



## Royal Commission on the Pike River Coal Mine Tragedy

Te Komihana a te Karauna mō te Parekura Ana Waro o te Awa o Pike

# Volume 2

+ Part 1: What happened at Pike River

+ Part 2: Proposals for reform

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Author: Royal Commission on the Pike River Coal Mine Tragedy

Date of Publication: October 2012

Place of Publication: Wellington, New Zealand

ISBN: 978-0-477-10378-7

Cover image: Western Escarpment, Paparoa Range, West Coast, New Zealand

Website: [www.pikeriver.royalcommission.govt.nz](http://www.pikeriver.royalcommission.govt.nz)

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# Glossary

<b>ABM</b>	Alpine bolter miner. A type of continuous miner that allows simultaneous cutting, bolting and roof support.
<b>Adit</b>	A near-horizontal access or tunnel into an underground mine.
<b>Alimak shaft/raise/rise</b>	The Alimak bypassed the collapsed lower section of the main ventilation shaft, measured 2.5m in diameter and was equipped with a 55m vertical ladder.
<b>Anemometer</b>	Instrument for measuring air velocity within roadways.
<b>Auxiliary fan</b>	Smaller fan used to ventilate dead-end roadways underground. Used in conjunction with ducting to force or extract air to or from the end of the road.
<b>Backbye</b>	See outbye.
<b>Barometric pressure</b>	Atmospheric pressure as indicated by a barometer.
<b>Booster fan</b>	Fan located underground within the main ventilation circuit to increase airflow.
<b>Borehole/drillhole</b>	Hole created by drilling to gather geology information or for gas drainage. Can be done from the surface or underground.
<b>Brattice</b>	Impervious plastic/fabric cloth used in the construction of ventilation control devices, e.g. stoppings.
<b>Bridging panel</b>	Also known as section or panel at Pike River. Mining area connected to the mains roadways consisting of access roads and extraction areas with a separate ventilation circuit. See panel.
<b>Brumby</b>	Multi-purpose four wheel utility vehicle which can be fitted with attachments such as an excavator bucket.
<b>Bypassing</b>	Refers to circumventing or working around safety devices.
<b>CABA system</b>	Compressed air breathing apparatus. A CABA system may include a fixed compressed air supply where units can be refilled while being used or a backpack system similar to scuba diving.
<b>C-ALS</b>	A cavity auto scanning laser system that uses laser beams to create a three-dimensional image of a void.
<b>Carbon dioxide (CO<sub>2</sub>)</b>	Formed underground by engine exhaust and/or oxidation of coal or fire and may be a coal seam gas. It is colourless but has an acidic odour at high concentrations.
<b>Carbon monoxide (CO)</b>	A colourless, odourless gas formed by the incomplete combustion of carbon or a carbonaceous material (e.g. diesel machines, mine fire, spontaneous combustion of coal).
<b>Caving</b>	See roof fall.
<b>CIMS</b>	The co-ordinated incident management system provides common management principles, structure and terminology for multi-agency emergency response activity in New Zealand.
<b>Cleanskin</b>	Worker with little or no underground mining experience.
<b>COC</b>	Certificate of competence. Also referred to as ticket, permit or licence.
<b>Continuous miner</b>	Purpose-built machine for driving/developing roadways in coal. Capable of continuously loading the cut material into the coal transport system (e.g. flume, shuttle car, conveyor).
<b>Contraband</b>	Items that are prohibited underground, for example, cigarettes.
<b>Control room</b>	Surface location performing the centralised function of monitoring, operating and controlling the mine.
<b>Conveyor</b>	Fixed equipment used for continuously moving stone or coal.
<b>Core logging</b>	The drilling of holes in an extraction zone's roof and floor to take core samples for geotechnical logging.

<b>CPP</b>	Coal preparation plant. Situated approximately 8.2km from the portal, the CPP received coal through the coal slurry pipeline and then washed and processed it for collection.
<b>Cross-cuts</b>	Underground roadways developed at regular intervals to join one or more main roadways.
<b>Crushing station/crusher</b>	An area at pit bottom stone where the coal from the working faces was sized and crushed to <35mm to form a slurry for transportation by flume and pipeline to the CPP.
<b>Cutter head</b>	Mechanical protection device on the continuous miner that will shear if sufficient force is applied to the cutting head of the machine.
<b>DAC</b>	Digital access carrier system. An underground communications system that operates like a party-line telephone system.
<b>Deputy</b>	Reporting to underviewers, the deputies carried out the safety inspections, examinations and reporting required by the company and by law and gave supervision and guidance to their crews.
<b>DOC</b>	Department of Conservation.
<b>DOL</b>	Department of Labour. Now part of MBIE.
<b>Down-dip</b>	Located down the slope of a dipping coal seam.
<b>Drift/drive/tunnel</b>	An underground roadway.
<b>Driftrunner</b>	Motorised vehicle used to transport miners to and from the surface.
<b>Drill stub</b>	A small area (2–5m) off a main roadway to allow drilling equipment to be set up to avoid blocking the main roadway.
<b>Egress</b>	An exit from a mine.
<b>Emergency refuge</b>	An underground room-like sealed facility to maintain a respirable atmosphere in emergencies. It may have an air source that is independent of the main ventilation air. See FAB.
<b>ERMP</b>	Emergency response management plan. The ERMP outlined Pike's procedures and plan for responding to emergencies.
<b>ESR</b>	The Institute of Environmental Science and Research (ESR) – a provider of forensic services to the New Zealand Police.
<b>Evasé</b>	The exhaust structure for the main underground and surface fans.
<b>EXITO</b>	Extractive Industry Training Organisation.
<b>Explosion panels</b>	Hinged doors/panels on the exhaust structure for the main fan that are forced open by the pressure generated by an explosion, to protect the evasé from the force of the blast.
<b>Explosive range</b>	Methane is flammable and explosive when mixed with oxygen between 5 to 15% methane in air by volume.
<b>FAB (fresh air base)</b>	An underground room-like sealed facility to maintain a respirable atmosphere in emergencies.
<b>Flame arrestor</b>	Metal ribbon flame cell elements designed to inhibit flame propagation by absorbing and dissipating heat from coal-seam gas passing through and venting into the atmosphere. Attached to the top of Pike's 6" gas riser at the surface next to the slimline shaft.
<b>Flameproof</b>	Flameproof equipment is enclosed in a special housing to ensure any ignition of methane is safely contained inside the enclosure.
<b>Floxal</b>	A unit used to generate and pump nitrogen into a mine to make the atmosphere inert.
<b>Flume system/slurry pipeline</b>	An open steel channel for transporting a coal and water slurry downhill from mining areas.
<b>Forcing fan</b>	A forcing fan sends air along the intake towards the working faces of a mine.
<b>FRAS</b>	Fire resistant anti-static. Can apply to brattice.
<b>Free venting</b>	The practice of releasing methane from the drainage boreholes into the return of a mine's ventilation system.

<b>GAG</b>	Górnicy Agregat Gaśniczy unit used to pump inert gases and water vapour into a mine to extinguish fire and stabilise the atmosphere after an explosion.
<b>Gas chromatograph</b>	Gas analysis equipment used to precisely measure the full range of gaseous constituents of a mine gas sample.
<b>Gas drainage</b>	Capturing and removing the naturally occurring gas in coal seams to prevent it entering mine airways. The gas can be drained in advance or after mining using different techniques. Often referred to as methane drainage if methane is the main gas component target to be captured.
<b>Gassing out</b>	Coal mining term for an excessive amount of flammable gas in the general body of a mine's air.
<b>Gassy mine</b>	A mine where tests on three successive days indicate the presence of flammable gas in an area, district, or main airway on the return or exhaust side.
<b>Goaf</b>	The void created by coal extraction that is usually unsupported and susceptible to roof collapse.
<b>Graben</b>	A block of strata between two faults that has moved downward.
<b>Grizzly</b>	Feeder and sizer for the conveyor. Situated 2.1km inbye of the portal.
<b>Gunningham and Neal</b>	Professor Neil Gunningham and Dr David Neal SC in February to July 2011 conducted an independent internal <i>Review of the Department of Labour's Interactions with Pike River Coal Limited</i> . The Australian authors are a social scientist and a senior counsel with specialist interests in occupational health and safety.
<b>Guzzler</b>	A machine located 18m behind the hydro monitor used to collect and direct the slurry away from the mining areas.
<b>Hard coking coal</b>	High-quality bituminous coal suitable to make coke.
<b>Headings</b>	Two or more roadways generally driven parallel to access an area of the mine.
<b>HSE Act</b>	Health and Safety in Employment Act 1992.
<b>Hydro mining/hydro monitor</b>	The use of a high-pressure water jet from a specialised hydro monitor machine to cut coal.
<b>Hydrogen (H<sub>2</sub>)</b>	Colourless, tasteless and odourless gas. Highly flammable (4 to 74%).
<b>Hydrogen sulphide (H<sub>2</sub>S)</b>	Colourless gas with rotten egg odour. Highly toxic.
<b>Improvement notice</b>	A notice issued by the health and safety regulator (a mining inspector) requiring a health and safety deficiency to be rectified.
<b>Inbye</b>	The direction towards the coal face from any point of reference.
<b>Ingress</b>	An entry into a mine.
<b>In-seam drainage</b>	Removal of coal seam gas with the use of in-seam drillholes and associated pipework.
<b>In-seam drilling</b>	Drilling of boreholes through the coal seam from an underground location.
<b>INSITE</b>	DOL's electronic data management system.
<b>Intake</b>	An underground roadway that has uncontaminated/fresh air moving through it.
<b>Interburden</b>	An interval of sediments of varying depth that lies between two or more coal seams.
<b>Joint investigation</b>	Investigation into the tragedy conducted by the New Zealand Police and Department of Labour.
<b>JSEA</b>	Job safety and environmental analysis. A safety management method to evaluate certain jobs, tasks, processes or procedures and eliminate or reduce the risks and hazards.
<b>Jugernaut</b>	Type of loader (LHD).
<b>Lag indicator</b>	A measure of performance made after a safety incident, e.g. lost time injury rates, methane readings.
<b>Lead indicator</b>	A forward-looking performance measure designed to help organisations introduce preventative measures before a safety incident occurs, e.g. near miss reporting.
<b>LHD or loader</b>	Load haul dump machine – low-profile front-end loader.

<b>Longwall mining</b>	A method of mining coal in long straight slices.
<b>Main fan/primary fan</b>	Largest fan(s) that draws air into or pushes air through a mine.
<b>Main ventilation shaft</b>	Vertical access with a primary purpose to exhaust air out of the mine.
<b>Mains</b>	Roadways that provide long-term access and ventilation pathways to and from the mining areas (panels/sections).
<b>Manometer</b>	Instrument for measuring pressure differences.
<b>MBIE</b>	Ministry of Business, Innovation and Employment.
<b>MED</b>	Ministry of Economic Development. Now part of MBIE.
<b>Metalliferous mine</b>	Defined by regulation as including a surface or underground mine extracting, processing or crushing any mineral.
<b>Methane (CH<sub>4</sub>)</b>	Highly flammable coal seam gas, which is tasteless and odourless. Highly flammable (5 to 15%).
<b>Methane make</b>	The volume of methane released into a mine. Can also mean the rate at which a mine produces methane.
<b>Methane outburst</b>	The sudden ejection from the coal face into the mine workings of methane and carbon dioxide, generally including coal and rock.
<b>Methane spike</b>	An increase in the level of methane in a mine atmosphere.
<b>MinEX</b>	MinEx Health and Safety Council, the national health and safety organisation for the New Zealand minerals industry.
<b>MRS</b>	New Zealand Mines Rescue Service, a specialist mines rescue service.
<b>MRT</b>	New Zealand Mines Rescue Trust. It is a separate legal entity to the MRS and was incorporated pursuant to the Charitable Trusts Act 1957.
<b>Negotiated agreement</b>	An agreement between the health and safety regulator (a mining inspector) that a health and safety deficiency will be rectified, usually within a defined time frame.
<b>NOHSAC</b>	National Occupational Health and Safety Advisory Committee. Established in 2003 to provide independent advice to the minister of labour on major occupational health and safety issues. NOHSAC was abolished in 2009.
<b>Northern Lights</b>	Electronic system for tracking workers underground.
<b>NZFS</b>	New Zealand Fire Service.
<b>NZQA</b>	New Zealand Qualifications Authority.
<b>Outbye/backbye</b>	The direction away from the coal face from any point of reference.
<b>Outcrop</b>	A segment of the coal seam or bedrock exposed to the atmosphere.
<b>Overcast</b>	A structure built in an underground roadway intersection to keep air paths separated, so that intake and return air can pass through the intersection.
<b>Overpressure</b>	A pressure peak in a mine ventilation system caused by roof fall/fire/explosion/blast.
<b>Panel</b>	Mining area connected to the mains roadways consisting of access roads and extraction areas with a separate ventilation circuit.
<b>Permit to mine</b>	Weekly detailed plan of the forecast underground mining activities. Production and health and safety risks of the planned activities are identified and mitigation measures outlined.
<b>Personal safety</b>	Addressing the risks of various types of physical injuries (slips/trips/falls/struck-by incidents) usually associated with a hazard that is close to workers.
<b>Pike</b>	Pike River Coal Ltd (in receivership from 13 December 2010). The company name was changed from Pike River Coal Company Ltd on 13 March 2006.

