MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Briefing for the Incoming Minister Responsible for Pike River Re-entry

26 October 2017

This document has been proactively released. Redactions made to the document have been made consistent with provisions of the Official Information Act 1982.

New Zealand Government

Contents

Purpose

1. This briefing provides you with background information on the Pike River Mine tragedy, and information on working with Pike River Families. Further briefings will be provided on specific topics, depending on your priorities.

Key MBIE contacts

2. The following table provides a summary of **key initial contacts** related to your portfolio as Minister Responsible for Pike River Re-entry:

Contact	Role	Contact details
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Background information on Pike River Mine

Executive summary

3. On 19 November 2010 an explosion occurred at the Pike River Mine. 29 men, whose last estimated locations placed them within the mine workings,[1] were found by the Chief Coroner to have died immediately or shortly after the explosion. Two men, who were in the drift[2] when the explosion occurred, managed to survive.

4. Three more explosions happened at the mine over the next nine days. No reliable atmospheric information could be obtained during this time, meaning there was no opportunity to attempt safe re-entry for rescue or recovery. The mine was temporarily sealed in late 2011.

5. In line with proposals made by the Pike River Families, the area where the mine is located now forms part of the Paparoa National Park. A Great Walk is also under construction – the Paparoa and Pike29 Memorial Track which is being established in memory of those who died. The tracks will provide access to the mine area where a memorial is intended to be located at the portal. A centre providing information on the tragedy is also planned.

The Royal Commission on the Pike River Coal Mine Tragedy

6. Convened in December 2010, the Royal Commission on the Pike River Coal Mine Tragedy (the Royal Commission), reported back in October 2012. As part of its extensive findings, it noted the tragedy occurred during a drive to achieve coal production where problems existed at leadership, operational systems and cultural levels, including of production before safety at the executive level.

7. The cause of the first explosion was found to be ignition of a substantial volume of methane gas, most likely discharged into the workings of the mine by a roof collapse in the goaf.[3] No definitive determination of the ignition source could be made. However, modelling indicated it was likely located in the middle of the mine workings.

8. The previous Government addressed all of the Royal Commission’s 16 recommendations. This included the establishment of WorkSafe New Zealand as a single-focus work health and safety regulator; a new regulatory regime for underground coal mining; improving emergency management in mines; and reforming work health and safety responsibilities for officers of organisations.

Solid Energy currently controls the mine

9. Solid Energy has controlled the mine since 2012. As part of its agreement with the previous Government, in considering the commercial viability of re-opening the mine, it undertook a full risk assessment of manned re-entry of the drift.

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[1] Everything behind the rockfall at the end of the drift (refer to the map in **Annex 2**). A glossary of key terms is contained in **Annex 1**.

[2] The access tunnel from the portal to the rockfall (refer to map in **Annex 2**).

[3] The void created by coal extraction that is usually unsupported and susceptible to roof collapse.

10. While manned re-entry of the drift was considered to be technically possible, there were risks that could not be mitigated to the satisfaction of the Board of Solid Energy. Solid Energy's decision not to re-enter the drift was announced in November 2014.

11. Solid Energy will be winding up its operations in December in anticipation of entering liquidation in March 2018. It will continue to maintain and monitor safety systems at the mine and run the unmanned exploration project until it enters liquidation, unless otherwise agreed with the Government.

Remote exploration of the drift and mine workings

12. Small, discrete areas of the mine workings have been explored by cameras and survey equipment lowered down existing drillholes following the explosion. All but 400m of the drift have been explored through remote methods.

13. In February 2017, following a request by the previous Government, Solid Energy put permanent sealing of the mine on hold to develop a plan for unmanned exploration of the drift. The unmanned exploration project currently has two stages:

    - **Unmanned exploration of the drift** (stage 1): This is planned and focuses on exploring the 400m of the drift not yet accessed, to establish whether human remains are present.
    - **Unmanned exploration of the mine workings** (stage 2): This is not yet planned but could focus activity towards key areas of the mine workings, with the aim of providing information on the cause of the initial explosion.

Manned re-entry of the drift

14. Solid Energy's risk assessment considered three possible methods for manned re-entry of the drift. There were key risks identified with all three methods, including:

    - injury or death from a strata failure (e.g. roof fall).
    - asphyxiation or explosion due to loss of control of the atmosphere within the drift (which could occur a number of ways, including being unable to ventilate following a mine equipment fire).
    - injury or entrapment due to failure of one of over 600 controls Solid Energy identified would need to be implemented.
    - entrapment and inability to rapidly recover workers from a strata failure or equipment fire. This was identified in Solid Energy's third-party report as the most significant risk to manned re-entry of the drift.

15. There are a number of known issues and information gaps about the original construction of the mine that informed Solid Energy and its third-party assessments, including:

    - the suitability of the construction of the original roof cannot be adequately ascertained.
    - areas of roof and wall supports are expected to have lost structural integrity.
    - there are obstructions to determining the condition of the existing supports.

16. Experts for the Pike River Families have prepared and submitted three reports to the Board of Solid Energy. All three reports are high level documents outlining proposed recovery procedures. They do not fully risk assess or cost the proposals.

17. A fourth "hybrid" plan was submitted during the Commerce Select Committee's hearing in February 2017 on the petition by Dame Fiona Kidman requesting that permanent sealing of the mine be stopped and remains of the 29 men brought home if humanly possible.

The explosion at Pike River Mine and its aftermath

18. At 3.45pm on Friday, 19 November 2010 an explosion occurred at Pike River Mine, located in a remote area of the Paparoa Range on the West Coast of the South Island.

19. 31 miners were underground at the time. The last estimated location of 29 of the men placed them within the mine workings (refer to the map in Annex 2).

20. An inquest by the Chief Coroner found these men would have died immediately, or shortly thereafter, from the force of the explosion or the effects of the irrespirable atmosphere. The Royal Commission agreed.

21. Two men were in the mine drift when the explosion occurred. Located some way from the mine workings (at 1.6 km and 1.9km from the portal) they managed to survive and emerged from the mine approximately 1 hour 40 minutes after the explosion.

22. The mine exploded three more times over the next nine days. Experts agreed no-one could have survived the smaller, but more powerful, second explosion on 24 November 2010.

23. No representative and reliable atmospheric information could be obtained from the mine at the time. As such, there was no opportunity to attempt safe re-entry for rescue or recovery.[4]

24. In 2011, the mine was temporarily sealed by Mines Rescue teams using breathing apparatus and the atmosphere made inert. This included the construction of a seal to reclaim and ventilate 170m of the drift inbye[5] of the portal to the mine. This 170m length of the drift was used for safety monitoring purposes.

25. A Royal Commission on the tragedy was appointed in December 2010. It was chaired by the Honourable Graham Panckhurst, and Stewart Bell and David Henry were also appointed as Commissioners.

26. The Royal Commission was given a wide mandate, including reporting on the cause of the explosions and loss of life; the practices used and steps taken operationally and at management level by Pike River Coal Ltd; and their effectiveness in achieving a healthy and safe workplace.

27. The Royal Commission reported back in October 2012. The first two parts of the report's overview are attached as **Annex 4**.

28. The mine was still in development phase and had only recently gone into production before the explosion occurred. Systems and infrastructure needed for safe production were found by

4 Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at page 13.
5 The direction towards the coal face from any point of reference. A glossary of key terms is contained in **Annex 1**.

the Royal Commission not to have been in place and health and safety systems were inadequate. Ventilation and methane drainage systems could not handle the volume of methane arising from the work being done.[6]

29. Reports of excessive methane levels were common and not addressed, including on the morning of the initial explosion. In the 48 days prior, 48 notifications were reported – 21 of which reached explosive levels for methane.[7]

30. A major theme that emerged was that the tragedy occurred during a drive by Pike River Coal Ltd to achieve coal production in a mine with problems at leadership, operational systems and cultural levels, including of production before safety at the executive level.[8]

31. There were also failures on behalf of government regulators, including insufficient regulatory oversight of the mine by the Department of Labour (the then work health and safety regulator).

32. The previous Government addressed all of the Royal Commission's 16 recommendations, including through:

- the establishment of WorkSafe New Zealand as a single-focus work health and safety regulator
- a new regulatory regime for underground coal mining, including reforming the statutory responsibilities of mine managers
- improving emergency management in mines, including extending the coverage and functions of the Mine Rescue Service
- reforming statutory responsibilities for directors in work health and safety, including a new, proactive due diligence duty on directors and officers of organisations
- strengthening worker participation in work health and safety in underground coal mines.

The cause of the explosion

33. The Royal Commission concluded the cause of the first explosion was ignition of substantial volumes of methane gas.[9]

34. Methane gas, which is found naturally in coal and released during mining, is explosive when it comprises 5 to 15 percent of the atmosphere (the explosive range). Within that range, methane is very easily ignited.[10]

35. The large volume of gas was most likely discharged by a roof collapse in the goaf section of the mine. This would have pushed the methane emitted from the hydro-mining panel into other

[6] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at 12.
[7] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 8 at paragraph 140.
[8] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at 15 and 19.
[9] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at pages 12 and 14.
[10] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at page 12.

parts of the mine through the ventilation system, causing methane levels within the majority of the mine to reach explosive range.[11]

36. The ignition source could not definitively be determined. Possibilities identified included arcing in the mine's electrical system; the diesel engine of mine equipment overheating; sparks from an electric motor; friction sparking from work activities; or contraband brought into the mine.[12]

37. These potential ignition sources are primarily within the mine workings, not the drift.

38. Modelling of the initial blast indicated the ignition source was likely inbye of the main ventilation fan. It is estimated to have been located in the middle of the mine workings.[13]

39. The further three explosions appear to have occurred near the ventilation shaft as air was sucked in through the mine portal, mixing with the methane rich atmosphere and then being ignited by an underground fire or heated coal.[14]

40. The explosions are suspected to have ignited the coal within the mine workings. These fires are now either extinguished or, due to lack of oxygen, smouldering. Should oxygen concentration increase within the mine, there is potential for re-ignition and further methane explosions.

The mine environment

41. The mine is a high-risk and complex environment that currently has only one egress – the drift, which runs upwards from the portal to the mine workings.

42. The Royal Commission found that roof and wall supports within the drift and mine workings to the west of the Hawera Fault were inadequately constructed. Supports were likely further damaged by the explosions and heat generated from the underground coal fire.

43. The explosions are known to have created roof falls and blocked tunnels, including a large rockfall at the end of the drift that now impedes acess from the drift to the mine workings.

44. The drift refers to the 2.3km of access tunnel from the portal to this large rockfall. The mine workings are everything behind this rockfall and contain approximately 5.5 km of tunnels (refer to the map in **Annex 3**).

45. Except for the drift, the only other potential egress was a 110m ladder up the ventilation shaft. This would not have been able to be used following the explosion – it could not have been climbed wearing a self-rescuer (a breathing device for use in toxic atmospheres) and because the ventilation shaft was "effectively functioning as a chimney." [15]

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11 Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 14 at paragraph 37.
12 Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 14 at paragraph 47 to 84.
13 Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 14 at paragraph 83.
14 Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 14 at paragraph 95.
15 Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at page 25.

46. The mine's ventilation system is one of a single intake (fresh air is provided to the whole of the mine through the portal) and a single return (foul air is taken out through the ventilation shaft). While common in New Zealand, it would not have been acceptable in Australia given the number of different work areas. This system makes ventilation management within the mine difficult.[16]

47. Changes had been made to the original mine design resulting in the main ventilation fan being located underground. This was a world first and a decision the Royal Commission found to have been inadequately risk assessed and not appropriately reviewed, even though a ventilation consultant and staff had voiced opposition at the time of installation.[17]

48. At the time of the first explosion, the main ventilation fan failed (it was not explosion protected). The back-up fan (at the top of the ventilation shaft) was also damaged and did not start automatically. This meant the ventilation system shut down and did nothing to assist management of the toxic atmosphere existing in the mine.[18]

49. A natural ventilation circuit was created after the explosion by fresh air travelling up the drift and being expelled out of the ventilation shaft. It was this natural ventilation that contributed to the survival of the two men in the drift.[19] However, it would have done little to the toxic atmosphere within the mine workings located beyond the ventilation shaft following the explosion.

50. The men carried 30 minute duration self-rescuers and were trained to self-rescue after an emergency by walking or driving out of the mine. The mine also contained fresh air bases (FABs). These are areas intended to maintain a respirable atmosphere during emergency and would have held survival gear.[20]

51. The Royal Commission found the FAB closest to the drift from inside the mine workings was a "FAB in name only." [21] It could not effectively be sealed, there was no assurance that fresh air would have actually flowed down to it, and it was unsuitable to allow someone to don a fresh self-rescuer.

