT
RATIO FEEDER No. 56
SHUTTLE CAR No. 442
CRIB ROOM
PE
OP
CONVEYOR BELT
PRIME MOVER
BUCKET
MFV
EIMCO 913 LHD No49
22 CT
21 CT
20 CT
19 CT
18 CT
17 CT
16 CT
15 CT
1
2
3
4
5
PH-Peter Hadden
GG-George Gain
DH-Darrell Hines
PW-Peter White
OP-Owen Peters
KW-Kevin Wolfenden
DW-David Wrixon
GS-Garry Smith
Probable Ignition Zone As indicated by USA Investigation
ENDEAVOUR COLLIERY
300 PANEL
LOCATION OF EQUIPMENT & PERSONNEL
DRAWING No. : ENDINV-10 DATE : 19 JANUARY 1996
MAPPED 'POINTS OF INTEREST' DERIVED FROM VISUAL EXAMINATIONS


BREAKER LINE SUPPORTS
BREAKER LINE JUMPER CABLE
CONTINUOUS MINER No. 30
SHUTTLE CAR No. 620
BREAKER LINE SUPPORT CABLE
CABLE OF SCAR No. 620
SHUTTLE CAR No. 465
CONTINUOUS MINER CABLE
(1) POINT WHERE CABLE ENTERS REEL
SHUTTLE CAR CABLE No. NEW 2 SC144 50 mm cus 200 METRES LONG
(2),(3) PRESSURE POINTS
'BACK TO BACK' CABLE COUPLER
PRIMARY AND SECONDARY ANCHOR POINTS
SECONDARY ANCHOR POINT & POSITION (6)
BACK TO BACK COUPLERS
EXTENSION CABLE FOR RAIL SCAR
POSITIONS (8) & (9)
CABLE ON FLOOR FROM 'BACK TO BACK' TO CABLE ANCHORS
EXTENSION CABLE FOR BLS'S
PRIMARY ANCHOR POINT & POSITION (5)
PRESSURE POINT (4) & POSITION (7)
RATIO FEEDER No. 56
SHUTTLE CAR No. 442
CRIB ROOM
DISTRIBUTION CONTROL BOXES (DCB'S)
RATIO FEDER CABLE No. NEW L2 - 29
MPV
300 AMP DISTRIBUTION CABLE
1
2
3
4
5
DRAWING No. : ENDINV-9 DATE : 2 FEBRUARY 1996
LOCATION OF ZONE 1 , ZONE 2 , ZONE 3
ENDEAVOUR COLLIERY
300 PANEL
LOCATION OF ELECTRICAL APPARATUS & CABLES