<b>Pike River</b>	The Pike River coal mine and/or the area near or surrounding the mine.
<b>Pit bottom in coal</b>	An area of permanent roadways inbye of the main drift that housed water storage, pumping systems, electrical infrastructure and the main fan.
<b>Pit bottom in stone</b>	A roadway area off the main drift containing underground services for coal collection, crushing and transport, water storage, high-pressure pumping systems and electrical infrastructure.
<b>Pogo sticks</b>	Expandable poles with an internal spring often used to hold up cables or brattice in a mine.
<b>Portal</b>	Surface entry point into a mine.
<b>PPM</b>	Parts per million.
<b>Process safety</b>	The prevention and mitigation of unintentional releases of potentially dangerous materials or energy from the mining process.
<b>Prohibition notice</b>	A notice issued by the health and safety regulator (a mining inspector) requiring that an activity cease until such time as a health and safety deficiency has been rectified.
<b>Range</b>	Refers to Pike's system of boreholes, pipes and other devices designed to capture and remove gas from coal seams to the surface. See gas drainage.
<b>Reflector sticks</b>	At Pike River these were pieces of PVC pipe about 1m long wrapped with reflective tape intended to reflect light or be easily visible.
<b>Rescue station</b>	MRS rescue station at Rapahoe on the West Coast providing logistical support, emergency equipment and 24 hour on-call rescue personnel.
<b>Return</b>	Any underground roadway that has 'used' or 'contaminated' air moving through it towards the surface after it has passed a mining area.
<b>Rib</b>	The walls of a roadway or heading.
<b>Rider seam</b>	The Brunner seam consists of the main seam and above it a narrower rider seam, separated by interburden of variable thickness.
<b>Riser</b>	At Pike River the riser refers to a vertical 6" pipe through which methane-laden air was discharged to the surface. The riser was connected to the 4" methane drainage pipe line running along the roof and ribs of the mine.
<b>Roadheader</b>	Purpose-built machine for driving roadways in stone or coal capable of loading the cut material into the stone/coal transport system (e.g. flume, shuttle car, LHD, conveyor).
<b>Robens report</b>	The seminal 1972 United Kingdom report that resulted in widespread health and safety legislative change in a number of countries, including New Zealand.
<b>Roof bolt/roof bolting techniques/cable bolts</b>	Boreholes from 1 to 2.5m long are drilled upward in the roof and bolts are inserted into the holes and anchored at the top by a chemical resin or mechanical device. Bolts may be inserted in a pattern. The purpose is to clamp together several roof beds to form a composite beam with strength considerably greater than the sum of the individual beds acting separately.
<b>Roof fall/caving</b>	Process where the roof fails to the extent that it collapses. It can be planned or unplanned.
<b>Safegas</b>	SIMTARS automated fire and explosive gas analysis system.
<b>SCADA</b>	Supervisory control and data acquisition is an industrial computer system that monitors and controls processes.
<b>Section</b>	See panel.

<b>Self-contained self-rescuer (SCSR)/self-rescuer</b>	A temporary breathing system for use when the mine atmosphere becomes unbreathable. There are two possible systems: one with a simple filter (rarely used); the other, using potassium super peroxide, reacts with exhaled CO <sub>2</sub> and water vapour and produces sufficient oxygen for approximately 30 to 60 minutes of use. Intended to allow the user to move from their current location to fresh air or another air source.
<b>Shotcrete</b>	Mortar or concrete sprayed through a hose and nozzle onto a surface at a high velocity. Used to form ground support in roadways and other structures in mines. Shotcrete can be unreinforced or reinforced with steel mesh/bars, steel fibres or synthetic fibres, e.g. polypropylene.
<b>Shot-firing</b>	The operation of dislodging coal and/or stone from a development or extraction face with explosives.
<b>SIMTARS</b>	Safety in Mines Testing and Research Station. A Queensland government organisation focusing on research, consulting, testing, certification and training services for the improvement of mining industry safety and health.
<b>Slimline shaft</b>	Small diameter shaft from the mine to the surface connected to the pit bottom area of Pike River.
<b>Slurry pipeline</b>	See flume system.
<b>Smoke lines</b>	A series of rope lines and small cones hung along underground roadways to assist in guiding people through the mine to a point of safety in the event of an emergency and low visibility.
<b>SOP</b>	Safe operating procedure. Procedure developed for safely undertaking tasks and operating equipment.
<b>Spaghetti Junction</b>	The intersection at the termination of the main drift, 2300m from the portal, so named because of the roadways and services that converged in this area.
<b>Spike</b>	See methane spike.
<b>Spontaneous combustion</b>	Coal reacts with oxygen to create heat. If the heat liberated during the process accumulates, the rate of the reaction increases and there is a further rise in temperature. When this temperature reaches the ignition temperature of coal, the coal starts to burn.
<b>Standpipe</b>	A gland driven into the wall face and grouted into position as a permanent access point to a methane drainage borehole.
<b>Steady state coal production</b>	The point at which a mine achieves a reliable coal extraction rate.
<b>Stone dust</b>	Limestone dusted over the roof, ribs, face, and throughout a mine to render exposed coal dust inert.
<b>Stopping</b>	A structure (temporary or permanent) built across a roadway to direct the air flow.
<b>Stratigraphic (strata) complexity</b>	The structure of sedimentary rocks, which have recognisable parallel beds of considerable lateral extent. The beds deposited reflect the geological history (relative complexity) of a region.
<b>Structural (faulting) complexity</b>	Fractures in the rocks that make up the Earth's crust, along which there has been relative displacement, i.e. rocks on either side have moved past each other.
<b>Stub</b>	A small dead-end extension (2–5m) off main roadway. Stubs may be used for drilling, or locating plant and equipment, or to allow one vehicle to pass another.
<b>Subsidence</b>	Downward movement of the ground surface.
<b>Surface collar</b>	Located at the top of the main ventilation shaft, a reinforced concrete collar designed to take the loads of the raise bore rig and the exhaust structure for the main underground and surface fan.
<b>Tag board</b>	System for identifying who is underground. Tags are placed on a board before entering the mine usually at the portal, and are removed on departure.
<b>TARP</b>	Trigger action response plans. Step-by-step process of what to do, who to call and actions to take when urgent action is required.



<b>Telemetric system (real-time)</b>	System where gas monitoring data is collected and analysed at an underground location and the result relayed electronically to another point (control room) for evaluation. Compare with Maihak system, where gas is pumped from underground but analysed on the surface.
<b>Tell-tale</b>	Device installed into the roof for measuring ground movement in the immediate/near roof strata.
<b>Tool box talk safety advisory notice</b>	Notice produced by the Pike safety and training department to notify underviewers of remedial action arising out of an incident at the mine.
<b>Tube bundle monitoring system</b>	Bundle of tubes spread throughout underground workings to transport gas samples to the surface for Maihak (or other) analysis.
<b>Tunnel</b>	Roadway that links the surface operations to the coal seam. Underground tunnels are sometimes known as roadways, drifts, or headings.
<b>Underground monitor pump</b>	Pump that generates high pressure and high volume water that is used to excavate coal via the hydro monitor.
<b>Underviewer</b>	Underviewers reported to the statutory mine manager. The underviewers were responsible for co-ordinating and planning activities, managing employee attendance and issues, ensuring safety systems were implemented and maintained, and carrying out inspections and examinations.
<b>Variable speed drive (VSD)</b>	Equipment that regulates the speed of an electric motor.
<b>Vent cans</b>	Tubing used to distribute or exhaust air from auxiliary fans.
<b>Ventilation circuit</b>	Pathway that air follows through the mine or a section or a panel of the mine.
<b>Ventilation control device (VCD)</b>	Used to create a ventilation circuit. They consist of stoppings, overcasts or air crossings (which send air over a roadway) and other devices designed to direct or control the flow of air.
<b>Ventilation fan</b>	A mechanical device used to create the air flow within the mine.
<b>Ventilation system</b>	The whole of the system used to direct, control, push, or pull air throughout the mine.
<b>Way-finder beacon</b>	Escape routes out of mines can be marked with way-finder beacons which produce an audible signal and flashing lights to assist people to escape in low visibility.
<b>Windblast</b>	The high velocity displacement of mine airways caused by a sudden strata failure.

## Explanatory note on the page numbering of references

The report includes endnotes referencing documents in the commission's Summation evidence database. The page number format is the document identifier followed by a forward slash and the cited page(s), for example, DOL0020010015/10. The page numbering used in Summation commences with the cover or first page and therefore may not match the page numbering used in the document.

# Part 1

+ What happened at Pike River





# Context

- + Friday afternoon, 19 November 2010
- + Accident analysis - some concepts
- + The promise of Pike

# Friday afternoon, 19 November 2010

## A tragedy unfolds: Friday afternoon, 19 November 2010

1. The Pike River coal mine lies under the rugged Paparoa Range on the West Coast of New Zealand's South Island. The mine was comparatively new, having shipped its first coal in February 2010, and the mine workings were not extensive. On the afternoon of Friday 19 November 2010 there were 31 men in the mine.
2. The three Pike mining crews, A, B and C, worked overlapping shifts. A crew worked the night shift, which began on Thursday night at 10:00pm and ended at 8:00am on Friday 19 November. B crew started the day shift at 7:00am and left the portal at 2:50pm to finish their shift at 3:00pm. C crew began the afternoon shift early, at 1:00pm. As recorded on closed-circuit television (CCTV), they entered the portal at 1:13pm.<sup>1</sup>
3. Miners who manned the hydro monitor worked 12-hour shifts that ran from 7:00am to 7:00pm. The day shift crew of three men was underground at the time of the explosion.
4. In addition to Pike workers, seven companies had men working underground on contract during the day. Men from each of these companies, save for McConnell Dowell Constructors Ltd and Skevington Contracting Ltd, were in the mine when the explosion occurred.
5. Investigators endeavoured to reconstruct the likely locations of the men who perished.

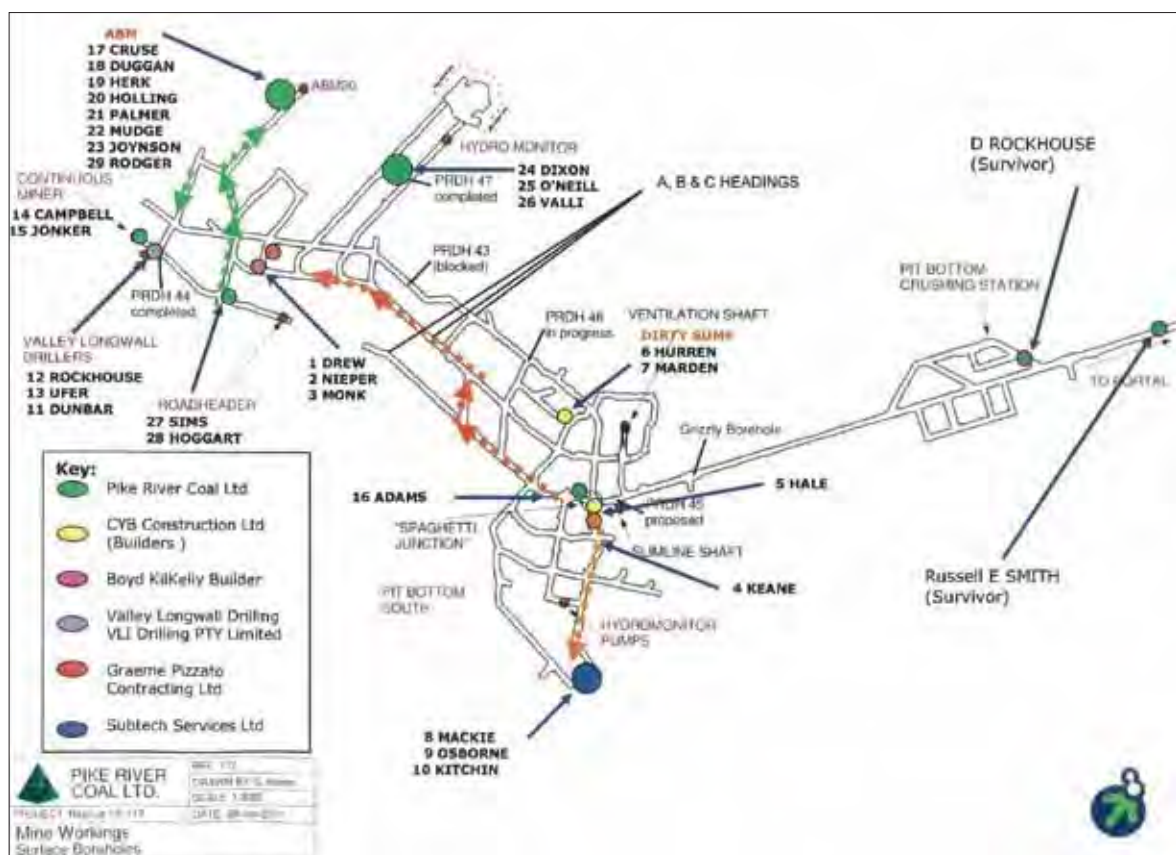


Figure 1.1: Last known position of the 29 deceased and two survivors<sup>2</sup>

6. The positions can only be indicative. They were fixed from the last sightings of the men by people who were also underground but left before the explosion, and also by reference to the work the men were to undertake that day.