Remote exploration of the mine following the explosion

52. Small, discrete areas of the mine have been explored by cameras and survey equipment that was lowered down existing drillholes after the explosion.

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[16] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 18 at paragraph 48.
[17] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at page 19.
[18] Royal Commission on the Pike River Coal Mine Tragedy *Volume 1* (2012) at page 19.
[19] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) at paragraph 47.
[20] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 16 at paragraph 118 and 127.
[21] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) Chapter 16 at paragraph 133.

53. Robots were also sent into the drift but could not get around the mining vehicle at the 1600m mark. An area outbye[22] of the rockfall has also been investigated by camera and downhole scanning survey equipment.

54. All except 400m of the drift has been explored using these methods (refer to the map in **Annex 3**). This remaining unexplored area does contain key infrastructure (the pit bottom in stone area contained pumping and electrical switch gear as well as vehicle fuelling infrastructure) and there is a conveyor belt that ran along the drift to the portal.

55. Pit bottom in stone is located off the drift within this 400m. Examination of infrastructure located in this area could assist in confirming whether the potential ignition source was electrical equipment within the mine workings.

56. Areas of the mine workings themselves have also been explored by camera. However, coverage of the camera survey is limited by the location of existing drillholes and image quality is poor.

57. This downhole survey work includes images of the FAB closest to the drift. One image of this area that was taken after the first explosion showed the open lid of a box containing self-rescuers. That someone survived the explosion to open the box is one possible explanation – it could also have been left open prior or blown open during the explosion. The Royal Commission considered someone surviving to open the lid was speculative and insufficient to alter the Chief Coroner’s findings that the men died at the time of the explosion or shortly thereafter.[23]

58. It was an image of this FAB area media reported in early 2017 had not previously been seen by the Pike River Families and where some consider human remains can be seen. As part of the Royal Commission, expert analysis of this image determined it is consistent with the shape of an upper torso but not a complete body and that it could possibly be debris.[24]

59. A further image following the subsequent explosions showed a substantial rock fall now in this area that obscures any further remote analysis.[25]

60. Human remains in the mine workings have been confirmed by remote imaging near the hydro-monitor panel.[26] This is the expected location of the three man hydro-monitor crew and supports the estimated locations of the men at the time of the explosion that places them in various locations across approximately 3.5km of the mine workings.

Solid Energy currently controls the mine but will liquidate in March 2018

61. Solid Energy took over control of the mine in 2012. It agreed with the Government that, in developing options for the commercial re-opening of the mine, it would consider whether

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[22] The direction away from the coal face from any point of reference. A glossary of key terms is contained in **Annex 1**.
[23] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) chapter 16 at paragraph 182 and 183.
[24] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) chapter 16 at paragraph 180.
[25] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) chapter 16 at paragraph 176.
[26] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) chapter 14 at paragraph 15.

body recovery could be achieved in a safe, technically feasible and financially credible manner.[27]

62. Following a detailed risk assessment process, Solid Energy announced its decision in November 2014 that manned re-entry of the drift and mine would not be undertaken. The Board considered risk to life remained too high and did not have confidence any re-entry plan could adequately protect the lives of those re-entering.

63. Focus then moved to the safe, permanent sealing of the mine. This was not completed as in February 2017 the Government, after meeting with representatives of the Pike River Families, asked Solid Energy to pause this work and develop and implement a plan for unmanned exploration of the drift.

64. Unmanned exploration is aimed at establishing (to a reasonable degree of certainty) whether the remains of any deceased miners are present in the drift; provide any information on the cause of the initial explosion; and provide insights that could improve future mine safety.

65. There is currently a total of $2m appropriated in Vote Conservation to fund unmanned exploration of the drift.

66. Solid Energy's unmanned exploration project currently has two stages:

- **Unmanned exploration of the drift** (stage 1): This is planned and focuses on exploring the 400m of the drift not yet accessed, to establish whether human remains are present.

- **Unmanned exploration of the mine workings** (stage 2): This is not yet planned but could focus activity towards key areas of the mine workings, with the aim of providing information on the cause of the initial explosion.

67. Solid Energy will enter into liquidation in March 2018. As far as possible operations will shut down by 15 December 2017. Solid Energy will continue to maintain and monitor safety systems at the mine and run the unmanned exploration project until it enters liquidation unless otherwise agreed with the Crown.

68. Following liquidation the responsibility for mine safety activities, and ultimately permanent sealing of the mine and site rehabilitation, will fall to the Department of Conservation should no other arrangements have been made.

69. Solid Energy has agreed to pay the Crown any additional costs for work that is not covered by the Crown indemnities that are funded by an appropriation administered by Treasury.

Unmanned exploration of the drift

70. Solid Energy has undertaken risk assessment of, and has a plan for, unmanned re-entry of the 400m of unexplored drift. Controls are proposed to be implemented to reduce the risks to a level that are acceptable to Solid Energy.

[27] Deed relating to Body Recovery at the Pike River Coal Mine dated 17 July 2012.

71. The plan requires at least one drillhole (more will possibly be needed) to be drilled from the surface to intersect the drift. A specialist robot with a camera would then be lowered approximately 150m to the drift floor.

72. Images would be transmitted back along the robot's tether cable. It is anticipated that the imaging captured will be of better quality than any obtained to date. The robot is also likely to have greater range of vision from the drift floor than through previous methods.

73. Delivery of the robot was expected by early December 2017 but the supplier has now advised Solid Energy this will not be possible. A 12-16 week timeframe from final order to delivery has been provided by the supplier.

74. Preparation for the initial drillhole has begun but drilling has not yet commenced. Drilling can be started and undertaken concurrently with construction and delivery of the robot. Solid Energy estimates that it would take two months to complete the initial drillhole.

There are risks and limitations with unmanned exploration of the drift

75. There are risks and limitations with unmanned exploration of the drift, including:

- ignition of gas within or around the drillholes – this poses risks to the safety of workers but measures are planned that will control and reduce these risks to what Solid Energy considered to be an acceptable level
- ingress of oxygen into the mine environment – this could change the atmosphere in the mine to reach the explosive range and risk further explosions
- the construction of drill platforms and the conducting of the drilling and robot operation in remote, mountainous country with only helicopter support poses risks in its own right.
- the robot's operating range (which is still to be confirmed with the supplier) – shorter distances may mean multiple drillholes are needed to traverse the whole 400m. Multiple deployments and retrievals will increase the risk of malfunction or that the robot is unable to be retrieved from the drift
- the robot's operation could be obstructed by debris – this increases the number of drillholes that would be needed and subsequently the number of times the robot is deployed and retrieved.

76. Solid Energy is currently seeking some exemptions from the mining regulations. These relate to the non-standard nature of the specialist robot (which is a potential ignition source). These are currently being processed by WorkSafe New Zealand. Solid Energy considers the robot safe for the environment but the regulations do not contemplate this type of scenario or activity. Decisions on any exemptions are expected shortly.

What information would unmanned exploration provide about the drift?

77. As previously noted, the Royal Commission concluded most of the men would have been killed by the initial explosion. Those that survived would have been rendered unconscious and succumbed to noxious gases or the lack of oxygen within minutes. Had someone managed to survive the first explosion, the self-rescuer they would have had with them would have lasted only 30 minutes after they came to and donned it. As previously noted, the FAB closest to the drift was considered by the Royal Commission to be unsuitable to don a new self-rescuer.

78. There is potential that while the rockfall currently impedes access, it may not have fallen immediately after the first explosion and an individual could possibly have navigated around it. Any survivor would then have had to travel an additional 60m for their remains to be located within the 400m of unexplored drift.

79. It also cannot be ruled out that men may have been in the drift at the time of the initial explosion.

80. Unmanned exploration of this 400m area of the drift would determine whether human remains are present. Additionally it, and potentially reassessment of other areas of the drift, might provide some useful information on the state of this area of the drift (such as location of any rock fall or blockages that would further impede safe, manned re-entry of the drift).

81. This information may also inform and enable better planning to be undertaken for any safe, manned re-entry. It could also provide some ability to:

- better examine the location for any proposed seal for atmospheric control in any future safe, manned re-entry of the drift
- provide readings on the current mine atmosphere, as the robot is proposed to be fitted with gas sensors
- investigate infrastructure in the pit bottom in stone area located off the drift. This area contains electrical infrastructure that is similar to that located within the mine workings. If indications of malfunction can be located on this infrastructure, it would lend weight to the potential ignition source being electrical equipment within the mine workings.

82. Discussions with Solid Energy suggest it is unlikely unmanned exploration of the drift will provide any essential information relating to the condition and stability of the roof. This cannot be visually determined through this method of exploration and the roof is likely to be obstructed by original supports or covered in shotcrete. This means unmanned exploration is unlikely to provide any additional information to assist in planning for unstable roof conditions.

The estimated cost of unmanned exploration of the unexplored 400m of the drift

83. Of the current $2m appropriated to fund unmanned exploration of the drift, Solid Energy has spent approximately $0.35m on the risk assessment process, geotechnical assessment of possible drillhole sites, development work on the robot, drill pipe and staff time.

84. Solid Energy's budget for the anticipated remaining expenditure estimates the total cost of unmanned exploration of the 400m of unexplored drift at $1.9m (without any contingency). Approximates of the major remaining costs are the:

- specialist robot = $565,000
- construction of the drillpad, establishing the drill rig and drilling the initial drillhole = $655,000
- additional drillholes as needed = estimated between $200,000 and $600,000 per drillhole (if drilled from the same drillpad)
- operation of the robot by technical personnel, communications, helicopter activity and image processing = $130,000.

Unmanned exploration of the mine workings

85. No plan or full risk assessment has yet been prepared for Stage 2 of the unmanned exploration project. However, it is anticipated a similar process to unmanned exploration of the drift (using drill holes and lowering the robot into the mine) could be used to examine selected areas of the mine workings.

86. Similar risks and potential limitations as those associated with unmanned exploration of the drift would exist. However, a full risk assessment of extending unmanned exploration into the mine workings would be needed. This would identify any additional risks and limitations and inform the control measures that would need to be put in place.

What further information would unmanned exploration of the mine workings provide?

87. Unmanned exploration of the mine workings could allow for examination into the cause of the explosion by examining the:

- **goaf** to see if a large roof fall did occur. The Royal Commission determined this was the likely source of the large quantities of methane gas released into the mine atmosphere. Conditions in the mine, such as roof collapse, would mean multiple holes may be required to locate an appropriate area to deploy the robot.
- **most likely ignition source**. While unable to be exactly determined, it is considered likely this could have been an electrical cause related to the timing of the re-activation of the hydro-monitor pumps seconds before the disaster. A minimum of two drillholes would likely be required to investigate the monitor pumps, monitor electrical equipment and monitor transformers.

88. Other key locations could also be targeted for unmanned exploration that could provide further information about other potential ignition sources; the conditions in the mine (eg, gas readings, areas where flooding has occurred, locations of obstructions in the mine workings); and location of the remains of the men.

The estimated cost of the unmanned exploration project to the mine workings

89. As no plan or formal risk assessment has been completed, costings can only be estimated. Excluding the cost of the robot, it is estimated to cost between $200,000 and $600,000 per drillhole. Based on minimum exploration of the goaf and anticipated ignition source, this would mean an additional $0.6m on top of the existing $1.9m estimated for the limited activity in the 400m of unexplored drift.

90. At a minimum, the total cost of stage 1 and 2 of the unmanned exploration project is estimated to be between $3m-$6m (up to $4m more than in the existing appropriation).

Manned re-entry of the drift

91. Solid Energy considered three possible methods for manned re-entry of the drift:

Method 1: Staged re-entry

This involved the purging of methane in the drift and replacing it with nitrogen. Workers in breathing apparatus would reclaim the drift by way of using temporary seals. They would advance 100m at a time, erecting and removing temporary seals as they went along. This proposal was rejected by Solid Energy as it required people to work in an irrespirable atmosphere. Additional mine machinery needed to enable inspection of the stability of the roof would not be able to be taken through the temporary seals.

Method 2: Remote permanent seal

This involved using Rocsil or another product to create a dam, then pouring concrete through a drillhole to create a permanent seal at the end of the drift. Atmospheric conditions in the drift could then be controlled. This proposal was rejected by Solid Energy as the permanent seal would be classified as an un-engineered dam. Gas and the water produced in the mine (the latter at a rate of four litres per second) would not be able to be managed, creating a risk of water inundation into the drift if the permanent seal failed.