7. Eight men from C crew, Glenn Cruse, Christopher Duggan, Daniel Herk, Richard Holling, Brendon Palmer, Stuart Mudge, William Joynton and Peter Rodger, were manning the alpine bolter miner (ABM), and driving a development road in the north-west corner of the mine. Daniel Rockhouse left the crew, driving a loader to uplift some gravel needed for the roadway. Conrad Adams, the acting C crew underviewer, was last seen near Spaghetti Junction, but could well have headed inbye to rejoin his men at the face.
8. Three men, Allan Dixon, Peter O'Neill and Keith Valli, were manning the monitor in the hydro panel at the most northern location in the mine. Because there were only two men, Blair Sims and David Hoggart, in the roadheader crew – too few to undertake roadway development – they were on maintenance duties near the roadheader. The continuous miner located at the westernmost point in the mine required servicing and engineer Malcolm Campbell and fitter Koos Jonker were undertaking this work.
9. VLI Drilling Pty Ltd employees, Joshua Ufer and Benjamin Rockhouse, were working at the in-seam drilling rig close to the continuous miner. Joseph Dunbar, aged 17, was in the mine on an orientation visit. He was to start work the following Monday, but he went into the mine with two of the company managers and elected to remain with the drilling crew until the end of their shift.
10. Three builders, Michael Monk, an employee of Graeme Pizzato Contracting Ltd, and Kane Nieper and Zen Drew, employees of Boyd Kilkelly Builder Ltd, were constructing a stopping in a cross-cut deep in the mine. Mr Drew, however, was last sighted in a nearby tool box area and could well have been walking back to the worksite at the time of the explosion.
11. John Hale, an employee of CYB Construction Ltd, was a permanent 'taxi driver', ferrying men in and out of the mine on a drifrunner. He was last seen at pit bottom in stone, but was understood to be en route to Spaghetti Junction. Other CYB employees, Andrew Hurren and Francis Marden, were inbye of the junction, preparing a sump area for concrete to be laid.
12. Terry Kitchin, Milton Osborne and Samuel Mackie, Subtech Services Ltd employees, were installing a water pipe in pit bottom south. Mr Kitchin, however, was last sighted in a roadway near Spaghetti Junction and could have been in transit at the time of the explosion. Riki Keane, an employee of Pizzato, was driving a loader used to remove spoil from the work site. His vehicle broke down near Spaghetti Junction sometime after 3:00pm and he was last seen there, trying to restart the vehicle. Daniel Rockhouse assisted him by obtaining hydraulic oil before he continued driving outbye into the drift.
13. As on any work day, others entered and left the mine at various times. A McConnell Dowell day crew of four men worked in stone, developing a stub to house equipment. The day shift finished at 4:00pm and the crew left the portal in a drifrunner at 3:41pm. The night crew of five workers was on the surface preparing to go underground when the explosion occurred.
14. Four employees of Skevington Contracting were also to finish work at 4:00pm and left the mine on the same drifrunner. Two surveyors, Callum McNaughton and Kevin Curtis, were walking out of the mine and flagged down the drifrunner. Earlier still, about 2:00pm, Lyndsay Main, a Coastline Roofing Ltd builder, finished work early and walked out of the mine about 70 minutes before the explosion. Pike technical staff had also been into the mine to undertake various tasks, but had returned to the surface before 3:45pm.
15. Chance played a big part in which men, and how many, remained underground at 3:45pm.

## A planned maintenance shutdown

16. Water used in the mine was piped from the Pike River coal preparation plant 8km to the east of the mine, next to the main access road. Because there was to be planned maintenance work at the plant, beginning at midday, underground mining operations were to be halted until water became available again. In the meantime the miners were to undertake pit bottom maintenance tasks.



17. Daniel Duggan was in sole charge of the surface control room. He had started a 12-hour shift at 7:00am. Mid-afternoon he received a phone call from the coal preparation plant to confirm that the maintenance work had been completed and that water to the mine could be restored. He activated the start sequence for the fluming pump system supplying water to the working faces. At 3:44:12pm Mr Duggan used the digital access carrier (DAC) system, which provided simultaneous communication to the work areas at pit bottom, to advise that mining could be resumed.
18. This exchange occurred:
- Daniel Duggan: 'Hello ABM or Road header.'
- Malcolm Campbell: [Eight seconds later] 'Hey Dan, who you looking for?'
- Daniel Duggan: [Three seconds later] 'I was just after ABM and Road header.'<sup>3</sup>
- At this point an unidentified sound interrupted the conversation. Mr Duggan did not interpret it as an explosion at the time. He recognised the voice from underground as that of Malcolm Campbell, an engineer with a distinctive Scottish accent, who was doing maintenance work on the continuous miner.<sup>4</sup>
19. Mr Duggan continued to make calls using the DAC. Over the next almost four and a half minutes he made calls asking whether there were any 'sparkies' (electricians) underground, anyone at the 'monitor place' and, finally, whether there was 'anyone underground'.<sup>5</sup> The DAC was functioning, but there was no response to his calls.

## Signs that all was not well

20. At the same time as the unidentified noise was recorded on the DAC system, alarms in the control room were activated. This indicated that reporting from underground had ceased. Power, ventilation, pump and gas data were no longer being fed to the control room. Previously, when power to underground had been lost, miners would quickly contact the controller. On this day there were no callers. Mr Duggan also tried ringing different sites underground, using the telephone system which, like the DAC, had a back-up battery system, but there was no reply.
21. Meanwhile Douglas White, the statutory mine manager, Stephen Ellis, the production manager, and George Mason, the hydro-mining co-ordinator, were meeting in Mr White's office in the main administration building. At one point the office lights flickered but no one was concerned. At about 3:47pm Mr Duggan spoke to Mr White and told him they had lost power and communication to the mine. Mr Duggan added that he would contact the communications and monitoring engineer, or an electrician.
22. At 3:48pm Robb Ridl, the Pike engineering manager, and John Heads, a contract electrician, entered the control room. Mr Duggan spoke of his concerns and said, 'I've got a real bad feeling about this.'<sup>6</sup>
23. At 3:52pm Mr Duggan again spoke to Mr White and asked whether the Mines Rescue Service (MRS) should be placed on standby. Mr White replied, 'Oh, we won't go there yet, we'll get someone up there.'<sup>7</sup> Mr White then left his office and went out to the car park near the administration building, where he spoke to Messrs Ridl and Heads. They noticed an unusual smell in the air, like excessive diesel exhaust fumes. Mr White then returned to his office and between 4:01 and 4:04pm he sent three emails on other matters.
24. The explosion had been recorded on CCTV footage taken by the portal camera. This footage was not seen until some time later. Beginning at 3:45:36pm and continuing for about 52 seconds, there was a pressure wave out of the portal. Movement of a tell-tale indicator tied to the rib opposite the camera showed the duration of the wave, and debris coming from the portal indicated the velocity of the explosion.

## An electrician enters the mine

25. Following the car park discussion Mr Ridl approached electrician Mattheus Strydom, who was working nearby. Mr Ridl said there was a power outage in the mine and communications had also been lost. He requested Mr Strydom



to head up to the mine and investigate. Mr Strydom asked whether both 'power and communication' had been lost.<sup>8</sup> He was concerned. Based on his 28 years of mining experience, he regarded this combination as significant. Messrs Ridl and Heads then drove to the mine and arrived at the portal at 4:03pm.

26. Mr Strydom obtained from the McConnell Dowell crew a drifrunner they had intended to use to enter the mine at 4:00pm. He commented to the crew deputy, 'I hope this isn't bad.'<sup>9</sup> Strydom then obtained from the control room a hand-held gas monitor that could test only for methane. Other gas monitors could test for methane, carbon monoxide, hydrogen sulphide and oxygen.
27. Mr Strydom filled the drifrunner with water and set off to the portal, where he encountered Messrs Ridl and Heads. Mr Heads said that he had already checked the portal substation and that power was on there. This indicated to Mr Strydom that the power outage must have occurred at pit bottom in stone, 1900m into the mine. At 4:11pm Mr Strydom entered the portal, without a self-rescuer, and Messrs Ridl and Heads returned to the administration area.
28. After sending his third email at 4:04pm Mr White went to the control room. Mr Duggan told him the situation was unchanged: there had been no response from underground, and no telemetric communication. Mr White said he would drive to the mine and test whether the portal DAC was working. He arrived there at 4:16pm and successfully called the control room. Mr Duggan told him that Mr Strydom was on his way and that Mr Ridl was returning to the portal to check the ventilation. Mr White responded that there was ventilation going up the tunnel.<sup>10</sup> At 4:18pm Messrs Ridl and Heads went back to the portal. The three men discussed the situation and satisfied themselves that there was a ventilation breeze entering the portal. At 4:23pm they left the portal area.<sup>11</sup>
29. As Mr Strydom was driving up the drift, his first thought was that 'something just didn't feel right'.<sup>12</sup> He noted that reflector sticks, pieces of PVC pipe wrapped with reflector tape, were missing from the conveyor belt infrastructure to which they were ordinarily tied. He wondered whether the sticks had been removed by a fitter, as the belt was to be decommissioned the following week. He also noted a cordite-like smell, which he likened to diesel exhaust fumes. The smell became stronger as he continued up the drift. Also missing were signs that identified the position of fire hoses. Other items attached to the ribs were displaced. He drove past the decommissioned fresh air base (FAB) at 1500m into the drift. The substation at pit bottom in stone was a further 400m inbye. The air became increasingly thick and the engine of the drifrunner began to falter. Mr Strydom looked for a place where he could turn the vehicle around.
30. Then he saw a light in the distance. Relieved, he went on, and recognised a Jugernaut and, some metres outbye of it, the figure of a man lying on the roadway. The man was on his back, with arms outspread and his head pointing outbye. From Mr Strydom's training, he knew this was the typical position of a person killed by explosive forces. Breathing had become difficult and the engine of the drifrunner continued to splutter. This was a dangerous situation. In fear of his life, Mr Strydom put the drifrunner into neutral and it began to run backwards downhill.
31. Then the engine revived. He put the vehicle into reverse gear and continued backing as fast as he could. At one point he stopped and considered driving back up the drift to attempt a rescue. Then he recalled his previous breathing difficulties and he continued to reverse. At about the 1150m mark he backed into stub 2 and then drove forward towards the portal.
32. He reached the portal at 4:25pm, only a few minutes after the departure of Messrs White, Ridl and Heads, and immediately called the control room. He told Mr Duggan, 'You better call the Mine Rescue, we've had an explosion and I've seen a man lying on his back in the road'.<sup>13</sup> He then spoke to Mr White who, thinking Mr Strydom was ringing from the FAB, instructed him to leave the mine and return to the surface.

## Calls to emergency services

33. Mr White then accepted that there had been a major event underground and that emergency services must be

contacted. Mr Duggan phoned the MRS at 4:26pm. At 4:35pm he dialled 111 and spoke to a St John Ambulance operator. He reported a major underground incident, possibly an explosion, and requested as much emergency care as possible. He said 25–30 people were underground, with no one yet accounted for and that he had not heard from those underground 'for almost an hour now'.<sup>14</sup> Mr Duggan then telephoned Coastwide Helicopters to order a helicopter so that Mr White could make a fly-over inspection of the main vent shaft.

34. At 4:45pm Mr Ridl phoned chief executive Peter Whittall in Wellington. He told him that there had been a major event underground and referred to Daniel Rockhouse's phone call from inside the mine, (see paragraph 39).
35. At 5:13pm Mr White flew by helicopter from the Pike River administration area to the top of the main vent shaft. He viewed the auxiliary fan site and returned to the administration area at 5:26pm. He saw smoke and damage and concluded that there had been an explosion.

## Daniel Rockhouse

36. Nearing 3:45pm Daniel Rockhouse was in the drift en route to stub 2 to uplift the gravel required for road repairs at the ABM worksite. He stopped at the diesel bay at pit bottom in stone to fill his loader with diesel and water. The loader was parked with the engine running. While he was turning on a water valve there was a bright white flash and he felt an extreme pressure blast. Felled by the explosion, Daniel Rockhouse hit his head and ended up lying on his back. His first impression was that the loader had blown up, but he then realised that the engine was still running, although spluttering. He turned it off. Small amounts of debris fell from the roof and the ribs, although there was no cave-in. Within seconds a pungent strong smell, and dense smoke, reached the area. The atmosphere was warm and breathing became difficult.
37. To escape the effects, Daniel Rockhouse went inbye towards the crushing station (see Figure 1.1). It was clearer, but there was no place of refuge. He donned and activated his self-rescuer and moved back out to the main drift. The self-rescuer did not seem to be working properly so he discarded it. In the drift, next to his loader, he was overcome and fell to the ground again. He shouted for help, but there was no response. His eyes watered, his body tingled and he thought he was 'shutting down'.<sup>15</sup> He lapsed into unconsciousness.
38. After some time he revived and sensed that feeling had returned to his fingers and toes. He was shivering with cold from lying in the mud. He tried to roll onto his stomach and push himself up, but he had no strength. Eventually he managed to stand, fell again and then was able to reach compressed air and water lines that ran along the rib. He turned on an outlet valve on the air line. There was only limited pressure, but enough flow to clear the smoke from around him. The fresh air was 'like gold'.<sup>16</sup>
39. After a minute or two breathing the fresh air and relieving the stinging of his eyes, Daniel Rockhouse looked for a telephone. Just inbye of his loader he located telephone 353 and rang the emergency number, 555. The telephone rang, but no one answered before the call was diverted to an answering service. He then dialled 410, the control room number. Mr Duggan answered the phone. Daniel Rockhouse said he was not injured, but that he could not see or breathe. At this point Mr White took the telephone, was told that the air seemed to be clearing and instructed Daniel Rockhouse to 'stay low', get to the FAB about 500m outbye and make contact from there.<sup>17</sup>
40. There is no record of the telephone call, or of its timing. However, it is apparent that Daniel Rockhouse made the call at approximately 4:40pm and that Mr Duggan answered it soon after his call to St John Ambulance. Immediately after Mr Strydom contacted him, Mr Duggan telephoned the MRS at 4:26pm. He then called and spoke to the St John operator until 4:39pm, twice mentioning he had not heard from anyone underground. Had Daniel Rockhouse already rung Mr Duggan, he would undoubtedly have said so.
41. It follows that Daniel Rockhouse was unconscious for a significant period, perhaps 50 minutes or so, after the explosion at 3:45pm until he made the phone call about 4:40pm.

## A rescue

42. After the phone call Daniel Rockhouse followed the compressed air and water lines along the rib and proceeded outbye. As he found outlet valves he opened them and breathed in fresh air. He left the valves open, thinking this would improve the atmosphere. About 300m outbye he encountered a vehicle stationary in the drift. A few metres beyond it, he found Russell Smith lying semi-conscious on the ground, with his eyes open, but rolling back in his head. He could hardly speak. He was not wearing a helmet and light. Daniel Rockhouse removed Mr Smith's self-rescuer from his belt, opened it and tried to insert the mouthpiece into the other man's mouth. He could not do so. Daniel Rockhouse discarded the self-rescuer, lifted Mr Smith from behind and dragged him outbye towards the FAB.
43. Mr Smith was also in C crew. He had missed the bus to the mine and was late for the 1:00pm start of the shift. He was driving into the mine when the explosion struck. Minutes before he had passed the McConnell Dowell drifrunner heading outbye. He received no warning before there was a flash of bright light and a deafening noise, followed by a shock wave. The pressure was unrelenting. In an attempt to escape it, Mr Smith lowered himself to gain protection within the cabin of the vehicle. As breathing became difficult he attempted to remove a self-rescuer from his belt, but he was in an awkward position and could not do so.
44. Mr Smith could remember nothing after this. He had no recollection of his rescue by Daniel Rockhouse. He came to in an ambulance en route to Greymouth Hospital. Subsequently, he realised he had minor pitted abrasions to his face and back. His speech was affected in the short term, as was his respiratory system.
45. On reaching the FAB, Daniel Rockhouse propped Mr Smith up in a sitting position against the rib and said, 'I'll be back in a sec.'<sup>18</sup> The FAB was a shipping container converted to include a two-door sealable entrance. Daniel Rockhouse thought it would provide a fresh air source, a telephone and spare self-rescuers. In fact, he found it had been decommissioned.
46. After venting his anger, Daniel Rockhouse returned to Mr Smith, got him to his feet and continued to drag him in an outbye direction. After a time he paused and asked Mr Smith whether he could walk. He tried, managed a few steps, but then fell. Daniel Rockhouse lifted him up again, and found that, if he supported Mr Smith, they could walk in tandem, with Daniel Rockhouse holding the rail of the conveyor belt to his left side for support. Periodically the pair stopped and looked inbye, hoping to see other lights coming down the drift. There were none. Daniel Rockhouse continued to open air valves as they went. To motivate Mr Smith, he told him to think of his family and to keep his legs moving for them.

## Two miners walk out of the portal

47. As they progressed outbye, the atmosphere became clearer and it was easier to breathe. Natural ventilation provided a fresh air flow inbye from the portal. At 5:26pm the two men completed the 1500m walk from the FAB to the portal. From the time of the phone call at 4:40pm it had taken them 46 minutes to walk out of the mine. No one was there to meet them. Daniel Rockhouse used the DAC to call the control room for help. Vehicles arrived at the portal within minutes. Mr Smith was incoherent and Daniel Rockhouse broke down. Paramedics gave both men oxygen and they were taken by ambulance to Greymouth Hospital.

## The emergency response

48. By 5:30pm the emergency response was well under way. Police, the New Zealand Fire Service, the MRS and St John Ambulance personnel were en route to or at the mine. Help from overseas would arrive over succeeding days, as a major search and rescue effort was launched to save the 29 missing men.

## ENDNOTES

<sup>1</sup> References to times throughout this chapter are taken from various sources, including equipment at Pike and from other organisations. The sources are not synchronised. As a result, there may be minor discrepancies between the times quoted from different sources.

<sup>2</sup> Department of Labour, Last Known Position of Deceased and Two Survivors. Final Version, 28 January 2011 (DOL Investigation Report, Appendix 3), DOL3000130004/2. ('A, B, & C headings' locations added to the map by the commission)

<sup>3</sup> Department of Labour: Transcription of the 'DAC' Underground Radio Communication System, 1 August 2011, INV.03.21043/32.

<sup>4</sup> Daniel Duggan, transcript, p. 1581.

<sup>5</sup> Department of Labour: Transcription of the 'DAC', INV.03.21043/32.

<sup>6</sup> Daniel Duggan, transcript, p. 1585.

<sup>7</sup> Ibid., p. 1586.

<sup>8</sup> Mattheus Strydom, transcript, p. 1037.

<sup>9</sup> Ibid.

<sup>10</sup> Department of Labour: Transcription of the 'DAC', INV.03.21043/32.

<sup>11</sup> Video recording, 19 November 2010, CAC0018.

<sup>12</sup> Mattheus Strydom, transcript, p. 1040.

<sup>13</sup> Ibid., p. 1047.

<sup>14</sup> Audio recording, 19 November 2010, CAC0047.

<sup>15</sup> Daniel Rockhouse, transcript, p. 1076.

<sup>16</sup> Ibid., p. 1077.

<sup>17</sup> Ibid., p. 1080.

<sup>18</sup> Ibid., p. 1086.

# Accident analysis – some concepts

## Introduction

1. The commission has sought the systemic reasons for the Pike River tragedy. The analysis, therefore, goes beyond the immediate cause to reveal the underlying causes and circumstances that allowed the tragedy to occur. In doing so, the commission has relied on expert evidence and international thinking. This chapter explains some concepts that have helped the commission in its evaluation and in preparing the report.

## The ‘what/why’ distinction

2. Causation can be a vexing issue. In determining the cause of an event, it is possible to focus on the immediate or proximate cause or causes, or to look beyond the immediate to identify not just what happened, but why. The commission has taken the second approach.
3. The ‘what/why’ distinction can be illustrated by an example. A machine operator in a factory overrides a protective guard and is injured. The immediate and proximate cause is human error (or violation): but for the operator’s action the machine could have been operated safely and the accident avoided.
4. Identifying what happened, and the result, has the advantage of simplicity. It allows responsibility to be assigned to an individual and blame to be attributed. And then the quest for explanation can stop.<sup>1</sup>
5. Until comparatively recently, accidents were routinely attributed to frontline operator error, and contributory causes were not considered, including the actions of those at management and governance level. The broader context, or setting, in which the operator acted was essentially ignored.<sup>2</sup>
6. If, by contrast, the question ‘why’ is asked – why did the operator act as they did? – a whole range of contributory factors may emerge. Perhaps the machine operator’s training was deficient, fatigue clouded their judgement, the machine guard inhibited production or overriding guards was commonplace in the factory.
7. The emergence of these factors prompts another level of inquiry. Why was operator training inadequate? Why was worker fatigue an issue? Why was the machinery not fit for purpose? Why was rule violation normalised? These questions invite greater scrutiny. Why were such problems not identified and addressed by management or at a governance level, where resources are allocated and an organisation’s direction is set?
8. The explosion and loss of 29 lives at Pike River demands a broad inquiry that extends to all levels of the company. Chapter 3, ‘The promise of Pike’, which examines the conception, approval and development of the mine, provides the backdrop for the examination of the mine and its systems in subsequent chapters.
9. But, as Dr Callaghan<sup>3</sup> explained, the inquiry must extend further still: ‘to interrogate the strengths and weaknesses at all levels of the “system” – the company, the industry, the regulator and the wider government’, at least if ‘intervention is [likely] to be as efficacious and efficient as it could be.’<sup>4</sup> The commission agrees.

## Human factors

10. Dr Callaghan also stressed the need to consider ‘human factors’ in accident analysis. Human factors are the ‘environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety.’<sup>5</sup> The definition identifies three interrelated aspects: the job,

the individual and the organisation, each of which requires consideration. The job is the task to be performed in a specific workplace, including, in particular, the demands posed by that task. The notion of the individual captures the characteristics that influence human behaviour, such as competence, experience, attitude and personality. Some of these are fixed; others are adaptable. The organisation includes such things as resources, leadership and culture – all the company-related factors that influence individual and group behaviour in a workplace.

11. The aim of the human factors discipline is to ‘understand and improve competence and safety at work.’<sup>6</sup> It seeks to answer such questions as:
  - Why do smart people do unsafe things?
  - Why don’t people do what they’ve been told?
  - Why are the same mistakes made over and over again?<sup>7</sup>

The questions expose the norm that error is a characteristic of human behaviour and therefore inevitable in any human system. It follows that any system relying on error-free human performance is fundamentally flawed. In any event, accidents are rarely the result of a single action, failure or factor, but rather of a combination of personal, task-related, environmental and organisational factors, some longstanding.<sup>8</sup>

## Personal safety and process safety

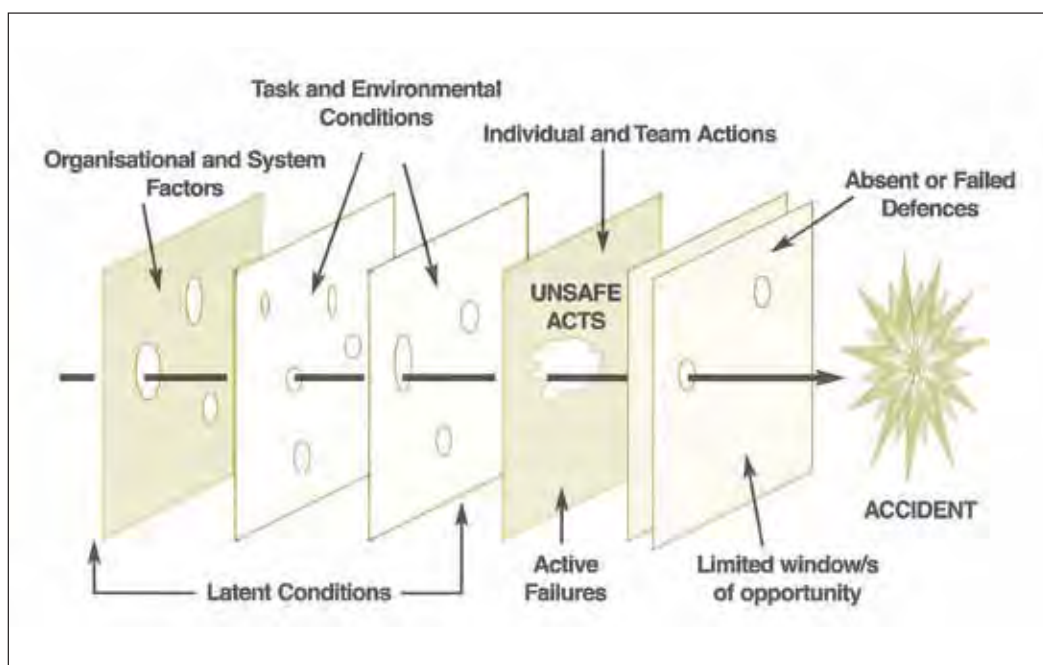
12. These terms distinguish between two types of accidents widely recognised in the literature. As well as having different characteristics, personal safety and process safety accidents require different approaches to their prevention and investigation.
13. Personal safety accidents may involve one person who is both the cause and the victim. The damage may be significant, but is confined to an individual or a small group of people. Such accidents are relatively frequent because they occur as a result of human errors or violations in relation to hazards that are close at hand (as in the machine operator example). Often they can be described as slips, trips and falls. The defences or protections that guard against them are normally simple and few in number. Typically there is little time between the failure and the accident.
14. Process safety refers to the prevention of the unintended escape of toxic substances, flammable material or energy from a plant or other workplace. In a mining context the consequence may be an explosion or a fire. Process safety accidents can be catastrophic, causing multiple deaths and large-scale personal and property damage. Typically the organisations that suffer process safety accidents have complex and layered defence systems intended to eliminate workplace hazards. These systems comprise a mixture of hard and soft controls. Hard controls are physical barriers and devices that guard against, monitor or automatically warn of hazards. Soft controls are the organisation’s practices and procedures, including operating standards, supervisory oversight and worker training.<sup>9</sup>
15. A layered defence system makes it unlikely that one failure, human or mechanical, will trigger an event. Rather, a combination of failures is required before the multiple defence systems are penetrated, with potentially catastrophic results. Hence the term ‘low frequency, high consequence events’ is used with reference to process safety accidents. Because these events are often separated by a number of years, or decades, complacency may develop, even to the point where an organisation becomes blind to a known catastrophic risk.
16. The indicators of personal safety and process safety are also different. The occurrence of personal safety accidents has usually been measured by the lost time injury rate of the company. This is a lag indicator, a measure of performance made after the event, actually a measure of failure. Many companies place considerable store on their lost time injury rate figures. They may be used to measure performance and thereby affect a senior manager’s bonus payment. They may attract the attention of the regulator, or even of an insurer in fixing a premium.
17. A measure of injury rates is of limited use, however, as an indicator of a looming process safety failure. For this, a mixture of lag and lead indicators is required. Lead indicators, sometimes called positive performance indicators, are

obtained from routinely monitoring selected critical risk controls to ensure their continued effectiveness. The choice of risk controls is important. They must be of a kind to measure process safety performance in relation to the major hazards at the particular workplace.<sup>10</sup>

18. An example relevant to Pike River illustrates the interaction of lag and lead indicators. Methane explosions in mines are prevented by gas management, a key element of which is methane monitoring. This is done partly by using methane sensors, hard controls, strategically located in the mine. The sensors provide a warning of excessive methane levels, or spikes. A high-level spike is a warning sign, while a number or pattern of spikes may be a critical indicator of a potential process safety failure. An associated soft control may be a maintenance programme used to routinely test the calibration and reliability of the sensors. Data confirming that the maintenance programme is carried out on time, and effectively, gives the added assurance that the information supplied by the sensors is accurate. But all indicators are not equal. Failure data, such as a pattern of methane spikes, may demand an immediate response; other indicators may be less critical. What matters most is that there is a range of safety indicators, and that they are analysed and used to drive improvements in safety performance.<sup>11</sup>
19. The explosion at Pike River was a process safety accident. Its occurrence raises many questions. Were the hard and soft controls at the mine adequate? How were the defence layers breached? Were lag indicators gathered and responded to? Were lead indicators used to check the effectiveness of hazard controls? Was there complacency about the existence of an explosion risk? These questions require the commission to look at the whole organisation, and to consider the actions of the regulator and others.