Method 3: Nitrogen Injection behind a Rocsil plug (temporary seal)

This involves using Rocsil or a similar product to create a plug outbye of the rockfall and injecting nitrogen into the area whilst the entire drift is ventilated by fresh air. A permanent seal permitting water drainage would then be created.

92. Method 3: Nitrogen Injection behind a Rocsil plug was Solid Energy's preferred method and the one risk assessed by the Solid Energy Steering Committee.

93. Key risks with all three methods identified by Solid Energy included:

- injury of death from a strata failure (eg, roof fall)
- asphyxiation or explosion due to loss of control of the atmosphere within the drift (which could occur a number of ways, including being unable to ventilate following a mine equipment fire)
- injury or entrapment due to failure of one of over 600 controls Solid Energy identified would need to be implemented
- entrapment and inability to rapidly recover workers from a strata failure or equipment fire.

94. Entrapment following a roof or wall collapse was identified in Solid Energy's third-party report as the most significant risk to manned re-entry of the drift. As there is no second egress, should collapse occur leading to entrapment it may take considerable time to clear and remediate the rock fall or bypass it to access the trapped workers.

95. The existing drillholes available to supply fresh air and provisions to entrapped workers are located inbye of the Hawera Fault. This is an area of the drift known to have inadequate roof supports. This could prevent air flow and the supply of provisions to the entrapped workers whilst any rockfall was cleared away.

96. The third-party risk report reviewed the 243 hazards and 586 proposed controls identified, identifying a need to be able to prevent such events as:

- ignition of flammable gas
- a fire on mobile plant
- injury from a roof or wall collapse
- an inrush of water from an accumulated water source within the mine workings
- the drift being filled by an irrespirable atmosphere
- re-ignition of gas caused by a spontaneous combustion event (eg, smouldering coal within the mine, or use of equipment in the drift)
- adverse health effects to workers from minor carcinogenic gasses from the coal fire, bacterial and fungal material in atmosphere and water
- injury to workers using mobile equipment inside the confined space in the drift and when carrying out activities above ground.

97. There are a number of known issues and information gaps about the original construction of the mine that informed Solid Energy and its third-party assessments, including:

- the suitability of the construction of the original roof cannot be adequately ascertained.
- areas of roof and wall supports are expected to be of sub-standard structural integrity.
- there are obstructions to determining the condition of the existing supports.

The Pike River Families' plan for manned re-entry of the drift

98. Experts for the Pike River Families have prepared and submitted three reports to the Board of Solid Energy. Submitted in November 2012, October 2014 and September 2016, all three reports are high level documents outlining proposed recovery procedures. They do not fully risk assess or cost the proposals.

99. The 2012 report is based on an assessment, by the Pike River Families' experts, of the three possible methods of manned re-entry of the drift identified by Solid Energy. It recommended Method 1 – undertaking staged recovery through the use of temporary seals to recover the drift a section at a time.

100. The October 2014 report agreed that Solid Energy's proposal for manned re-entry of the drift (Method 3 – creating a permanent seal at the end of the drift to enable atmospheric control of the drift) was a more feasible option as it reduced the need for the bulk of the work to be conducted in an irrespirable atmosphere.

101. The Pike River Families' experts disagreed with the Board of Solid Energy that the residual risks in relation to strata failure, asphyxiation, entrapment, explosion and spontaneous combustion could not adequately be mitigated with standard mining procedures and a team of highly skilled miners.

102. The 2016 report withdrew the Pike River Families' prior approval to permanent sealing of the mine. This was because Solid Energy had successfully re-ventilated approximately 10m of the drift inbye of the portal seal located at 170m (as part of the work required to permanently seal the mine). The Pike River Families therefore considered there was potential to do this for the entire drift. As previously noted, the 180m area from the portal has been re-entered for safety monitoring purposes and management of the risk of flooding or debris building up around the seal.

103. The Pike River Families' experts considered that the drift could be re-ventilated (without the need for workers to go underground during the process) by flooding the mine with nitrogen and then ventilating the drift with fresh air from the portal.

104. This proposal does not include the installation of a remote seal to assist in atmosphere control, but relies on injection of nitrogen and the buoyancy of methane to vent it out of existing drillholes. Solid Energy did not consider that this method would provide for a barrier to the risks from the atmosphere in the mine workings until a permanent seal is created.

105. In February 2017 the Commerce Select Committee heard evidence on the petition of Dame Fiona Kidman which requested permanent sealing of the Pike River Mine stop, and the remains of the 29 men brought home if humanly possible.

106. As part of the submission and evidence heard by the Committee, Tony Forster (a former New Zealand chief mines inspector) presented a "hybrid" plan on behalf of the Pike River Families for manned re-entry of the drift. This plan was similar to that outlined in the 2016 report and is considered by Mr Forster to be safe and technically feasible.

107. The "hybrid" plan's starting basis is that the coal (which was on fire within the mine workings) has cooled and no other ignition sources now exist within the mine workings. The plan involves filling the drift and mine workings with nitrogen before re-ventilating with fresh air. This operates on the density differences, and therefore buoyancy, of methane and nitrogen in relation to fresh air to ensure the potentially noxious atmosphere within the mine workings does not flood the drift and to prevent oxygen from entering the mine workings.

108. This would occur prior to any manned re-entry by Mines Rescue staff trained in "fresh-air" degassing techniques. Mines Rescue would reinforce any damaged sections of the drift using steel arch supports as the drift was recovered.

Initial estimates on cost required for any safe, manned re-entry of the drift

109. The funding required to implement any safe re-entry plan is highly uncertain. It would depend on the plan itself, including the nature and extent of any control measures necessary to ensure safety of those re-entering the mine.

110. However, costings in 2014 by Solid Energy were estimated at $7.2m. It is likely to cost more than this and an initial estimate for assessing and undertaking safe, manned re-entry of the drift may be upward of $10m.

Manned re-entry of the mine

111. Emeritus professor Galvin (from the University of New South Wales) provided advice to Solid Energy on the risks associated with, and likelihood of, body recovery.

112. Professor Galvin considered there were substantial risks involved in re-entry of the mine workings, as opposed to the drift. These included:

- drowning, if water has accumulated in the mine
- explosion, if air enters the workings and hot spots exist

- fire from spontaneous combustion.
- roof fall owing to the absence of strata maintenance
- exposure to carcinogens (products from underground coal fires), fungi and bacteria that can flourish in an unventilated mine environment
- there would likely to be a need to clear rock falls within the mine using mining machinery in an irrespirable atmosphere. Working in these conditions, wearing breathing apparatus, was considered to be particularly hazardous.

113. The Royal Commission noted Professor Jim Galvin's conclusion that it was 'extremely unlikely' the risks could be managed 'irrespective of the level of expenditure.' [28]

Legal action taken over the tragedy

114. In November 2011, following investigations into the disaster, the Department of Labour (then the work health and safety regulator) commenced prosecutions against Pike River Coal Ltd (in receivership), VRI Drilling Ltd and Mr Whittall.

115. Pike River Coal Ltd and VRI Drilling Ltd where both convicted and sentenced for breaches of work health and safety legislation. No charges under the Crimes Act were laid by Police.

116. Mr Whittall pleaded not guilty to all charges brought against him.

117. During the criminal disclosure and briefing process, Mr Whittall offered to pay the reparations ordered against Pike River Coal Ltd ($3.4m) if the prosecution was discontinued against him.

118. After a review of the charges, the prosecutor concluded that the evidential sufficiency test was met, but there were a number of difficulties with the case. It was concluded it was not in the public interest to continue with the prosecution. A number of factors were taken into account in making this determination, including the proposed payment in the nature of reparations if the prosecution did not proceed.

119. Two members of the Pike River Families sought a judicial review of this decision, alleging the decision not to offer evidence against Mr Whittall was an unlawful bargain to stifle the prosecution by the payment of money.

120. They were unsuccessful before the High Court and Court of Appeal. Neither Court found that any such unlawful bargain existed. This was then appealed to the Supreme Court.

121. The matter was heard by the Supreme Court on 5 October 2017 and a decision is pending on whether to grant a declaration that the decision not to prosecute Mr Whittall was unlawful.

[28] Royal Commission on the Pike River Coal Mine Tragedy *Volume 2* (2012) chapter 16 at paragraph 201.

Working with the Pike River Families

122. The following provides information on how the Pike River Families are organised; the way government has previously worked with them; and identifies those family members who play prominent roles within the group.

How the families are organised

123. The families group is large and diverse. Early on they recognised that organising themselves as much as possible into a united front, was critical to achieving progress on issues of importance to them.

124. While this approach has been effective, it is important to bear in mind that there are some family members who do not agree with positions taken on issues such as re-entry of the mine.

125. As such Bernie Monk, and other family members, are careful to clarify that they are speaking for some of the families.

126. The primary way the families have organised themselves is through the Pike River Families Group. This group meets monthly with an open invitation for all family members to attend. The group is chaired by Colin Smith, with Bernie Monk as spokesperson.

127. It is this meeting that Ministers and government agencies have generally utilised to meet and engage with the families.

128. More recently a sub-group of the families, under the banner 'Stand with Pike', have led the 2016 protests at the mine and the campaign for re-entry. This sub-group has primarily been led by Anna Osborne, Sonia Rockhouse and Bernie Monk.

129. The 'Stand with Pike' campaign is endorsed by the wider Pike River Families Group and has broad, but not universal support, from family members.

130. The Pike River Families Group has generally been an effective organisation. They have well developed mechanisms for communication within the families group as a whole and have been effective to deal with in progressing specific issues. This includes work on the design of the Paparoa Great Walk and the current process around the design of the memorial at the mine site.

Communication with the Families

131. In 2012 the families requested a single liaison point with government who could act as a channel for their issues and help progress issues more effectively. This reflected the families view that there too many government agencies to work with; inconsistent views within and between agencies; and a kaleidoscope of changing faces.

132. Since December 2012, this liaison role has been carried out by Bruce Parkes, a Deputy Director-General in the Department of Conservation. Bruce is currently leading MBIE's Pike River Establishment Unit.

133. For the last 4 ½ years there has been a fortnightly audio-conference with a subgroup of the Pike River Families group. This has involved DOC and Solid Energy and on occasion other government agencies (such as Worksafe). The audio-conferences focuses on ensuring the families are regularly updated on what is happening at the mine and progress with the Great Walk.

134. Previous Ministers have met regularly with the families in Greymouth. These meetings have been organised by the Pike River Families Group and are well attended by family members, both in person and by tele-conference. This has provided an effective way to communicate with the families.