## The ‘Swiss cheese’ model of causation

20. James Reason also devised a causation method, commonly referred to as the ‘Swiss cheese’ model, which is of particular relevance to process safety accidents.<sup>12</sup>



**Figure 2.1: ‘Swiss cheese’ model of causation**

Each slice of cheese represents one layer of an organisation’s defence system. These are labelled by type (at the top), and also divided into latent conditions and active failures, and windows of opportunity. The holes in each slice represent gaps in the defence system. Some arise from active failures, human errors or violations, which are short-lived. Latent conditions reflect the decisions and actions of the people who design, influence, implement and manage aspects of an organisation’s operational systems, such as equipment selection and monitoring, information



gathering or safe operation systems. These are latent because they can lie undiscovered and dormant for long periods until a combination of failures triggers a near miss or an actual event.<sup>13</sup>

21. An organisation's defence systems reduce the likelihood of major accidents because an accident occurs only when the holes in the multiple defences align, hence the reference in the model to limited windows of opportunity. Chance plays a part in the occurrence, and timing, of accidents. Defence systems are also difficult to understand and manage. No one person can be expected to oversee the entire system.
22. An organisation-wide safety culture can help to keep holes in the defence systems to a minimum. Active failures, worker errors and violations are likely to diminish in a workplace with a good safety attitude. Latent failures should be more readily discovered if those who design, establish, monitor and review the safety systems are also well motivated. And, most important of all, a safety culture should help to ensure that warning signs are not ignored, but heeded and addressed.<sup>14</sup>
23. The commission has had regard to this model in its analysis.

## ENDNOTES

<sup>1</sup> Andrew Hopkins, *Failure to Learn: The BP Texas City Refinery Disaster*, 2008, CCH Australia, p. 10.

<sup>2</sup> Ibid.

<sup>3</sup> The commission acknowledges the evidence provided by Dr Kathleen Callaghan, the director of the Human Factors Group, Faculty of Medical and Health Sciences, University of Auckland.

<sup>4</sup> Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/59, para. 213(f).

<sup>5</sup> Health and Safety Executive (UK), *Introduction to Human Factors*, <http://www.hse.gov.uk/humanfactors/introduction.htm>

<sup>6</sup> Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/6, para. 9.

<sup>7</sup> Ibid.

<sup>8</sup> James Reason, 'Understanding Adverse Events: Human factors', *Quality in Health Care*, 1995, Vol. 4, No. 2, p. 85, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1055294/pdf/qualhc00016-0008.pdf>. Reason, who was Professor of Psychology at the University of Manchester 1977–2001, is a prolific writer on many aspects of safety management, including *Managing the Risks of Organizational Accidents*, Ashgate, 1997.

<sup>9</sup> BP U.S. Refineries Independent Safety Review Panel, *The Report of the BP U.S. Refineries Independent Safety Review Panel*, 2007, pp. 21–23, [http://www.bp.com/liveassets/bp\\_internet/globalbp/globalbp\\_uk\\_english/SP/STAGING/local\\_assets/assets/pdfs/Baker\\_panel\\_report.pdf](http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/SP/STAGING/local_assets/assets/pdfs/Baker_panel_report.pdf)

<sup>10</sup> Health and Safety Executive (UK), *Developing Process Safety Indicators: A Step-by-Step Guide for Chemical and Major Hazard Industries*, 2006, <http://www.hse.gov.uk/pubns/priced/hsg254.pdf>

<sup>11</sup> Andrew Hopkins, *Thinking About Process Safety Indicators* (Working Paper 53), May 2007, National Research Centre for OHS Regulation, Australian National University.

<sup>12</sup> Safety Wise Solutions Pty Ltd, 'Analyse Findings', in *Incident Investigation Reference Guide*, 2010, section 7, p. 2.

<sup>13</sup> James Reason, 'Beyond the Organisational Accident: The Need for "Error Wisdom" on the Frontline', *Quality and Safety in Health Care*, 2004, Vol. 13, Suppl. 2, p. ii29, [http://qualitysafety.bmj.com/content/13/suppl\\_2/ii28.full.pdf+html](http://qualitysafety.bmj.com/content/13/suppl_2/ii28.full.pdf+html)

<sup>14</sup> James Reason, 'Achieving a Safe Culture: Theory and Practice', *Work & Stress*, 1998, Vol. 12, No. 3, pp. 293–306.

# The promise of Pike

## Introduction

1. This chapter describes the physical characteristics of the Pike River coal field and the history of the mine's development over the 28 years between 1982 and the explosion in 2010. In broad terms there were three relevant periods: exploration of the coal field to 1995, mining feasibility studies to a final investment decision in 2005 and mine development to November 2010.

## Physical characteristics of the coal field

### Location of the coal field

2. The Pike River coal field is in a remote location on the eastern side of the Paparoa Range, about 45km north-east of Greymouth. It lies between Mount Hawera (1190m) to the north and Mount Anderson (1069m) to the south. The coal field occupies an area of about 7km<sup>2</sup>.



Figure 3.1: Location of the Pike River coal mine

3. Access to the coal field is from the Taylorville–Blackball Road on the western side of the Grey River, then up the Big River Valley on Logburn Road, from where an 11.7km private road leads to the mine.

## The land

- The coal field lies under conservation land, and partially under the Paparoa National Park. Its western boundary is a sheer 200m escarpment that is marginally within the eastern perimeter of the park. From the escarpment the coal field dips to the east and terminates at a major fault line, the Hawera Fault. The mine portal, situated more than 2km to the east of the fault, is on the true right bank of the White Knight Stream, 120m upstream from its confluence with the Pike Stream.
- The land area under which the coal field lies is administered by the Department of Conservation (DOC), the western margin and an area to the north under the National Parks Act 1980 and the balance under the Conservation Act 1987. DOC granted an access arrangement that authorised coal mining under the conservation estate. Easements granted by the Crown and a private landowner enabled construction of the mine access road. Pike River Coal Ltd owned an area of 87ha where its coal preparation plant (CPP) was built near the northern end of Logburn Road. Because of its remoteness the land above the coal field contains areas of virgin rainforest.

## Geology

- The geology of the coal field is complex, as can be seen from the simplified cross-sectional figure below. There are two coal measures, the Brunner seam, which was mined, and, approximately 200m below it, much older Paparoa seams. The Brunner seam consists of the main seam and above it a narrower rider seam, separated by interburden of variable thickness. The seams outcrop on the western escarpment. The Hawera Fault not only marks the eastern margin of the coal field, but has also deformed the seam upwards adjacent to the fault line.

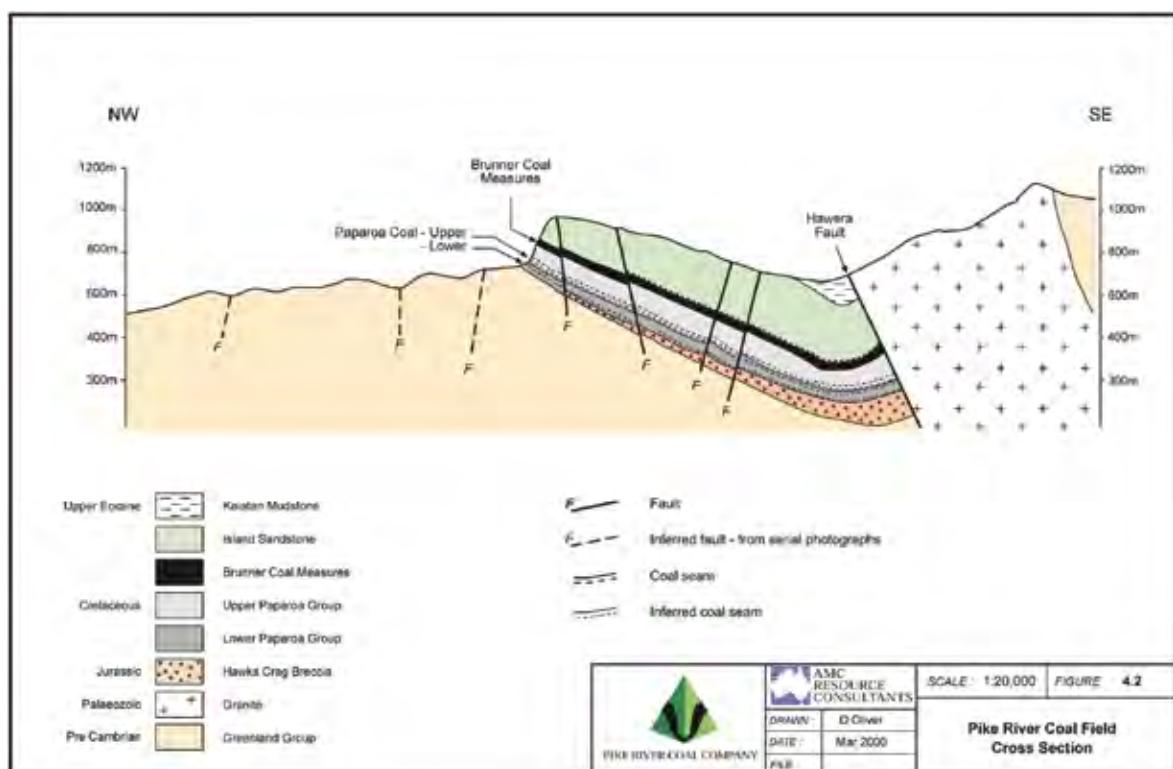


Figure 3.2: Pike River coal field cross-section<sup>1</sup>

- Other faults intersect the Brunner seam, which dips at a gradient of between 10° and 20°. Island sandstone of varying depths overlies the coal field depending upon the surface contours. As can be seen in the simplified diagram of the west to east cross-section below, the surface contour is highly variable, this being rugged country intersected by gullies and streams.

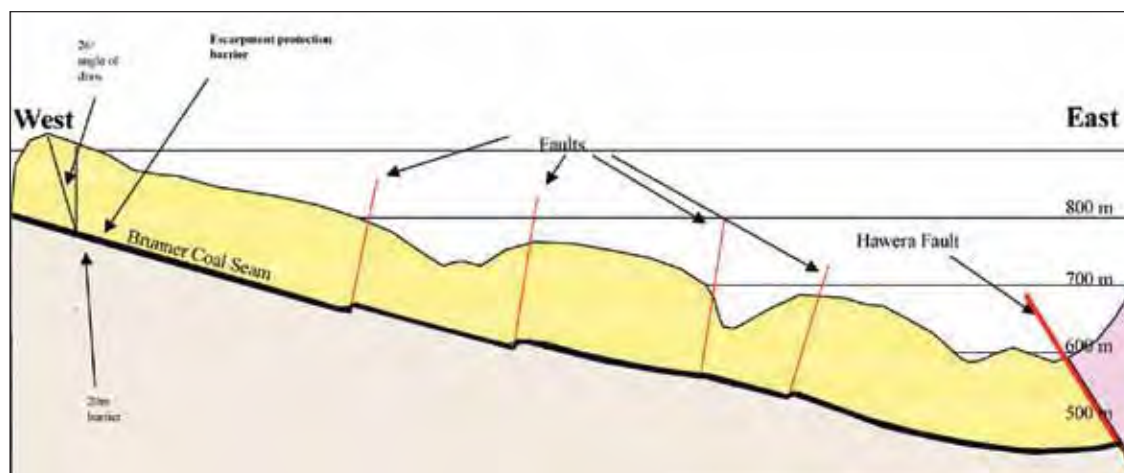


Figure 3.3: Pike River coal field west–east cross-section<sup>2</sup>

8. The Paparoa Range forms a barrier to the dominant westerly air flow from the Tasman Sea. As a result the coal field area has rainfall of up to 6m per annum. The altitude of the area makes it prone to snowfalls in winter; cloud and rain are the predominant climatic features for most of the year.

## Exploration of the coal field

### Outcrop sampling and drilling programmes

9. Although the existence of the two coal seams was well known, because of the outcrops on the western escarpment, exploration of the field did not begin until 1980. A mineral exploration company obtained prospecting licences and undertook geological mapping and the sampling of coal from the outcrops.
10. In 1982 the Pike River Coal Company Ltd (as it then was) was incorporated and took over the two prospecting licences by transfer from the previous holder. The following year the new company undertook a six-hole drilling programme (numbered PRDH1–6), using a drilling rig flown to each drill site by helicopter. Numerous core samples were obtained from the holes to a depth of between 130 and 270m.
11. In 1988 Pike became a wholly-owned subsidiary of New Zealand Oil & Gas Ltd (NZOG). Two years later, under a government-funded exploration scheme, one additional hole (PRDH7) was drilled to intersect both the Brunner and Paparoa seams. In 1993 the company obtained an exploration permit for a four-year term over an area of about 1782ha. In 1993 a further seven holes were drilled (M1–7) under a joint venture programme with Japanese firm, Mitsui Mining Engineering Co. Ltd.
12. On the strength of the testing of the cores obtained from these 14 drillholes, the company commissioned a pre-feasibility study in 1995, and the following year applied to the Ministry of Commerce for a coal mining permit. During mine construction, additional holes were drilled, but mainly in the area of the stone drift to the east of the coal measures, or in the area of the mine workings. Angled holes were sometimes drilled from a single site, to avoid moving the drilling rig. These holes provided geological information for the siting of underground infrastructure.
13. Dr Jane Newman gave evidence about the geology of the Pike River coal field. She first studied the area as a PhD student in 1980, was involved in some of the early drilling programmes and a geological modelling project in 2008. She subsequently offered the company informal advice during the construction of the mine. She said the coal field demonstrates both stratigraphic (strata) complexity and structural (faulting) complexity, and that one superimposed on the other does not simply double the complexity but increases it greatly. Given this complexity, it was not unusual for in-fill drilling to provide a grid at 100m spacings, given complex West Coast mining conditions.<sup>3</sup>
14. Dr Donald Elder, chief executive officer of Solid Energy, concurred, noting that detailed geological and coal information would have required boreholes at about 100m spacing.<sup>4</sup>

15. At Pike River boreholes were drilled on average from 400 to over 500m apart.<sup>5</sup>

#### Coal characteristics

16. Pike River contains one of New Zealand's largest deposits of hard coking coal. It has a low ash and phosphorus content, which gives it a competitive advantage over other coking coals. Early studies indicated a wide variation in the sulphur content of coal within the Brunner seam. Selective mining would be needed to ensure sulphur limits were not exceeded.
17. In 2007 Pike planned to extract and export high-quality, hard coking coal.<sup>6</sup>

## From feasibility to final investment decision

#### Pre-feasibility study

18. A Christchurch mining consultant, CMS Ltd, undertook the 1995 pre-feasibility study. The key recommendations were that assessment of the coal field should continue to the feasibility stage, that seven more drillholes were required to confirm the coal reserve quality and to provide geotechnical assurance, and that access agreements should be obtained as early as possible. Development costs were estimated to be \$29 million, including \$13.65 million to develop the access road and establish the mine, \$4.55 million for plant and equipment and \$5.85 million as a 25% contingency allowance.<sup>7</sup>
19. NZOG commissioned a further pre-feasibility study in 1998 from Auckland-based Minserv International Ltd. The study included an assessment of the benefits of using hydro mining at Pike River. It described the 'significant dip' of the seam, allowing a water-assisted gravity flow of coal from the workings to pit bottom, from where it could be carried by a slurry pipeline to the CPP. Using this method, annual production of between 460,500 and 502,380 tonnes was estimated.<sup>8</sup> Minserv also completed a revised financial model, including hydro-mining costings, and arrived at a capital outlay of \$43.26 million for the three initial development years.<sup>9</sup>

#### Mining permit

20. The company applied for a mining permit in March 1996. The application estimated the total recoverable coal reserves to be 26.7 million tonnes. Three years would be needed to develop the mine to the point of coal production, after which the life of the mine was estimated at 40 years.<sup>10</sup>
21. Mining permit number 41-453 for an underground coal mine was granted in September 1997. It was issued for a period of 40 years subject to mining beginning within five years and an average of 300,000 tonnes of coal being mined per annum. The total area covered by the permit was 1611 ha, but this area was increased by 333ha in January 1998.<sup>11</sup>

#### An access arrangement

22. In June 1998 the company applied to DOC for an access arrangement so it could mine for coal beneath the conservation estate. No application for an open cast mine was made, nor was such a proposal discussed. A detailed six-year process followed before the terms of an agreement were resolved. DOC was concerned to safeguard and preserve the land as required of it under the Conservation Act 1987 and the National Parks Act 1980. Its concerns included land subsidence, fire control, protection of flora and fauna, mine water discharge, protection of the western escarpment and protection of breeding habitats.
23. Numerous environmental reports and risk assessments were obtained to assess the risk from surface activities and underground mining. DOC engaged its own experts and there were exchanges between consultants in an endeavour to find acceptable solutions. In October 2000 the access application was amended after the area of the mining permit had been enlarged to include the area required for the mine access road.<sup>12</sup>



24. In March 2004 the minister of conservation approved the arrangement, but subject to the drafting of conditions.<sup>13</sup> On 21 October 2004 a 25-year access arrangement was signed. The agreement conditions were extensive. Surface subsidence limits were prescribed, and the company agreed to develop 'trial mining panels' to demonstrate that any surface disturbance fell within the defined limits. A mining buffer zone prevented mining close to the western escarpment, and no 'untreated mine water' could be allowed into the tributaries of the Big River. Specific consent was required for any surface activity that could affect flora or fauna, such as establishment of drilling sites, roadworks or the construction of helicopter landing areas. The company also had to provide an annual work plan, fund a liaison person for the term of the agreement and arrange insurance and bonds for its obligations under the agreement.<sup>14</sup>
25. The rigour of the process and the detailed controls contained in the access agreement left no room for doubt concerning the high level of protection to be given to the surface environment of the mine. Pike understood and respected DOC's requirements. Regular liaison meetings occurred, mostly at the mine site. These worked well, so that for example every drillhole approval sought by Pike was approved by DOC.<sup>15</sup>
26. During the mine development seven variations to the access arrangement were negotiated to cover unanticipated environmental requirements and 144 work plan variations occurred.<sup>16</sup>

### Resource consents

27. In mid-1998 the company applied for various resource consents from the Greymouth and Buller District Councils and the West Coast Regional Council. These were granted in June 1999. They covered a wide range of activities, including taking water from the Pike Stream; construction of the stone drive, ventilation shaft, access road, slurry pipeline, bridges, power and telecommunications lines, and the CPP; as well as consents required for a coal stockpile. However, in July 1999 interested parties lodged appeals to the Environment Court against the resource consent decisions.
28. In May 2002, to respond to concerns raised by the appellants, the company obtained a report on the environmental effects of the coal field development from consultant URS New Zealand Ltd. This outlined changes in the company's approach, including relocating the mine portal from beside the Pike Stream to its eventual location on the White Knight Stream. This increased the length of the stone drift by 400m, but avoided the need for road development beside the Pike Stream.<sup>17</sup>
29. In the end the Environment Court appeals were resolved by a consent order of the court, which approved numerous resource consents incorporating changes to those originally granted.<sup>18</sup>

### The final investment decision

30. In June 2000 AMC Resource Consultants Pty Ltd provided the company with a final feasibility study. This assessed all aspects of the mine project from the extent of the resource to the proposed mine systems and required workforce. AMC was not paid a consultancy fee, but instead received a 25% shareholding in the company.
31. The study was not acted upon for some time. Instead the company focused on obtaining the access arrangement and resource consents, which were finally in place by late 2004. Minarco Asia Pacific Pty Ltd (previously AMC) then prepared an updated study, particularly of the capital costs to continue the project.
32. These were reflected in a mine plan and financial model ('the joint report') presented to the Pike board in July 2005 by Gordon Ward, the general manager, and Peter Whittall, the mine manager. Mr Ward was an NZOG appointee who, in 1998, assumed responsibility for the Pike River project. His background was in accountancy and auditing, not mining. Mr Whittall, who joined the company from Australia in February 2005, was a mining engineer and experienced in coal mine development and management.<sup>19</sup>
33. The joint report recommended that the board accept the proposed mine plan and development strategy, and authorise management to execute the plan including employing 'such staff as are required to complete the capital works within the approved budget'. On 20 July 2005 the board made a final investment decision in the terms recommended.

34. The capital development of the mine was costed at \$124.1 million to September 2007, including the following amounts and completion dates:

Access road	\$11.75 million	April 2006
Tunnel (drift) development	\$21.3 million	September 2006
Hydro set-up	\$28.4 million	October 2007
Full coal production	-	February 2008

Production capacity was estimated at 'up to 1.4Mtpa' (million tonnes per annum), comprising 20% from mine roadway development and 80% from hydro mining. A peak workforce of about 150 people was contemplated to enable a seven-day, three-shift operation; contractors would be used for 'specialist activities'.<sup>20</sup>

### Optimism prevailed

35. The company embarked upon development of the mine with optimism and confidence. Mr Ward, speaking at the November 2008 annual general meeting, referred to Pike River as a 'special mine', with 'the largest and most valuable hard coking coal deposit in the country' and 'the lowest ash content in the world and a high fluidity level'. These properties would make the coal attractive to the international steel and coke industries. These qualities were complemented by investment in 'new modern machinery and equipment, and [a] recruited skilled mining staff to make sure we achieve that target ... approximately one million tonnes of coal a year for each of the next 18 years'.<sup>21</sup>
36. At the 2009 annual general meeting Mr Ward told shareholders that 'Pike River's state-of-the-art hydro monitors will cut ... around 2,200 tonnes per day; that's about 800,000 tonnes a year' while roadway development would 'add another 200,000 tonnes a year on average'. The mine enjoyed advantages because of 'mining uphill nearly all the time and being able to use gravity to flume and pipe coal out of the mine', and because it had 'much larger hydro-mining pumps' and was generally 'designed to be a bigger mine than all other New Zealand underground mines'.<sup>22</sup>

## Mine development

37. The mine infrastructure includes the coal stockpile and loadout facility at Ikamatua, 22km from the CPP and bathhouse, and the mine amenities area, about 7km up the access road from the CPP. The amenities area includes offices, the operations control room, and workshop. The portal is a further kilometre up the access road from the amenities area.

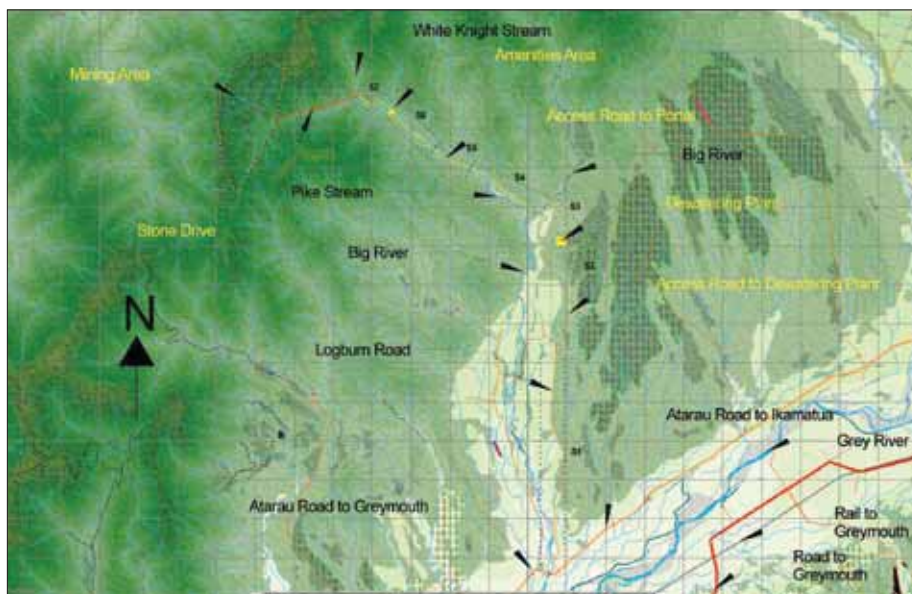


Figure 3.4: Pike River mine environs<sup>23</sup>



38. Underground, the stone drive, or drift, stretches about 2.3km from the portal to the coal seam. It provided intake air, transport for men, materials and coal, and provision for power, water and communications services. A vertical ventilation shaft, over 100m deep, provided return ventilation and a second means of egress. A second drive was to be established as the mine developed towards the north-west of the licence area.

#### Access road

39. Work on construction of the access road from the CPP to the mine portal began in December 2005. As well as establishing a single-lane roadway, with passing bays, Ferguson Brothers, the Greymouth contractor, was required to construct several bridges.<sup>24</sup> The road was completed in September 2006, five months after the completion date envisaged in the joint report to the board. In November Ferguson Brothers won the Canterbury Contractors Federation Environment Award and Contractor of the Year for projects over \$1 million for its successful construction of the road through virgin native forest and conservation estate.

#### Pike River share offer

40. On 22 May 2007 Pike River Coal Ltd issued a prospectus offering 65 million \$1 shares for public subscription.<sup>25</sup> The company was still a subsidiary of NZOG, which held a 54% stake. The next two biggest shareholders were Indian companies, Saurashtra World Holdings and Gujarat NRE Ltd. Their combined shareholding was about 32%, with smaller investors holding the balance of the shares.<sup>26</sup>

41. The prospectus included these financial details:

Total development costs:	\$207 million	(exclusive of pre-development costs of \$16 million) being:
	\$64 million	spent to May 2007
	\$99 million	to finish development
	\$11 million	contingency sum
	<u>\$33 million</u>	production working capital
	<u>\$207 million</u>	

The capital required, therefore, was \$143 million, which was to be sourced from the share issue, some cash on hand and new borrowings. The prospectus anticipated coal production (in tonnes) of 243,000 in 2008, 1.039 million in 2009 and 968,000 in 2010.