Prominent Pike River family members

135. Some of the more prominent family members are:

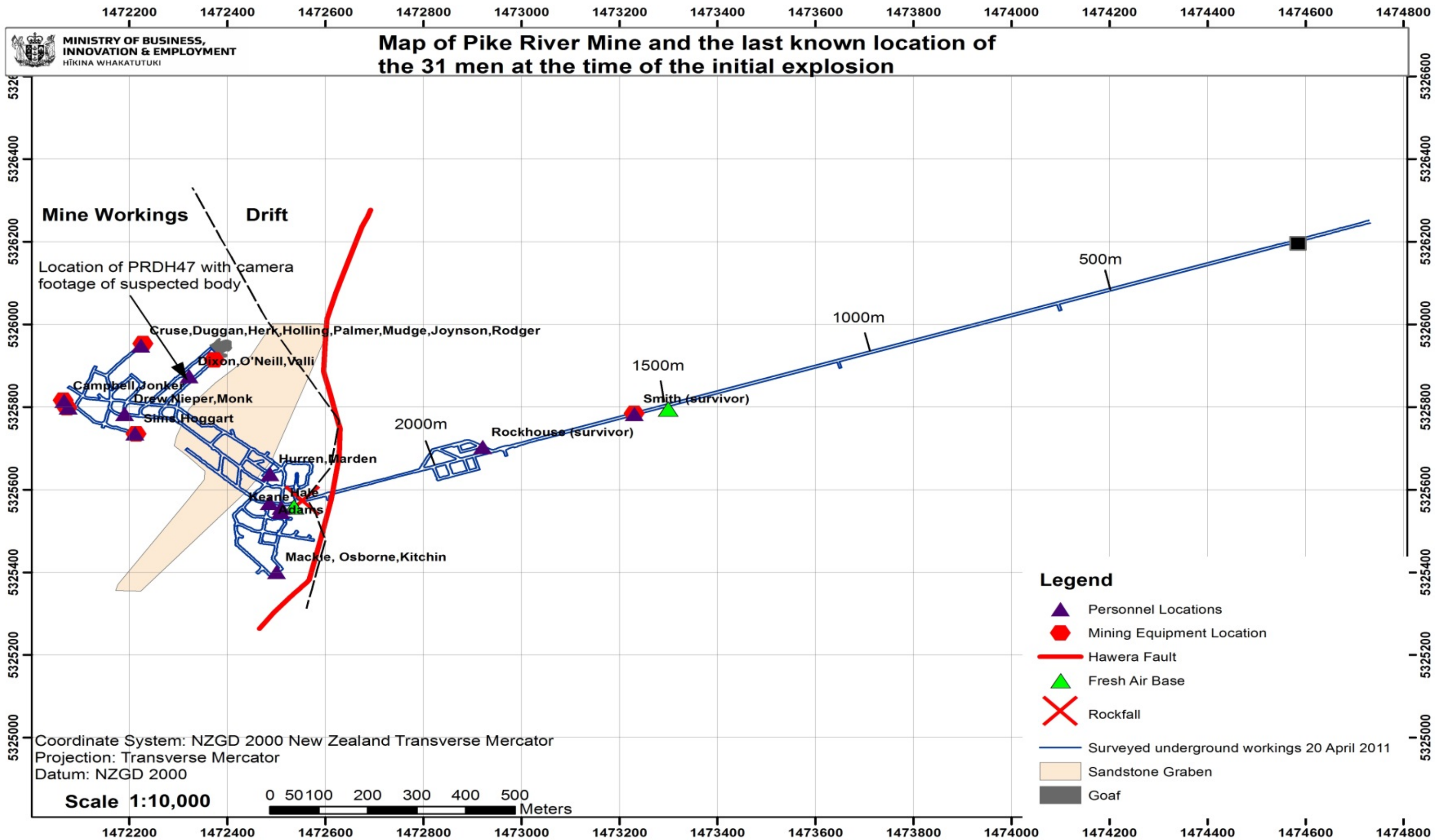
Colin Smith	Colin is the Chair of the Pike River Families Group. He is a well-respected local lawyer and Bernie Monk's brother-in-law. His nephew, Michael Monk, was killed in the tragedy.
Bernie and Cath Monk	Bernie and Cath's son Michael was killed in the mine. He was aged 23 at the time. The family run a local pub and hotel business. Bernie has been the highly visible families' spokesperson from the early days after the tragedy.
Carol Rose	Carol's son Stu was killed in the mine. He was 31 at the time. Carol is the secretary of the families group and is central to the smooth running of the group, particularly around communication.
Anna Osborne	Anna's husband Milton was killed in the tragedy. Milton was 54 at the time. Anna has been a very visible presence in the media commenting on Pike River matters. Anna, along with Sonya Rockhouse have been central in the campaign for manned re-entry of the drift and in the Supreme Court case appeal on the decision not to pursue charges against Peter Whittall.
Sonya Rockhouse	Sonya had two sons in the mine at the time of the first explosion. Ben Rockhouse, aged 21, was killed in the tragedy. Daniel Rockhouse was one of the two survivors and he assisted with the rescue of Russell Smith the second survivor. Sonya, along with Anna Osborne, have been prominent in the campaign for manned re-entry and the Supreme Court proceedings.

136. Colin, Bernie and Carol received MNZMs in the 2016 New Year's Honours reflecting their service to the Pike River Families.

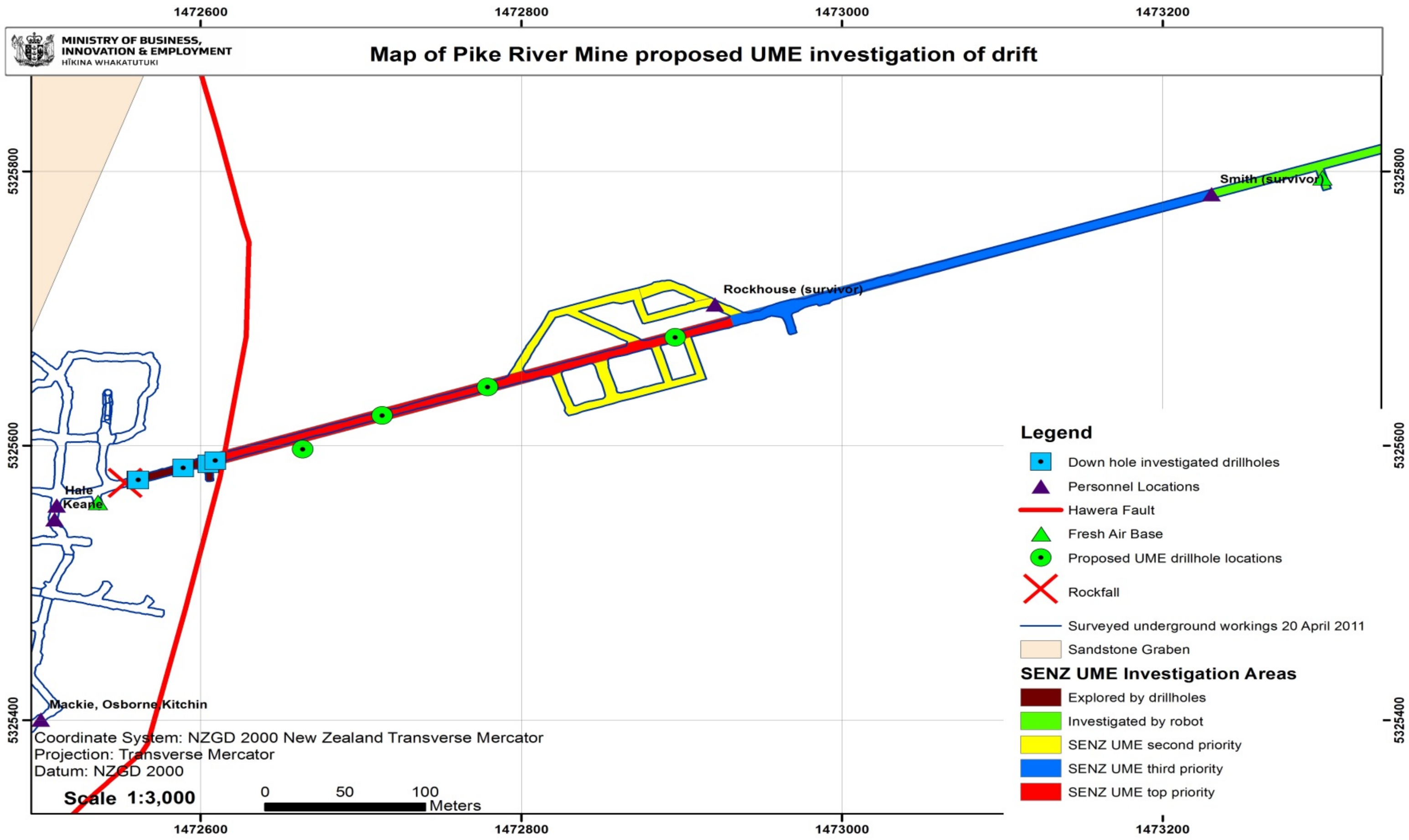
Annex 1: Glossary

Term	Definition
Drift	The 2.3km of access tunnel from the portal to the large rockfall.
Goaf	The void created by coal extraction that is usually unsupported and susceptible to roof collapse
Inbye	The direction towards the coal face from any point of reference.
Mine workings	Everything behind the rockfall at the end of the drift, and that contains approximately 5.5 km of tunnels.
Portal	The entrance to the mine at the beginning of the drift.
Outbye	The direction away from the coal face from any point of reference.

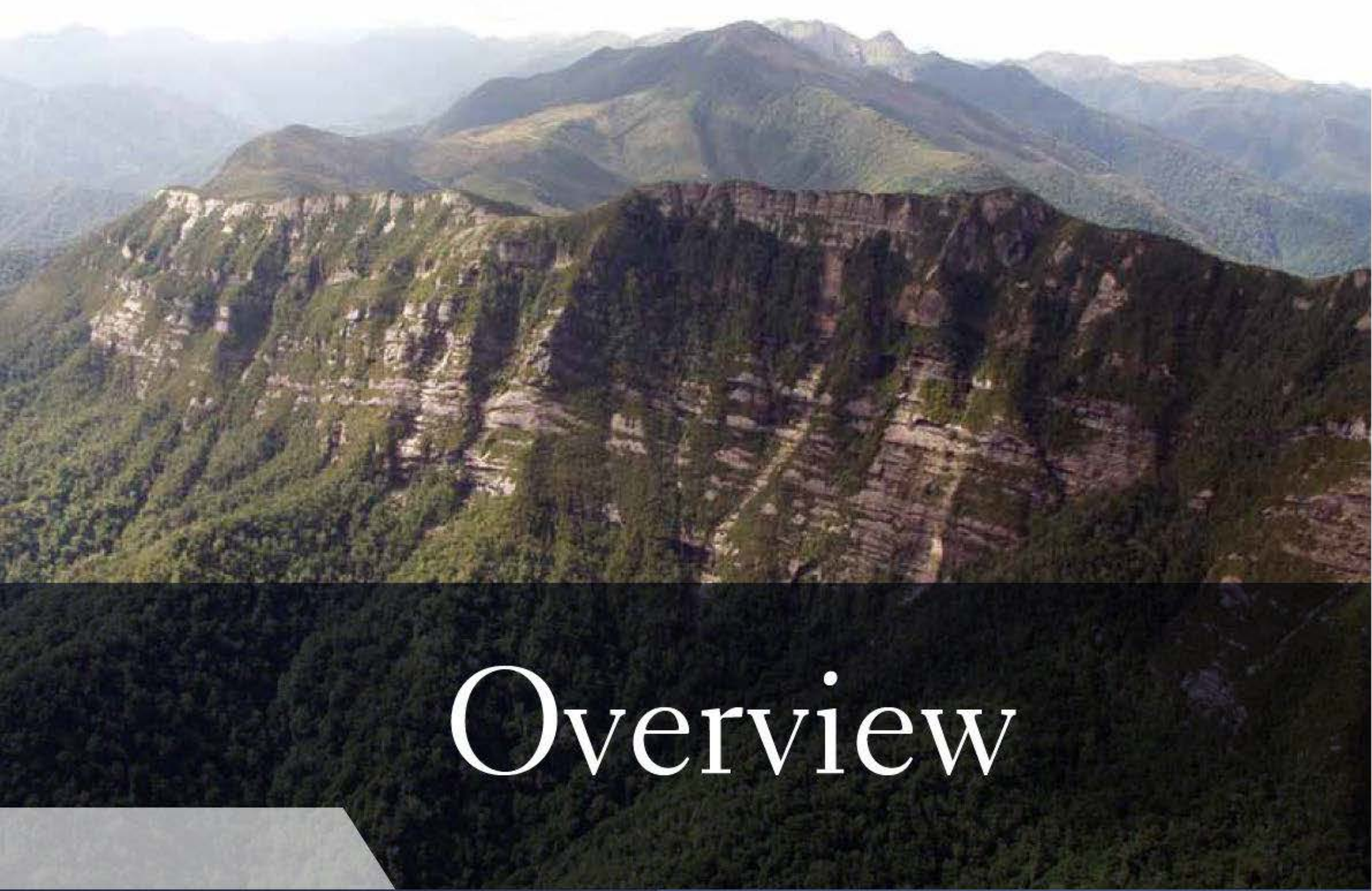
Annex 2: Map of Pike River Mine and the last known locations of the 31 men



Annex 3: Map of Pike River Mine proposed UME investigation of drift



Annex 4: Royal Commission on the Pike River Coal Mine Tragedy (Overview, parts 1-2)



Overview

This overview is in three parts.

First there is a snapshot of the report, identifying some main points. The second part, which is essentially factual, sets out the commission's views on what happened at Pike River and why. The third part takes a broader view, identifying the lessons learnt from the tragedy and the significant changes required to avoid future tragedies. Recommendations are then made.

Readers requiring more detail should consult the main report (Volume 2).

Snapshot

The Pike River underground coal mine lies high in the rugged Paparoa Range on the West Coast of the South Island. Access to the mine workings was through a single 2.3km stone drift, or tunnel, which ran upwards through complex geological faulting to intersect the Brunner coal seam.

On Friday 19 November 2010, at 3:45pm, the mine exploded. Twenty-nine men underground died immediately, or shortly afterwards, from the blast or from the toxic atmosphere. Two men in the stone drift, some distance from the mine workings, managed to escape.

Over the next nine days the mine exploded three more times before it was sealed. There is currently no access to the mine.

The commission is satisfied that the immediate cause of the first explosion was the ignition of a substantial volume of methane gas. The commission's report identifies a number of possible explanations for the source of that accumulation of methane, and the circumstances in which it was ignited.

Methane gas, which is found naturally in coal, is explosive when it comprises 5 to 15% in volume of air. In that range it is easily ignited. Methane control is therefore a crucial requirement in all underground coal mines. Control is maintained by effective ventilation, draining methane from the coal seam before mining if necessary, and by constant monitoring of the mine's atmosphere.

The mine was new and the owner, Pike River Coal Ltd (Pike), had not completed the systems and infrastructure necessary to safely produce coal. Its health and safety systems were inadequate. Pike's ventilation and methane drainage systems could not cope with everything the company was trying to do: driving roadways through coal, drilling ahead into the coal seam and extracting coal by hydro mining, a method known to produce large quantities of methane.

There were numerous warnings of a potential catastrophe at Pike River. One source of these was the reports made by the underground deputies and workers. For months they had reported incidents of excess methane (and many other health and safety problems). In the last 48 days before the explosion there were 21 reports of methane levels reaching explosive volumes, and 27 reports of lesser, but potentially dangerous, volumes. The reports of excess methane continued up to the very morning of the tragedy. The warnings were not heeded.

The drive for coal production before the mine was ready created the circumstances within which the tragedy occurred.

A drive for production is a normal feature of coal mining but Pike was in a particularly difficult situation. It had only one mine, which was its sole source of revenue. The company was continuing to borrow to keep operations going. Development of the mine had been difficult from the start and the company's original prediction that it would produce more than a million tonnes of coal a year by 2008 had proved illusory. The company had shipped only 42,000 tonnes of coal in total. It was having some success in extracting coal as it drove roadways but it was pinning its hopes on hydro mining as the main production method and revenue earner. Hydro mining started in September 2010 but was proving difficult to manage and output was poor.

It is the commission's view that even though the company was operating in a known high-hazard industry, the board of directors did not ensure that health and safety was being properly managed and the executive managers did not properly assess the health and safety risks that the workers were facing. In the drive towards coal production the directors and executive managers paid insufficient attention to health and safety and exposed the company's workers to unacceptable risks. Mining should have stopped until the risks could be properly managed.

The Department of Labour did not have the focus, capacity or strategies to ensure that Pike was meeting its legal responsibilities under health and safety laws. The department assumed that Pike was complying with the law, even though there was ample evidence to the contrary. The department should have prohibited Pike from operating the mine until its health and safety systems were adequate.

After the explosion a major search and rescue effort was launched. There was no predictable window of opportunity within which the Mines Rescue Service (MRS) could have safely entered the mine. Pike had no system for sampling the mine atmosphere after an explosion and without that information it was impossible to assess the risks of entry. The placement of the main fan underground and the damage caused to the back-up fan on the surface meant that the mine could not be reventilated quickly.

The New Zealand Police led the emergency response and made the major decisions in Wellington. There had been no combined testing of an emergency response of this nature involving Pike, mining specialists, the MRS, the police and emergency services.

For the first few days the families were given an over optimistic view of their men's chances of survival, but this was inadvertent. When the second explosion occurred five days later any remaining hope disappeared.

The new owner of the mine, Solid Energy New Zealand Ltd, has agreed that it will take all reasonable steps to recover the bodies provided this 'can be achieved safely, is technically feasible and is financially credible'.[1] Any recovery will hinge on a resumption of commercial mining operations.

The mine is sealed and its atmosphere is inert. Solid Energy is ensuring the safety of the mine, including physical security, monitoring of the underground atmosphere, checking of seals and contingency planning.

New Zealand has a poor health and safety record compared with other advanced countries. The government has set up an independent ministerial task force to determine if New Zealand's health and safety system is fit for purpose. The task force will no doubt examine on a broader scale some of the matters that the commission has considered.

To reduce the risks of future tragedies, the commission makes 16 principal recommendations, set out at the end of this volume. Some recommendations have implications beyond the underground coal mining industry.

The commission recommends that there should be a new regulator with a sole focus on health and safety. The new regulator should be a Crown entity with an expert board accountable to the minister and working closely with the Ministry of Business, Innovation and Employment, employers and workers.

Based on the commission's inquiries, the Health and Safety in Employment Act 1992 is generally fit for purpose but many changes are required to update the mining regulations. The commission recommends that the changes be progressed by an expert mining task force separate from the ministerial task force. The Queensland and New South Wales regulations provide good precedents.

More worker participation in managing health and safety is needed and will require legislative change and guidance from the regulator.

Major improvements to emergency management are required. The first step should be a joint review by the organisations that responded at Pike River, then amendments to the co-ordinated incident management system and finally a programme of testing and simulation of emergencies to iron out any problems.

The statutory responsibilities of directors for health and safety should be reviewed to reflect their governance responsibilities, including their responsibility to hold management to account.

Leaving aside regulatory change, the commission recommends that directors should rigorously review their organisation's compliance with health and safety laws and assure themselves that risks are being properly managed. Managers should access the best practice guidance available on leading health and safety in the workplace.

The changes recommended by the commission rest firmly on the principle that health and safety in New Zealand can be improved only by the combined efforts of government, employers and workers.

What Happened at Pike River

The tragedy

On Friday 19 November 2010 at 3:45pm there was an underground explosion at the Pike River coal mine. Twenty-nine men lost their lives, and their bodies have not been recovered. Their names and details appear on pages 4-5.

Two men survived the explosion. They were in the stone access tunnel (drift), a distance from the pit bottom area where the main workplaces were located. Although initially overcome, Daniel Rockhouse rescued himself and his colleague Russell Smith.

The New Zealand Police led the emergency response that involved emergency services, and mines rescue crews from New Zealand, New South Wales and Queensland. Despite strenuous efforts by everyone involved, a lack of information concerning the conditions underground prevented a rescue attempt.

A second explosion on Wednesday 24 November extinguished any hope of the men's survival. The emergency focus changed to recovery of the bodies.

The commission

On 29 November 2010 the prime minister announced the government's intention to establish a royal commission. In December 2010 the commission's terms of reference and the appointment of three commissioners, the Hon. Graham Panckhurst, David Henry CNZM, and Stewart Bell PSM, the Commissioner of Mine Safety and Health for Queensland, were announced. The terms of reference are on pages 6-9. In broad terms the commission was required to report on:

- the cause of the explosions and the loss of life;
- why the tragedy at Pike River occurred;
- the effectiveness of the search, rescue and recovery operation;
- the adequacy of New Zealand mining law and practice and the effectiveness of its administration; and
- how New Zealand mining, and associated conservation and environmental, law and practice and its administration compares with that in other countries.

The commission was also asked to make recommendations about the prevention of mine disasters, the improvement of search, rescue and recovery operations, any necessary changes to mining law and practice and how to make the Pike River mine safe should it not be reopened.

The immediate cause

The immediate cause of the tragedy was a large methane explosion. Methane is found naturally in coal. It is released during mining and also accumulates in mined out areas. A group of mining experts assembled by the police and the Department of Labour (DOL) concluded that a substantial volume of methane fuelled the explosion. The area most likely to contain a large volume of methane was a void (goaf) formed during mining of the first coal extraction panel in the mine. A roof fall in the goaf could have expelled sufficient methane into the mine roadways to fuel a major explosion. It is also possible that methane which had accumulated in the working areas of the mine fuelled the explosion, or at least contributed to it.

Methane is explosive only when diluted to within the range of 5 to 15% in volume of air. Following a roof fall methane would be diluted as it was carried through the mine by the ventilation system. It is not possible to be definitive, but potential ignition sources include arcing in the mine electrical system, a diesel engine overheating, contraband taken into the mine, electric motors in the non-restricted part of the mine and frictional sparking caused by work activities.

Effective methane management is essential in an underground coal mine. Undoubtedly there was a failure to control methane at Pike River on 19 November 2010.

The underlying causes

The commission has endeavoured to establish both the operational factors and the systemic reasons that contributed to the tragedy. The inquiry was not limited to events at the mine, but extended to the actions of the regulators and the effectiveness of mining regulation and practice in New Zealand.

Some major themes became evident in the course of the inquiry:

- This was a process safety accident, being an unintended escape of methane followed by an explosion in the mine. It occurred during a drive to achieve coal production in a mine with leadership, operational systems and cultural problems.
- Such problems coincided with inadequate oversight of the mine by a health and safety regulator that lacked focus, resourcing and inspection capacity.
- The legal framework for health and safety in underground mining is deficient.
- Those involved in the search and rescue were very committed, but the operation suffered from an absence of advance planning for a coal mine emergency and from a failure to properly implement the principles of the New Zealand co-ordinated incident management system (CIMS).
- The families of the 29 men received generous community support, but would have benefited from better communications during the search, rescue and recovery phases.

The New Zealand mining industry

Background

Coal has been mined in New Zealand since about 1850. It was initially mined almost exclusively underground, but open cast mining is now predominant, producing over 80% of total production. New Zealand mining conditions are typically complex and characterised by faulted and dipping coal seams. Comprehensive geological exploration is essential to define the coal reserve and facilitate the planning and development of a successful mine. Mining methods such as hydro mining, suited to the difficult conditions, are required.

The New Zealand coal mining industry is small. Annual production is about 5 million tonnes – approximately 2% of Australia's production. In 2010 fewer than 2000 people were working in 22 coal mines, only five of which were underground.

A failure to learn

New Zealand's health and safety record is inferior to that of other comparable countries. The rate of workplace fatalities is higher than in the United Kingdom, Australia and Canada, worse than the OECD average and has remained static in recent years.

New Zealand also has a history of underground coal mine tragedies including:

1879	Kaitangata mine	34 deaths
1896	Brunner mine	65 deaths
1914	Huntly, Ralph's colliery	43 deaths
1939	Huntly, Glen Afton No. 1 mine	11 deaths
1967	Strongman mine	19 deaths

Lessons from the past, learnt at the cost of lives, have not been retained.

Comparative analysis

The commission's terms of reference require it to compare New Zealand mining law and practice, its administration and implementation, and its interaction with other requirements to that in 'other countries'. New Zealand's most appropriate comparators are Queensland and New South Wales. These states mine 97% of Australia's coal production. The New Zealand industry has a close working relationship with the Queensland and New South Wales industries. There is a mining labour flow across the Tasman, and New Zealand operators consult Australian mining standards. These two states are frequently used for comparative analysis throughout the report.

The Pike River mine

Location of the mine

The mine is remote on the eastern side of the rugged Paparoa Range, 45km north-east of Greymouth. The coal seam lies deep below the surface and mainly within the Paparoa National Park. The seam dips in an easterly direction between a sheer escarpment to the west and the Hawera Fault to the east.

Conception

Pike River Coal Company Ltd (Pike) was formed in 1982 and acquired by New Zealand Oil & Gas Ltd (NZOG) in 1998. Over a 13-year period Pike explored and then acquired the necessary authorisations for the mine, including a mining permit, an access arrangement and resource consents. Initial exploration indicated a recoverable coal reserve of 19 million tonnes of high-quality hard coking coal.

In 2005 the Pike board decided to proceed with development of the mine. In May 2007 Pike offered shares in the company for public subscription and allotted 85 million one-dollar shares to over 5000 new investors. NZOG remained the major shareholder, but no longer held a controlling interest. Development costs were estimated at $124 million, with annual coal production of more than a million tonnes projected by 2008. Pike River was developed as an underground mine, because open cast mining was not economic owing to the depth of the Brunner coal seam.

Development

The construction of an access road began in September 2006, followed by a 2.3km tunnel (drift) driven through stone to access the eastern side of the coal seam. In November 2008 the mine was officially opened.

The coal seam was intersected to the west of the Hawera Fault and development of the pit bottom area began in early 2009. By November 2010 the extent of underground development was as shown in the mine plan below.