A total production of 17.6 million tonnes over a 19-year mine lifespan was predicted, at an average annual extraction rate of 967,000 tonnes.<sup>27</sup>

42. The share offer was oversubscribed and 85 million shares were allotted to new investors. NZOG's shareholding reduced to 31%, so that the company ceased to be an NZOG subsidiary.<sup>28</sup> In July 2007 the company was listed on the New Zealand and Australian stock exchanges.<sup>29</sup>

#### Construction of the drift

43. McConnell Dowell Constructors Ltd developed the drift and the main ventilation shaft, as well as some surface facilities. Tunnelling work started in September 2006. The drift was to have a horseshoe profile, to form a roadway 5.5m wide and 4.5m high.<sup>30</sup> It was inclined upwards by about 5° over its length. This allowed the drift to intersect the Brunner seam near to its lowest point.
44. There were variations to the contract during the development of the mine. The most significant change was the inclusion of an area known as pit bottom in stone.<sup>31</sup> This comprised 500m of roadways, either side of the drift, at about 1900m inbye, as depicted below. This area was to house a coal crushing station and water pumps used to provide water to the working faces in the mine, and water to the slurry pipeline leading to the CPP. During construction methane was encountered and some frictional ignitions occurred. Until then the work was deemed

tunnel development, but the ignitions caused the Department of Labour (DOL) to designate the tunnel a 'gassy mine'.<sup>32</sup> This designation meant that project control also passed from McConnell Dowell to Pike.

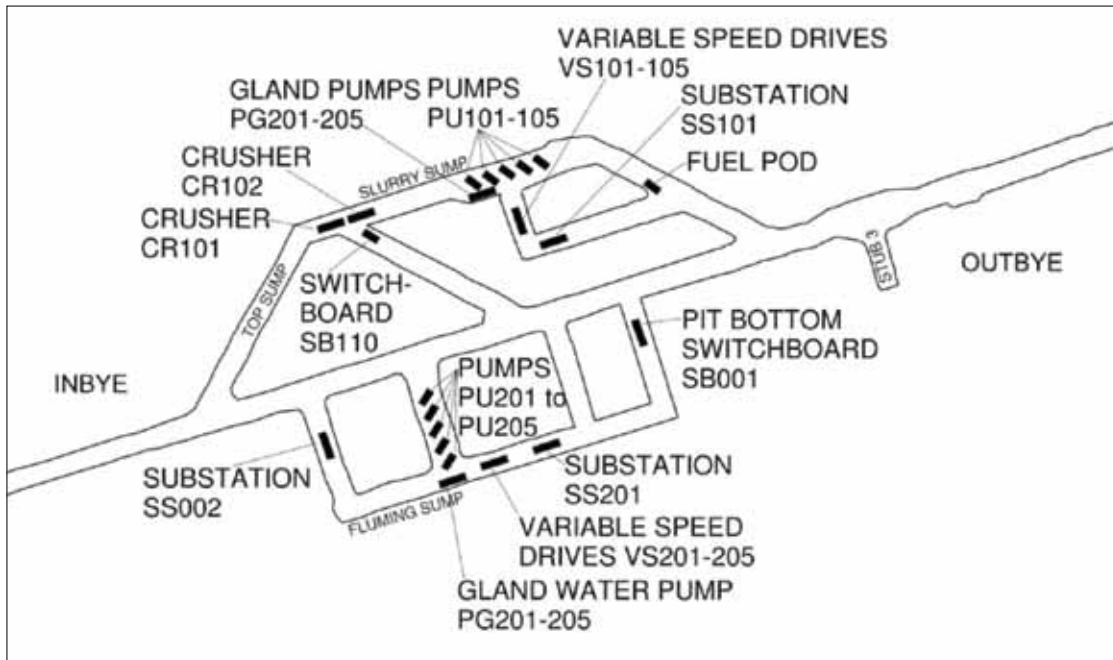


Figure 3.5: Plant location pit bottom in stone<sup>33</sup>

Originally this area was to be developed to the west of the Hawera Fault, but a decision was taken to develop it in the hard gneiss stone.

45. In December 2008 the drift and pit bottom in stone were completed. This was two years and three months after the completion date in the joint report, and five months after the estimated date in the prospectus. Even allowing for the additional work, there was considerable delay, caused largely by unfavourable ground conditions. The contract with McConnell Dowell included a per metre payment rate based on rock quality. Because most of the drift attracted the highest metre rate, the total cost was about 100% over budget.<sup>34</sup> In August McConnell Dowell won a New Zealand Contractors Federation award for its work on a 'technically and geologically complex project' in the over \$20 million category.
46. On 27 November 2008 the mine was officially opened to mark 'the breakthrough to coal and achievement of operational status'.<sup>35</sup>



Figure 3.6: Minister of Energy and Resources, the Hon. Gerry Brownlee, Pike Chief Executive Gordon Ward, Chair John Dow and General Manager Peter Whittall at the opening of the Pike River mine

### Development of the ventilation shaft

47. By late 2007 a final decision was required about the site of the ventilation shaft, so that McConnell Dowell could develop the surface collar to the shaft over summer. The company did not want it outbye of the Hawera Fault, in stone, because of cost and significant problems with land stability. The site of an existing drillhole (PRDH13) was investigated, and a new drillhole (PRDH31) was bored. In September a site inbye of the Hawera Fault was finalised and in late summer McConnell Dowell constructed and grouted the surface collar.<sup>36</sup>
48. But the shaft could not be completed until the drift was through the Hawera Fault and a roadway was driven to the ventilation shaft site. In December 2008 a bore began to ream out the shaft from the bottom up to the surface. This was completed in January 2009, but in early February 2009, before the 4.2m diameter shaft was fully lined, the bottom section collapsed, sealing any connection between it and the mine roadway.<sup>37</sup>
49. Following investigation the company decided to abandon the bottom 35m, cap it with concrete and construct a bypass to reconnect to the upper 70m of the shaft, as shown in the diagram.

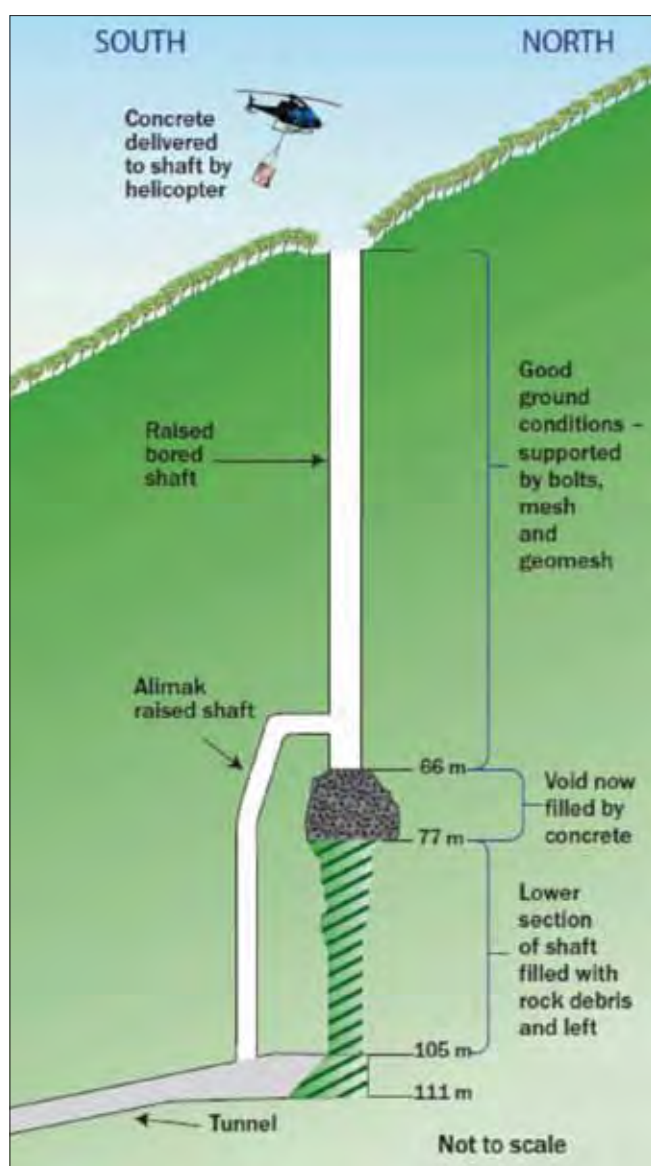


Figure 3.7: Ventilation shaft and Alimak raise<sup>38</sup>

The bypass, called the Alimak raise, was constructed between April and June 2009. The raise was only 2.5 by 2.5m, and connected to the 4.2m diameter shaft. Obviously, the cost of the Alimak raise was unexpected, as was the five-month delay.

50. During this period, Pike also drilled a 600mm 'slimline' shaft to improve air capacity. It was completed in May 2009. A fresh air base, so called, was later established at the bottom of the slimline shaft to provide air in the event of an emergency.

### Mine roadway development

51. From November 2008, when the drift reached its 2.3km design length and was through the Hawera Fault, mine roadway development began. The first roadway was driven 75m north, to the base of the proposed ventilation shaft.<sup>39</sup> Further roadway development was planned to the south, where there would be more mine facility infrastructure, and to the west, where coal extraction was to be centred.
52. These roadways, 5.2m wide by 3.6m high, provided access for men and machines, and carried such services as ventilation ducting; water, compressed air and methane pipes; and a coal flume to transport coal and water from the working faces. The roadway walls (ribs) and roof were bolted and secured with mesh for strata support.
53. In anticipation of roadway development, horizontal in-seam drilling of the Brunner coal seam began, using a drilling rig. Exploratory boreholes were drilled hundreds of metres into the seam to define the seam limits and to obtain geological data. The boreholes also released methane from the seam, although this was secondary to seam exploration.
54. Holes drilled to the west revealed the existence of a graben, a downthrust zone between two fault lines, which in this instance had depressed the coal seam and substituted a zone of island sandstone. Situated close to the Hawera Fault, the graben was about 200m wide. Driving roadways through the sandstone 'took several months longer than initially expected' and delayed mine development.<sup>40</sup>
55. By April 2010 roadways through the graben were completed and the rate of development improved.

### Mining machinery

56. The company purchased three mining machines for use in roadway development, two continuous miners and one roadheader at a total cost of \$14 million.<sup>41</sup> The continuous miners were configured to cut the width of a roadway in two passes, bolting the roof and ribs at the same time. The roadheader was also suited for cutting stone.
57. The continuous miners proved unsatisfactory for the conditions. They were not fast enough and suffered heavy wear and tear while cutting through the graben. In the third quarter of 2010 one was withdrawn from service so it could be modified. This work was expected to take three months.
58. In August 2010 another brand of continuous miner, called the ABM20, was leased and began operating. It could cut a 5m roadway in a single pass and bolt at the same time. The ABM20 achieved improved daily advance rates. This led the company to buy another ABM20, to be delivered towards the end of the year.<sup>42</sup>

### Hydro mining

59. Initially the mine plan and access arrangement required trial panels in the north-western corner of the coal field to assess whether coal extraction caused surface subsidence. Roadways were to be driven to this area and hydro-mining panels established. Mining would then retreat back in a south-easterly direction, so that the last coal taken would be from the pit bottom area. However, delays and cost overruns forced a rethink. Mr Whittall raised with DOC the concept of a 'commissioning panel' to allow initial coal extraction close to pit bottom. This would provide \$15–\$20 million of revenue, and the company would then revert to the original plan.<sup>43</sup> This proposal was agreed to. In early 2010 approval was given to develop a smaller 'bridging panel' nearer to pit bottom.
60. Hydro mining started in September 2010. A hydro monitor cut the coal, using a high-pressure water jet. The coal was then collected and flumed under gravity to the slurry pipeline. The monitor gradually retreated, leaving a void, or goaf, from which coal had been extracted.
61. Teething problems affected hydro extraction. Coal production was not at the desired rate, owing to equipment problems, the hardness of the coal, mining crew inexperience and methane control difficulties.<sup>44</sup>

### Ventilation

62. Effective ventilation is essential in an underground coal mine. The ventilation system must deal with coal gases and dust, as well as supplying the miners with sufficient air at acceptable temperature and humidity levels. During the development of the drift a fan at the portal ventilated the mine. It was replaced in mid-2009 by a fan at the top of the ventilation shaft. In mid-2010 a new main ventilation fan was installed underground next to the main vent shaft. It was designed to draw air into the mine from the portal and expel polluted air up the shaft and out of the mine. The fan was commissioned in October 2010.
63. This is thought to be the first time a main fan had been located underground in a coal mine anywhere in the world. Some metalliferous mines have underground main fans, but they do not face a methane hazard. In locating the fan underground the company faced a number of challenges. The fan motor was not flameproof and had to be situated 'in fresh air' in an intake roadway, with the fan blades located in a return roadway to expel polluted air up the ventilation shaft. The fan was vulnerable in the event of an underground fire or explosion, dependent on a power supply cabled into the mine from the portal and inaccessible to electricians in the event of an underground emergency. It also experienced teething problems after it was installed.

### Workforce

64. In October 2008 Pike River employed 82 full-time staff members.<sup>45</sup> Two years later the workforce numbered 174. Over the previous 12 months the company had been engaged in a 'significant offshore recruitment drive to build a top quality workforce'. The workforce included about 80 locals, other New Zealanders and a significant number from overseas.<sup>46</sup>
65. The company also employed between 20 and 60 contractors including 'significant use of local contracting companies'.<sup>47</sup> This exponential increase in numbers created a demand for training courses, particularly as many people were new to New Zealand conditions, or new to the industry.
66. There was also a staff retention problem. One example of this was the turnover of mine managers at Pike River. From September 2008 until the date of the explosion six men held the position on a permanent or acting basis. A seventh person, Stephen Ellis, was to assume the role, as soon as he obtained a first class mine manager's certificate of competence.