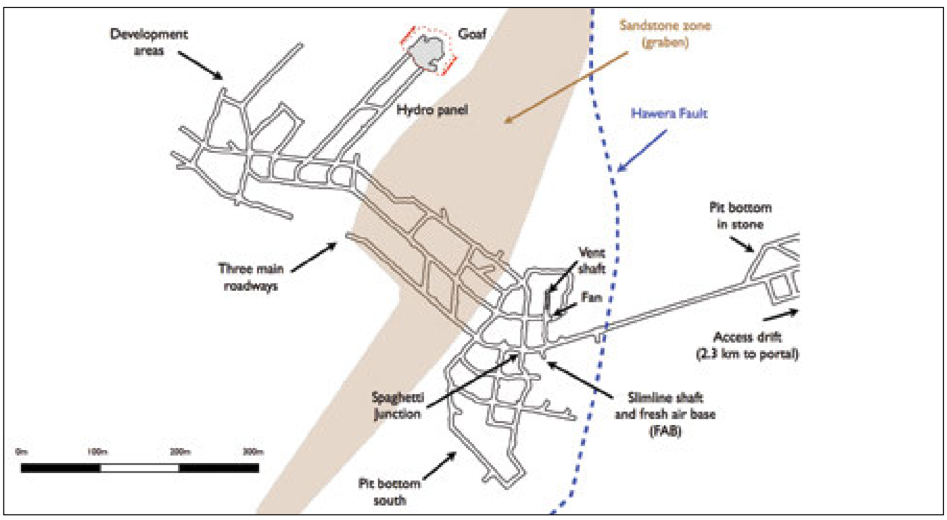


Figure 1: The mine plan as at November 2010[2]

There were two mine infrastructure areas (pit bottom in stone and pit bottom south), three main roadways, the hydro-mining panel and further development areas to the north-west. Spaghetti Junction was the meeting point of the drift and pit bottom, with two surface-to-mine shafts nearby – the main ventilation shaft, and the slimline shaft, at the bottom of which was a so-called fresh air base (FAB). Pike River was a small mine, still at an early stage of development.

The company situation

Pike's knowledge of the geology and the extent and location of the coal seam was based on an initial 14-borehole exploration programme, supplemented by a similar number of boreholes drilled subsequently. These provided insufficient geological information, which led to adverse unexpected ground conditions hindering mine development. Construction of the drift took much longer than anticipated, as did mine roadway development. Delays were caused by a downthrust between faults, called a graben, which created a zone of sandstone instead of coal, and the collapse of the bottom section of the ventilation shaft during construction. The collapse meant that a bypass had to be built to reconnect to the upper part of the shaft about 50m above pit bottom. The first coal sales, totalling 42,000 tonnes, were delayed until 2010.

Development costs escalated over the $143 million figure projected in 2007. Pike required capital and during 2010 it raised $140 million from shareholders, was seeking another $70 million as at 19 November and also borrowed $66 million from NZOG.

In September 2010 the Pike chief executive, Gordon Ward, resigned and was subsequently replaced by Peter Whittall. The board demanded 'better' forecasting from management, as Pike had 'over-promised and under delivered'.[3]

In November 2010 Pike was still in start-up mode and considerably behind its development schedule. Market credibility, capital raising, higher coal production, increased ventilation capacity, methane management and upskilling the workforce were significant challenges facing the company.

History demonstrates that problems of this kind may be the precursors to a major process safety accident. Whether an accident occurs depends on how the company responds to the challenges and the quality of its health and safety management.

Pike River Coal Ltd

Pike's vision

Pike River Coal Ltd (renamed from Pike River Coal Company Ltd in March 2006) set out to develop a safe, world-class coal mine. The company was also very committed to good environmental management, as was acknowledged by conservation leaders. Underground coal mining is both hazardous and complex at the best of times. Pike faced added challenges as it developed a new mine in a mountainous area where difficult geological conditions required some innovative solutions.

Pike recruited some well-qualified managers, many from overseas, including, for instance, Douglas White in early 2010, who was a former deputy chief inspector of mines in Australia. Over several months he tried to introduce some health and safety initiatives at the mine.

Pike also obtained advice from New Zealand and Australian consultants throughout the various stages of the mine's development. The commission's attention was drawn to the number, 36, and qualifications and experience of these consultants. They provided advice across a range of disciplines, including geotechnical engineering, ventilation, strata control, electrical safety and methane management, to mention a few.

These aspects are acknowledged at the outset partly because the commission's analysis of Pike River's operation and systems in 2010 is necessarily concerned with aspects, often negative, of likely relevance to the cause of the explosion. This does not mean that the commission has overlooked the company's aim to develop a productive and safe mine. Unfortunately Pike lost sight of that aim as its drive for production intensified.

A short-term focus

Pike's long-term mine plan had been to develop roadways to the north-west corner of the mine, establish a second intake and begin hydro mining in that area, and for mining to retreat back to pit bottom over the life of the mine – approximately 19 years. However, development delays and the consequent need for cash flow led to the need for a quick solution.

In September 2010 Pike started mining in the hydro panel close to pit bottom. The second intake, had it been developed, would have doubled as a walkout egress from the mine and also improved the efficiency of the ventilation system.

Governance by the board

The Pike board of directors was required to set the strategic direction of the company and delegate its implementation to management. The directors then had to ensure that appropriate systems were in place, including risk management, internal reporting and legal compliance systems, and also monitor the performance of management. A two-man health, safety and environment committee was to lead this process and report to the board. It could commission external reports and audits.

The board received a monthly report containing a health and safety section. Although this was helpful, it did not cover the hazards relevant to a catastrophic event such as an explosion. The board did not assess critical design and health and safety issues, including, for example, the location of the main fan underground at pit bottom. An insurance risk survey received in July 2010 identified serious concerns about the hazards posed by hydro mining, windblast and a gas explosion, and urged the need for a comprehensive risk assessment of the mining operation. Neither the board nor its committee saw the report.

The mine manager attended a board meeting four days before the explosion and told the directors that gas management was 'more a nuisance and daily operational consideration than a significant problem or barrier to operations'.[4] The board was not well placed to assess this assurance.

The board did not verify that effective systems were in place and that risk management was effective. Nor did it properly hold management to account, but instead assumed that managers would draw the board's attention to any major operational problems. The board did not provide effective health and safety leadership and protect the workforce from harm. It was distracted by the financial and production pressures that confronted the company.

Management

At the time of the explosion the management team at Pike River comprised Peter Whittall, chief executive officer; Douglas White, site general manager; Stephen Ellis, production manager; and seven department managers. However, there was constant management change over the years. There were six mine managers in the 26 months before the explosion. Mr Ellis was to become the next mine manager as soon as he acquired the required New Zealand qualification. In the meantime Mr White was the mine manager on top of his other duties. Gordon Ward was the chief executive until succeeded by Mr Whittall in October 2010. There was also significant change in other management positions.

Throughout 2010 the management team faced planning changes and operational challenges, including improving coal production, establishing the hydro panel, commissioning the new main underground fan, upgrading the methane drainage system and resolving problems with mining machinery. These coincided with the drive to achieve coal production.

Pike's mine management plans and procedures needed considerable attention. The health and safety management plan was largely in draft, partly while awaiting technical input from other managers. The ventilation management plan was deficient, and Mr White assumed responsibility for ventilation in the absence of a ventilation engineer when his workload was already formidable.

The investigation of incident reports was haphazard, with the result that in October 2010 a backlog of outstanding investigations was written off. Other information from underground, including methane readings from fixed and portable sensors, was not systematically analysed and the problems addressed.

Executive management, Messrs Ward, Whittall and White, was focused on hydro coal production, as was the board. Associated risks were not properly assessed. At the executive manager level there was a culture of production before safety at Pike River and as a result signs of the risk of an explosion were either not noticed or not responded to.

The workforce

Pike recognised the need for good training programmes, given the inexperience and diversity of much of its workforce. Miners received comprehensive induction training and continuing training was introduced in 2010 but deferred as the push for production gathered momentum. Numerous contractors were engaged on a long-term basis. Contractor health and safety management was less effective. The induction and underground supervision of the smaller contractors in particular was lax. This was recognised and was about to be addressed when the explosion intervened.

Underground, difficulties arose because of a shortage of underviewers and deputies, a high ratio of inexperienced to experienced miners and the presence of overseas miners unused to New Zealand mining conditions. A serious problem was the workers' practice of bypassing safety devices on mining machinery so work could continue regardless of the presence of methane. This was reckless behaviour. There were also reports of other conduct and incidents caused by inexperience, inadequate training and failures to follow procedures.

Ventilation

A mine ventilation system must provide fresh air throughout the workings, and take return (foul) air out of the mine. At Pike River the intake of fresh air was from the portal, and return air was expelled to the surface up the ventilation shaft. The main fan and movable auxiliary fans circulated the air, with the assistance of ventilation control devices that guided air flow and stopped the mixing of intake and return air.

The original mine plan specified two main fans located on the mountainside next to a ventilation shaft. Two planning changes were made. Pike decided to relocate the fans underground in stone at the bottom of a ventilation shaft. In 2007 the site of the ventilation shaft was moved to its eventual location north of Spaghetti Junction. Placing a main fan underground in a gassy coal mine was a world first. The decision was neither adequately risk assessed nor did it receive adequate board consideration. A ventilation consultant and some Pike staff voiced opposition, but the decision was not reviewed. Putting the fan underground was a major error.

The fan significantly increased Pike's ventilation capacity, at least in the short term. After the explosion, however, the joint investigation expert panel used computer modelling to establish the ventilation sufficiency at the time of the explosion and found air supply to the inbye (further into the mine) areas of the mine would have been fragile, particularly in an emergency.

Ventilation consultants advised Pike on an as required basis, but no one at the mine had dedicated responsibility for ventilation management.

The main fan failed in the explosion. It was not explosion protected. A back-up fan at the top of the ventilation shaft was damaged in the explosion and did not automatically start as planned. The ventilation system shut down.

Methane management

To provide safe working conditions in a gassy coal mine effective methane management is essential. Methane levels at Pike River were managed through the ventilation system and some pre-drainage of the coal seam from in-seam boreholes.

The in-seam boreholes were primarily to map the limits of the coal seam and were not designed for pre-drainage. Some pre-drainage still occurred, requiring Pike to install a gas pipeline to vent methane to the surface. By April 2010 the pipeline could not cope and an underviewer emailed management, stating: 'History has shown us in the mining industry that methane when given the write [sic] environment will show us no mercy. It is my opinion that it is time we took our methane drainage … more seriously and redesigned our entire system.'[5]

Gas consultants were engaged and advised that the pipeline required urgent upgrading. As a stopgap measure methane was 'free vented' into the mine's return airway to be handled by the ventilation system. The upgrade of the drainage pipeline was put on hold and free venting of large volumes of methane continued up to the time of the explosion. Free venting is no longer recognised as normal practice in modern underground coal mines.

Continuous monitoring of methane levels is essential to understanding the underground atmosphere and trends. Pike installed fixed sensors that reported to the control room, but at the time of the explosion there were too few and they were not well sited. There were only four fixed sensors in return air. One in the hydro panel reported to the operator of the water jet, and another was not functional. Sensors were also located at the bottom and near the top of the ventilation shaft. The bottom one was broken for 11 weeks before the explosion and the other was unreliable and could not read above 2.96% methane. There were no fixed sensors reporting to the surface from the working areas of the mine inbye of the main fan.

Gas readings were also taken throughout the mine using hand-held detectors and readings were noted in shift reports. Methane sensors attached to machinery were generally well maintained and calibrated to trip power at a set methane level. There was constant tripping on some machines, which led to the bypassing of sensors by some workers.

Despite its limitations, the monitoring system showed there was a serious methane management problem. After hydro mining began, high readings – many dangerously high – were recorded most days. This information was not properly assessed and the response to warning signs of an explosion risk was inadequate.

Electrical safety

Considerable electrical equipment was located underground at Pike River. High-voltage cables through the drift supplied power to underground. At Spaghetti Junction cables were intertwined with utility services, including drainage pipes carrying methane, creating a hazard.

Regulations require a gassy mine to have a restricted zone where all electrical equipment must be incapable of sparking an explosion. The dividing line at Pike River is shown below.

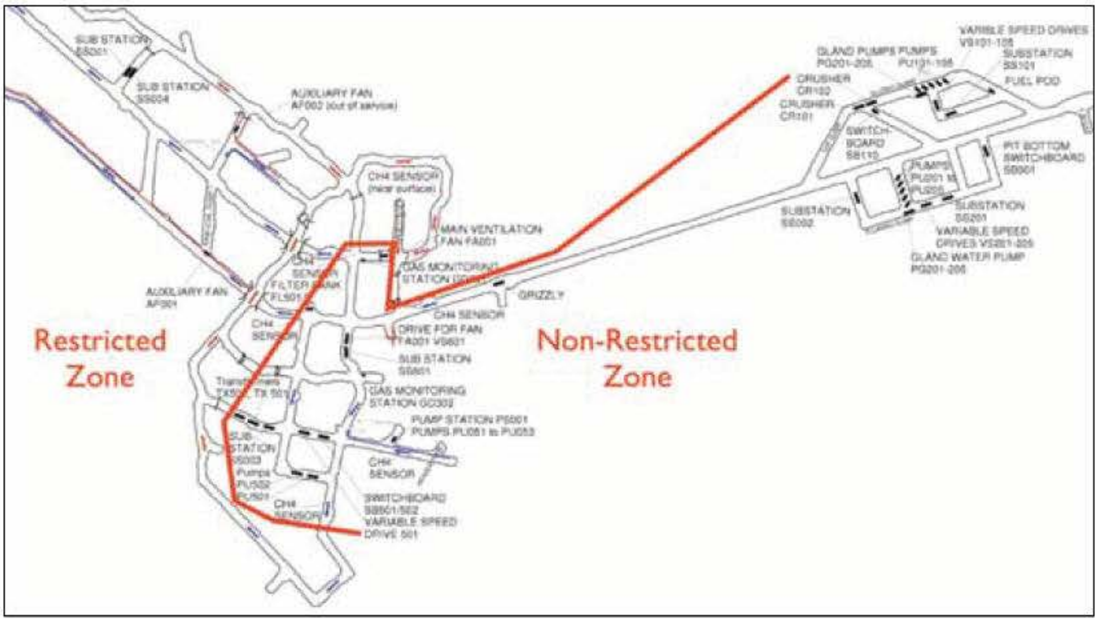


Figure 2: Boundary between the restricted and non-restricted zones[6]

The non-restricted zone, as drawn, allowed unprotected electrical equipment to be located on the right-hand side of the line in most of pit bottom south. The zone was fixed without a risk assessment, after electrical equipment was already installed and after the location of the main fan motor had been determined.

A number of variable speed drives (VSDs) were located underground. VSDs controlled power supply to the fan and water pumps. There were problems with the VSDs, one of which was replaced and a number of which were removed for repair. The extent of these problems underlined the need for a comprehensive risk assessment of the electrical installations underground at Pike River.

Mine documents suggested the appointment of a senior electrical engineer to oversee electrical safety in the mine. An appointment was made but he had not started at the time of the explosion. DOL did not have the capacity to inspect Pike's electrical systems following the major underground installations.

Investigations are continuing to establish whether an electrical cause could have initiated the explosion, but answers will depend on gaining entry into the mine.

Hydro mining

Hydro mining started at Pike River in September 2010. This is an uncommon and specialised mining technique that uses a water jet to cut the coal face and requires expert design of the mining panel and equipment. Operators must be trained to follow a set cutting sequence and to direct the water jet to avoid the undue disturbance and release of methane. The hydro panel was developed as shown in this plan.

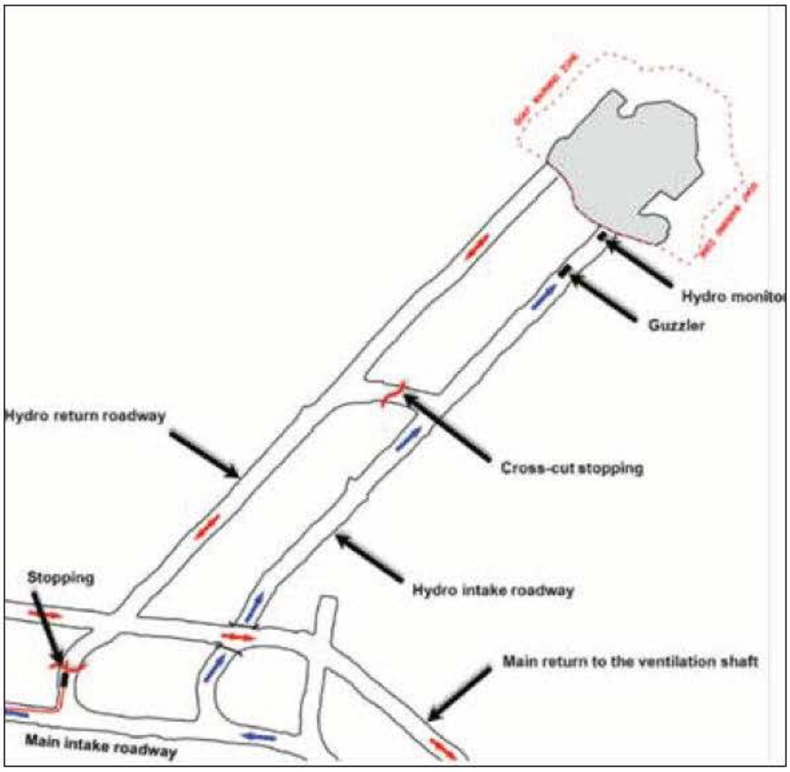


Figure 3: Diagrammatic outline of hydro panel[7]

The water jet was mounted on the monitor, with an operator stationed at the guzzler. The goaf was unsupported and roof falls were expected. The intake of fresh air is represented by the blue arrows and the outflow of return air by the red arrows.

When hydro mining began, the workers had the incentive of a $13,000 bonus if they met production targets by late September, after which the payment would decrease from week to week. Despite a number of set-up problems the targets were met towards the end of the month. After the new fan was commissioned, ventilation to the hydro panel improved and during October 2010 hydro mining became a two-shift, 24-hour operation.

In October the width of the extraction area was increased from 30m to 45m, although a consultant geotechnical engineer had indicated the risk of a major roof collapse in the goaf could not be excluded. On 30 October a significant roof fall did occur, causing a pressure wave that took out the stopping in the hydro cross-cut intended to separate intake and return air. Methane readings were high, but there was no explosion.

Hydro mining continued into November without reassessment of the risk of further roof falls in the goaf. Production levels did not improve, and spikes in the methane levels continued to be recorded in the weeks leading up to the explosion.

The regulators

The Coal Mines Act 1979

This was the main act governing coal mining activities until 1992. A specialist coal mines inspectorate administered mining. The inspectorate reviewed applications for exploration and mining licences and inspected the mine once it was developed. This meant that the inspectorate had a hand in the safety of a mine from its planning to closure.

By 1992 a new legislative framework was in place. The granting of exploration and mining permits, the assessment of environmental effects and the regulation of health and safety in coal mining were administered by separate entities under separate acts. The mines inspectorate no longer had a role throughout the life of a mine.

Ministry of Economic Development (MED)

MED approved the issue of Pike's mining permit in 1997. Its focus was the economic benefits to New Zealand. MED did not fully apply the criteria set out in its coal policy programme, which included requirements to check the experience of the applicant and its proposed mining methods, and to ensure that these represented good mining practice. In terms of the coal programme, health and safety, which is intrinsic to good mining practice, was not MED's concern. MED did not consult DOL so no one looked at the health and safety implications of the proposed mine.

MED's subsequent monitoring of the mine development was limited to ensuring that work statements were filed and storing mining plans.

Until 1 January 2009 MED carried out electrical safety inspections for DOL. After that date MED ceased to conduct inspections and DOL had no capacity to continue them.

Department of Conservation (DOC)

In 1998 Pike applied for access to the conservation land where the mine was to be developed. Over the next six years the potential environmental effects of the development were assessed in detail. DOC was concerned to minimise disturbance from surface activities and ensure that underground mining caused only minimal subsidence. In late 2004 an access arrangement was signed. It set out detailed controls.

DOC discharged its statutory function to protect the conservation value of the land. During development of the mine it met the company regularly to manage operational issues and accommodate a number of variations to the access arrangement.

Pike gave no evidence to indicate that DOC's controls compromised its ability to develop a productive and safe mine. The explosion, when the mine was still in start-up mode, limited the commission's assessment of whether underground coal mining and conservation and environmental values would have been compatible at Pike River over the longer term.

Local and regional authorities

Pike required resource consents from the Grey and Buller District Councils and the West Coast Regional Council. These were initially granted in 1999, but a number of appeals were not resolved until 2004. The councils considered environmental and public safety issues in terms of the Resource Management Act 1991. Health and safety in the workplace was not part of their mandate.

Department of Labour (DOL)

DOL's function was to ensure that Pike River was a legally compliant coal mine. The first workplace inspection was conducted in early 2007 when the drift was under construction and the mine design was already settled. From then, mining inspectors conducted quarterly inspections.

DOL's policy was to tailor a regulatory approach appropriate for individual employers. Because Pike was assumed to be a 'best practice' and 'compliant' employer the inspectors adopted a low-level compliance approach. This proved ineffective, as was most evident regarding the need to provide two emergency exits from the mine. In mid-2009 the main ventilation shaft was designated the second means of egress out of the mine. To use it involved a 110m ladder climb that was physically exhausting in normal conditions, but probably impossible in an emergency.

In April 2010 an inspector told the mine manager that the shaft, although technically compliant, was not a suitable emergency escapeway. In August DOL advised Pike by letter that a new egress was required 'as soon as possible'.[8] In November 2010 Pike said a new egress would be established by mid-2011. DOL considered this unsatisfactory, but took no further action before the explosion.

Pike was not a best practice or compliant employer in relation to this and some other obligations. The workforce had voiced concern to management about the unsuitability of the second egress. The start of hydro mining in September 2010 increased the level of risk in the mine to the point where DOL should have issued a notice prohibiting hydro mining until a suitable second egress was in place.

DOL's compliance strategy did not require an assessment of Pike's safety and operational information. The inspectors did not have a system, training or time to do so. When, at the hearings, they were shown examples of safety information obtained by the commission from Pike's records, the inspectors were visibly dismayed. This was not a case of individual fault, but of departmental failure to resource, manage and adequately support a diminished mining inspectorate.

The cause of the explosions

Activities in the mine

Sixteen Pike workers and 13 contractors perished in the mine. Their locations at 3:45pm on 19 November 2010 are not known with any certainty. Eight men, mainly contractors, were probably in the pit bottom area. The other 21 men were most likely at various workplaces, including the hydro panel and four work areas inbye of the panel.

The contractors, other than an in-seam drilling crew, were due to finish work at 4:00pm and could have been preparing to leave the mine when the explosion occurred.

Source of the methane

The expert panel concluded that the size and duration of the explosion indicated it was fuelled by a large volume of methane, perhaps up to 2000m^3. Methane accumulated in the hydro goaf following mining was estimated at up to 5000m^3. Another roof fall like that which occurred on 30 October 2010 would have caused a large pressure wave bearing a substantial volume of methane.

The pressure wave would have flowed down the hydro panel roadways and entered the main mine roadways, with the potential to flow inbye, particularly if a temporary stopping failed and allowed the wave to enter the main intake roadway. Methane carried along the roadways by the pressure wave would be diluted by air into the explosive range.

Another potential source of methane was an accumulation in the elevated inbye western areas of the mine. High methane readings were reported in these areas right up to the morning of 19 November.

Potential ignition sources

There are a number of possible ignition sources, since a spark is sufficient to ignite methane diluted to within the explosive range.

About midday on 19 November the water supply to the mine was stopped for a maintenance shutdown and mining and roadway development underground had to cease. Late afternoon, the maintenance work was completed and the control room operator reactivated a main pump at pit bottom in stone to restore water to the mine. He then called underground to advise the miners and as he spoke to an engineer all reporting to the control room from underground was lost. The coincidence of the switching on of the pump and the explosion seconds later suggested that an electrical cause may have been the ignition source.

An electrical expert thought that the VSD used to power the water pump could have produced electrical wave form distortion, called harmonics, and caused sparking in the mine earthing system or in a metal pipeline. This theory, however, is disputed and unless experts can re-enter the mine and examine the electrical systems the timing coincidence will remain a matter of conjecture.

Another potential ignition source is contraband. Smoking materials and battery-powered devices, including wristwatches and cameras, are prohibited underground because they are an ignition risk. Contraband incidents occurred at Pike River, despite preventative actions taken by management. Underground vehicles powered by diesel engines incorporated flameproof enclosures to prevent hot surfaces igniting gases, but these systems can be prone to failure. Frictional ignitions caused by metal to metal contact during vehicle or work activity underground could also ignite a gas explosion. The main fan was not flameproof, and other underground electric motors could also have been potential ignition sources.

The site of the ignition

The characteristics of the explosion, its effects upon the two survivors in the drift and computer modelling undertaken by the expert panel indicated that the most plausible ignition site was one inbye of the main fan, in about the middle of the mine workings.

The subsequent explosions

There were three further explosions on the afternoons of 24, 26 and 28 November. These were also methane-fuelled, but were shorter and more violent than the first one. They were probably sited nearer to the main ventilation shaft. The pattern of the explosions indicated that, during the afternoon, air was naturally drawn into the mine from the portal and became mixed with accumulated methane so that an explosive fringe developed. An underground fire or hot coal could then have ignited the explosive atmosphere.

The cause of the deaths

Following an inquest the chief coroner found that the men died 'at the immediate time of the large explosion … or a very short time thereafter' from the force of the explosion or the effects of the irrespirable atmosphere.[9] This finding was based on reports from medical experts produced at the inquest. The commission heard additional evidence concerning survivability.

The evidence from a number of mining experts generally supported the inquest finding. Based on the history of similar disasters, the small area of the mine, the force, heat and toxicity of the explosion, and the effects experienced by the survivors in the drift, the experts considered that survival for any appreciable time in the working area of the mine was most unlikely.

Laser images of the FAB taken by a device lowered down the slimline shaft showed that the lid of a box containing self-rescuers was open, raising the suggestion that someone could have survived to open the box. This, however, is only one possible explanation. The lid could have been left open before the explosion, opened by someone afterwards or possibly blown open during the explosion.

The commission considers these suggestions speculative and insufficient to alter the chief coroner's finding. It agrees that the men probably died at the time of the explosion or a short time after it.

Search, rescue and recovery

The initial emergency response

Pike's emergency response management plan required the most senior manager on site to take control of any emergency. Within minutes of the 3:45pm explosion the mine manager was told that all reporting from underground had stopped and no one had called the control room – an unprecedented situation. An electrician was sent underground and drove 1500m inbye before a toxic atmosphere forced him to retreat, but not before he saw a vehicle and someone lying on the roadway. He reported this at 4:25pm. Emergency services were then contacted.

It would have been better to call for emergency help once it was clear the situation was unprecedented. Emergency services could have been stood down if necessary. The delay probably made no difference to the survival of the men, but the mine manager was not to know this.

Police assume control

Within the hour local police officers reached the mine and officers at Police National Headquarters in Wellington decided that the police would lead the emergency response. This brought initial order to a very difficult situation as Pike managers, mines rescue crews, the New Zealand Fire Service, DOL, St John Ambulance and others rallied at the mine site.

The next day further New Zealand and Australian mines rescue and mining experts arrived at the mine, their travel needs facilitated by the police, who expertly managed many logistical demands throughout the response effort.

Conducting the emergency response was very complex, given the need to co-ordinate multiple agencies, make crucial decisions and maintain external communications, including with the families, when time was of the essence.

Self-rescue

After an underground fire or explosion coal miners worldwide are trained to self-rescue by walking or driving out of the mine. It is standard practice for miners to carry a self-rescuer, a form of breathing device for use in a toxic atmosphere. The workers at Pike River carried 30-minute duration self-rescuers and were trained to use the drift as the preferred escapeway in an emergency.

As at November 2010 it was the only useable means of egress. Climbing up the 110m ventilation shaft – the designated second egress – would not have been possible wearing a self-rescuer and with the shaft effectively functioning as a chimney after the explosion. As far as is known, the explosion did not cause a roof fall sufficient to block off the drift, so the absence of a second means of egress probably did not affect the men's chances of survival.

The Mines Rescue Service (MRS)

The MRS operates through a charitable trust to provide training and emergency response services to the mining industry. It is funded from a coal levy and payments received for its ancillary services.

Mines rescue crews were deployed to Pike River immediately after the 4:30pm callout. Throughout the rescue phase local crews made up of volunteer miners, assisted by their Australian counterparts, were on standby, but to their frustration conditions did not permit entry into the mine.

The MRS also played a major role in sealing and using the Queensland MRS inertisation device to stabilise the mine following the sequence of explosions, and successfully led an operation to reclaim and reventilate the first section of the drift in 2011.

The fresh air base (FAB)

During the emergency response reference was made to a place in the mine where the men could be waiting in fresh air to be rescued. This was the stub near Spaghetti Junction and at the bottom of the slimline shaft called the FAB. The methane drainage pipeline passed through the stub, which also contained a supply of spare self-rescuers, and first aid and fire-fighting equipment. There was a roll-down brattice curtain at the entrance, but it did not provide an effective seal. Nor was there any assurance that, following an explosion, fresh air would flow down the slimline shaft.

The stub was an FAB in name only, not a place of safety in an emergency. Nor was it suitable as a changeover station for anyone wanting to don a fresh self-rescuer.

A lack of information

The emergency response was hampered by a lack of information. The number of men missing underground remained uncertain until Saturday morning, 20 November, when the correct figure and the breakdown between employees and contractors was announced.

There could be no rescue attempt without information on the mine atmosphere. Reporting from underground stopped at the time of the explosion and Pike had no back-up system. For the first five days the only samples available for analysis were taken from near the top of the ventilation and slimline shafts, but they were not considered representative of conditions underground. A new borehole drilled into the heart of the mine reached pit bottom on the morning of 24 November. The availability of representative samples stimulated hope, but the second explosion that afternoon put paid to any thought of a rescue attempt.

The window of opportunity fallacy

There has been criticism that rescuers did not go into the mine during a so-called 'window of opportunity' when it was supposedly safe to enter immediately after the explosion. The commission rejects this criticism and any suggestion of a lack of courage on the rescuers' part.

There is no predictable period during which a gassy coal mine may be safely entered before a second explosion may occur. Secondary explosions are unpredictable, and the window of opportunity fallacy has claimed many lives in mines throughout the mining world. International best practice is to re-enter an underground coal mine only on the basis of representative and reliable atmospheric information. This did not exist at Pike River.

Entry into the mine would also have been unusually challenging with no ventilation or second egress, and a 2.3km inclined drift to negotiate.

The co-ordinated incident management system (CIMS)

CIMS is a system designed to co-ordinate the response activities of New Zealand emergency services. CIMS is generic, not specific to mining. A core concept is an incident management team comprising planning/intelligence, operations and logistics managers who formulate an incident action plan. That plan must be approved by an incident controller. The controller and the management team are based close to the incident site, where decisions are made promptly and with the benefit of expert advice.

After the police assumed the lead agency role at Pike River the three management and the incident controller roles were assigned to police officers, meaning the leadership group at the mine lacked mining expertise. Superintendent Gary Knowles, the incident controller, based himself at Greymouth, but was required to refer many decisions to an assistant commissioner at Police National Headquarters in Wellington.

This three-level structure was cumbersome and unsuited to the rapidly changing situation faced by the rescuers at the mine. Instead of decisions being made at Pike River, where mining and rescue experts were gathered, many were made by non-experts in Wellington. This slowed the emergency response and could have impeded a rescue had one proved possible. Preparations to seal the mine to reduce the chances of further explosions were hindered, and some experts at the mine became disillusioned.

The commission considers that management of the response over the crucial rescue period was not in line with CIMS principles. The difficulties experienced highlighted the need for advance planning for an underground coal mining emergency, involving all the relevant agencies, including the MRS.

Recovery of the men's bodies

After the explosions the mine entrances were sealed and inert gas was pumped underground. This extinguished fires and stabilised the atmosphere, which became methane rich and irrespirable.

In March 2011 the police handed control of the mine to receivers, appointed following Pike's voluntary receivership. Late that year the receivers, assisted by the MRS, established permanent seals that enabled the drift to be reclaimed and ventilated to 170m inbye of the portal.

In July 2012 Solid Energy New Zealand Ltd purchased the mine and also signed an agreement with the government to recover the bodies as part of any future mining operation if it 'can be achieved safely, is technically feasible and is financially credible'.[10] The government has a watchdog role, and may also contribute to any recovery costs over and above the costs arising from a resumption of commercial mining.

There is no prescribed timeframe and the risks involved in re-entering the mine workings beyond the drift make body recovery from this area very uncertain.

The families of the men

Attendance at the hearings

The loss of 29 lives at Pike River exacted an enormous toll on the men's families, friends and colleagues. Many family members attended the commission's hearings. A number provided written witness statements and some provided heart-breaking oral evidence to the commission. The commission was impressed with their fortitude and courage.

Were false hopes raised?

Some families consider they were given false hope concerning the prospects of their men's survival. The families were initially briefed twice daily by Superintendent Knowles and Peter Whittall, based on information they received from the mine site shortly beforehand. Over the first weekend Mr Whittall in particular referred to fresh air being pumped into the mine, men waiting underground and the possibility of a rescue attempt when the mine conditions were better understood.

The commission has concluded that Mr Whittall gave false hope, but did not do so deliberately. Although some of his comments were over optimistic, even unwise, they reflected his state of mind at the time. Under extreme stress he allowed his desire for a successful outcome to intrude, showing that someone not so close to the situation should be selected for the spokesperson's role.

Advice of the second explosion

Superintendent Knowles and Mr Whittall were at the mine at 2:37pm on 24 November when the second explosion occurred. Experts agreed that no one could have survived this even more forceful explosion. People were advised by text message of a 'significant update' at the 4:30pm family briefing.[11]

Mr Whittall began by referring to improved gas levels and preparations to go into the mine. This caused great excitement. But as soon as order was restored he referred to the second explosion and Superintendent Knowles added that it was not survivable, so the operation had moved to a recovery phase. The scene turned to one of profound distress.

Mr Whittall agreed that this announcement went horribly wrong. However, the commission accepts his evidence that this outcome was unforeseen and entirely unintended. The stress of the occasion and a few ill-chosen words raised hope before all hope was dashed, but this was a human error.

The recording of the first explosion

The CCTV recording of the first explosion was not shown to the families until Tuesday 23 November. Some were critical of the delay and there was also a suggestion that the recording was edited and was shorter than the original.

The delay, although unfortunate, arose because the recording was not drawn to Mr Whittall's attention until Sunday 21 November. He then acted promptly in obtaining and arranging for the recording to be shown to the families. The evidence of those who supplied the recording to Mr Whittall confirmed that it was not an edited version.

Body recovery

Following the second explosion most families sought the recovery of the men's remains above all else. Early comments to the effect that recovery could be only 'some weeks' off led to optimism.[12] Then, during 2011, progress towards re-entry into the mine stalled, frustration set in and family members felt that they were alone and unsupported.

The sale of the mine to Solid Energy in 2012 revived hope, but in May the families were told that the prospects of body recovery were remote. They were ill prepared for this news.

The commission received expert evidence that the delay and uncertainty concerning body recovery had hindered the grieving process and increased the toll on many family members. This was clearly evident as relatives gave evidence at a hearing in late 2011, and emphasised the need for communications with families to be both factual and balanced.

Support for family members

The commission acknowledges the outstanding level and value of the support given to the families from the time of the first explosion. Family members expressed heartfelt appreciation for the comfort and assistance they received.

A Pike liaison group, police and Air New Zealand family liaison teams, St John Ambulance, the Red Cross, the Focus Trust, the mayor, churches and people of Greymouth, Tai Poutini Polytechnic, the Salvation Army, central and local government agencies and others offered support in a variety of ways. Based on the lessons learnt from this tragedy, the police are training 40 staff members as victim liaison officers and developing liaison guidelines for major crisis management. This is commendable.

Safety of the mine and the surrounding area

The main shafts into the mine were capped in late 2010, a step towards extinguishing any hot spots underground. In December 2011 permanent steel doors were installed at the mine entrance. The mine atmosphere remains methane rich, and therefore inert. Gas samples taken from six boreholes are continuously monitored.

Control of the mine is now the responsibility of Solid Energy. Access to the site is controlled by a series of security gates and, following a recent review, increased remote monitoring of the site and access road is under development. These steps are sufficient to safeguard the mine in the meantime. If the mine is not to be reopened measures to permanently seal it should be effected by the mine owner in consultation with the local authorities and the land owner.

ENDNOTES

1 Deed relating to body recovery at the Pike River Coal Mine, 17 July 2012, SOL0503445.001/2.

2 Pike River Coal Ltd, Roadway Names: Rescue_101119_208, 4 August 2011, MBIE3000010015/1. (Labels added by the commission and geological information taken from: Pike River Coal Ltd, Activities Report: Quarter ended 30 September 2010*, DAO.007.11332/5.)

3 Pike River Coal Ltd, Minutes of a Meeting of Directors, 13 September 2010, DAO.007.05996/9.

4 Pike River Coal Ltd, Minutes of a Meeting of Directors, 15 November 2010, DAO.007.29383/3.

5 Email, Brian Wishart to Jimmy Cory, 11 April 2010, DAO.025.32975/1.

6 Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission)

7 Ibid.

8 Kevin Poynter, Operational Review Process Monthly Report – Staff Member, 2 September 2010, DOL3000090046/3.

9 Counsel's Submissions and Coroner's Findings, 27 January 2011, INV.01.27510/8.

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11 Wendy Robilliard, witness statement, 1 July 2011, POLICE.BRF.54/4, para. 12.

12 Andrea Vance, Michael Fox and Amy Glass, 'New Blast Makes Mission More Difficult', The Press, 29 November 2010, http://www.stuff.co.nz/the-press/news/pike-river-disaster/4399940/New-blast-makes-mission-more-difficult