### An environmental award

67. In September 2008 DOC recognised Pike River for 'the environmental consideration it had demonstrated in the establishment of [its] mining facilities'.<sup>48</sup> The surface footprint on conservation land was restricted to only the 13ha needed to establish the 10km access road and locate administration buildings. Predator control programmes, constructing the road to wind through ancient native trees and blending buildings into the native bush setting also won praise. Two months later, on a visit to the mine, Minister of Conservation Chris Carter added that it was a 'showcase development which had set a new environmental standard for coal mining'.<sup>49</sup>

### Coal production and capital fundraising

68. In its 2007 prospectus Pike River anticipated that coal production would begin in the March 2008 quarter, with production of 243,000 tonnes for that calendar year, which would generate a cash flow of \$38 million at an average sale price of \$157 per tonne.<sup>50</sup> The first two coal shipments were not until February and September 2010, when 20,000 and 22,000 tonnes, respectively, were sold for around \$9 million.<sup>51</sup> In October the company announced that its production forecast to June 2011 was downgraded from 620,000 to 320,000–360,000 tonnes.
69. The company therefore had to raise funds to meet operational and capital costs in each of its last three years of operation. In February 2010 Pike River announced a \$90 million fundraising initiative. It raised \$10 million from a share placement in April and \$40 million from a rights issue in May. By October 2010 capital raised over the previous three years had increased the number of ordinary shares on issue from 200 million on listing in 2007 to over 405 million.

70. In May 2010 NZOG advanced the company US\$28.9 million (NZ\$41 million) upon the security of a convertible bond. This sum was required to repay a debt owed to a Goldman Sachs entity (Liberty Harbor), after Pike River breached a production covenant contained in the loan agreement. In September NZOG also granted a short-term loan facility of \$25 million to meet a projected cash shortfall. In October Pike River drew down \$13 million.<sup>52</sup>
71. On 18 November, the day before the explosion, the company was on the brink of raising a further \$70 million capital involving a share placement to ordinary shareholders of \$25 million and to institutional investors of \$45 million, fully underwritten by a major international investment bank. John Dow, chair of the board, considered that this \$70 million would have carried the company through to the third quarter of 2011 when 'we expected to be in fully steady state hydro-mining.'<sup>53</sup>

#### NZOG's review of its investment

72. NZOG reviewed its investment in Pike during 2010.<sup>54</sup> It obtained management and technical reviews of Pike from Behre Dolbear Australasia Pty Ltd (BDA). The reviews contained recommendations, including the need to address equipment matters, tighten reporting and project management, ramp up production and accelerate training programmes. BDA noted that 'the impression (correct or otherwise) is that there does seem to be more of a focus on the market than the project, and there is a lot of effort being expended on presenting the project to the broking community'.<sup>55</sup>
73. David Salisbury, the managing director of NZOG, says that, on 23 August 2010, he and Antony Radford, chairman of NZOG and a director of Pike, told Mr Dow that NZOG had lost confidence in both Pike's chief executive officer, Mr Ward and general manager, Mr Whittall,<sup>56</sup> but Mr Dow recalled that the criticism as confined to Mr Ward.<sup>57</sup> On 10 September Mr Ward's resignation was announced. On 13 September Pike's board announced the promotion of Mr Whittall to chief executive officer. Mr Dow commented in the board minutes that 'Pike River had in the past consistently overpromised and under delivered. This time it was important that we did a better job of forecasting the production schedule.'<sup>58</sup>
74. On 23 November 2010, four days after the explosion, the company sought to draw down the remaining \$12 million under the short-term facility; NZOG agreed.<sup>59</sup> On 8 December Pike River was insolvent and was placed in voluntary receivership.

## Challenges faced in 2010

75. The commission considers that Pike River faced several serious challenges during 2010:
- It was operating in an area where, as Dr Elder said, 'the geology, geography and climate of the West Coast [made] all the processes around coal mining, not just the mining extraction process itself, as hard or harder than most other locations in New Zealand and in the world'.<sup>60</sup>
  - Development of the mine had been affected by uncertainty owing to insufficient geological investigation before construction work began. Problems in driving the drift, the collapse of the vent shaft and the discovery of the graben demonstrated the extent of the deficit, which was likely to cause further difficulties.
  - Unsuitable machinery significantly hindered the mine's development, though good progress had been made towards addressing this issue.
  - The mine was in start-up mode, with a recently recruited and inexperienced workforce, and faced retention problems, particularly in relation to those in statutory and management positions.
  - A new main ventilation fan had been installed in an underground location, a first in the coal mining world, and was still being bedded down.
  - Hydro mining had begun, but production was held back by a combination of inexperience, equipment limitations and a methane control problem.



- Delayed production weakened the company's financial situation, resulting in a need to focus on fundraising.
- Its failure to meet targets, increased borrowings and shareholder discontent meant that the company faced significant risks to its reputation and credibility.

76. Together, these issues represented a major challenge to the company. In her evidence, Dr Kathleen Callaghan highlighted many of these same factors and expressed the opinion that 'the information I have seen shows me recurring patterns of causal factors that I know are well established in the literature to increase the likelihood of a process safety event.'<sup>61</sup> The commission agrees with this assessment.

## ENDNOTES

- <sup>1</sup> AMC Resource Consultants Pty Ltd, Final Feasibility Study, Vol. 1, 23 June 2000, DOC0010030006/23. ('Hawera' corrected by the commission)
- <sup>2</sup> Ibid., DOC0010030006/92. ('Hawera' corrected by the commission)
- <sup>3</sup> Jane Newman, transcript, pp. 192, 200.
- <sup>4</sup> Donald Elder, witness statement, 8 June 2011, SOL306956\_1/26, para. 70.
- <sup>5</sup> Donald Elder, transcript, p. 20; Jane Newman, witness statement, 30 March 2012, NEW0069/5, para. 11.
- <sup>6</sup> Pike River Coal Ltd, New Zealand Prospectus: An Offer of Shares in a Major New Zealand Coal Company, 22 May 2007, DAO.012.02790/133, para. 4.1.
- <sup>7</sup> CMS Ltd, Pike River Coal Mine Pre-feasibility Study, 25 May 1995, DAO.012.03289/33,42.
- <sup>8</sup> Minserv International Ltd, Pre-feasibility of the Pike River Coal Mining Project, March 1998, DAO.012.03362/3.
- <sup>9</sup> Minserv International Ltd, Pike River Coal Field Pre-feasibility Study, September 1998, DAO.012.03403/10.
- <sup>10</sup> Pike River Coal Company Ltd, Application to the Ministry of Commerce for a Coal Mining Permit Covering the Pike River Coal Field, February 1996, MED0010070015/4, 12,15.
- <sup>11</sup> Paul Carpinter, (Secretary of Commerce), Certificate of Extension of Permit Area, 21 January 1998, DAO.012.03587/2–5.
- <sup>12</sup> Department of Conservation, Tier Two Paper, 3 June 2011, DOC0000010001/46–47.
- <sup>13</sup> Ibid., DOC0000010001/51.
- <sup>14</sup> Access Arrangement Under Crown Minerals Act 1991, Mining Permit 41-453 Pike River Coal Company Limited, 21 October 1994, DOC0010020044.
- <sup>15</sup> Mark Smith, transcript, p. 487.
- <sup>16</sup> Craig Jones, transcript, p. 461; Department of Conservation, Tier Two Paper, 3 June 2011, DOC0000010001/63–66.
- <sup>17</sup> URS New Zealand Ltd, Assessment of Environmental Effects for the Pike River Coalfield Development, 3 May 2002, DOC0010020043\_24/22–23.
- <sup>18</sup> John Dow, witness statement, 9 June 2011, DAO.001.0003/25–26, para. 146.
- <sup>19</sup> New Zealand Oil & Gas Ltd, Paper Phase One – Context, 25 May 2011, NZOG0067/55, paras 6.88, 6.89.
- <sup>20</sup> All preceding quotes and figures from Peter Whittall and Gordon Ward: Pike River Coal Company Ltd, Pike River Coal Company Final Mine Plan and Financial Model, 13 July 2005, DAO.012.03499.
- <sup>21</sup> Pike River Coal Ltd, AGM Managing Directors Address, 28 November 2008, DAO.009.10795.
- <sup>22</sup> Pike River Coal Ltd, 2009 AGM – Managing Directors Address, 23 November 2009, DAO.008.16781.
- <sup>23</sup> Map, DAO.004.11082/1.
- <sup>24</sup> New Zealand Oil & Gas Ltd, Paper Phase One, NZOG0067/57, paras 6.97, 6.99.
- <sup>25</sup> The company name was changed from Pike River Coal Company Ltd on 13 March 2006.
- <sup>26</sup> Pike River Coal Ltd, Prospectus, DAO.012.02790/156.
- <sup>27</sup> Ibid., DAO.012.02790/12.
- <sup>28</sup> New Zealand Oil & Gas Ltd, Paper Phase One, NZOG0067/8, para. 2.8.
- <sup>29</sup> John Dow, witness statement, DAO.001.0003/5–20.
- <sup>30</sup> Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/12, paras 44–45.
- <sup>31</sup> Pike chose to put pit bottom in stone so that large excavations could occur in a stable environment: Peter Whittall, transcript, p. 713.
- <sup>32</sup> Health and Safety in Employment (Mining Underground) Regulations 1999, regs 2, 35–40, 55–59; Email, Kevin Poynter to Kobus Louw, 14 November 2008, DOL3000010087.
- <sup>33</sup> Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119\_181, 22 March 2011, DAO.010.13140/1. (Extract of plan with typographical error corrected by the commission)
- <sup>34</sup> Behre Dolbear Australasia Pty Ltd, Pike River Coal Project – Greymouth New Zealand Independent Technical Review, 20 May 2010, NZOG0065/8,10.
- <sup>35</sup> Pike River Coal Ltd, Activities Report: Quarter Ended 31 December 2008\*, DAO.008.04847/1.
- <sup>36</sup> Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/22–23, paras 90, 93.
- <sup>37</sup> Don McFarlane, witness statement, 30 May 2011 RM.0002/14–15, paras 8.13–8.20.
- <sup>38</sup> Pike River Coal Ltd, Activities Report: Quarter Ended 30 June 2009\*, DAO.007.10907/2.
- <sup>39</sup> Pike River Coal Ltd, Submission for Pike River Coal Limited (In Receivership) in Relation to Certain Topics for Consideration in Phase One of the Royal Commission of Inquiry, 27 May 2011, DAO.001.0002/36, para. 245.
- <sup>40</sup> Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/5.
- <sup>41</sup> Pike River Coal Ltd, Activities Report: Quarter Ended 31 December 2008\*, DAO.008.04847/2.
- <sup>42</sup> Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/6.
- <sup>43</sup> Department of Conservation, Meeting Notes, 21 December 2007, DOC3000010003/2.
- <sup>44</sup> Masaoki Nishioka, transcript, pp. 3488–544.
- <sup>45</sup> Pike River Coal Ltd, Submission, DAO.001.0002/36, para. 244.
- <sup>46</sup> Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/11.
- <sup>47</sup> Ibid., DAO.008.05092/12.
- <sup>48</sup> Department of Conservation, certificate, 11 September 2008, DOC0010020097/1; Pike River Coal Ltd, Annual Review 2008: Breakthrough to Coal, DAO.007.04664/11.
- <sup>49</sup> Pike River Coal Ltd, Activities Report: Quarter ended 31 December 2008\*, DAO.008.04847/1.
- <sup>50</sup> Pike River Coal Ltd, Prospectus, DAO.012.02790/7.
- <sup>51</sup> Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/12.
- <sup>52</sup> David Salisbury, witness statement, 25 May 2011, NZOG0068/24, paras 95, 147, 151.
- <sup>53</sup> John Dow, transcript, pp. 3931–32.



<sup>54</sup> NZOG remained the cornerstone shareholder, holding 29.37% of the shares.

<sup>55</sup> Behre Dolbear Australia Pty Ltd, Independent Management Review, 19 May 2010, NZOG0064/7; Behre Dolbear Australia Pty Ltd, Pike River Coal Project – Greymouth, New Zealand: Independent Technical Review, 20 May 2010, INV.03.28442.

<sup>56</sup> David Salisbury, witness statement, 25 May 2011, NZOG0068/35, para. 137.

<sup>57</sup> John Dow, witness statement, 21 July 2011, DAO.001.0005/2, para. 5.

<sup>58</sup> Pike River Coal Ltd, Minutes of a Meeting of Directors, 13 September 2010, DAO.007.05996/9.

<sup>59</sup> David Salisbury, witness statement, 25 May 2011, NZOG0068/39, para. 158.

<sup>60</sup> Donald Elder, witness statement, 8 June 2011, SOL306956\_1/11, para. 21.1.

<sup>61</sup> Kathleen Callaghan, transcript, p. 3280.

A photograph of a coal mine site. In the foreground, a large sign on a blue frame is visible. The sign features the Pike River Coal logo at the top, followed by the text "PIKE RIVER COAL" in bold black letters. Below that, a red banner reads "NO UNAUTHORISED ENTRY". Underneath, it says "UPON ENTERING THIS SITE:" followed by two numbered instructions: "1. All visitors to the Coal Preparation Plant must report to that office and sign in" and "2. All visitors to Mine Site must proceed along mine road (aprox. 7.5km) and report to mine office/reception and sign in." Further down, it says "BEYOND THIS POINT" and "TURN ON HEADLIGHTS & HAZARD LIGHTS. A FLASHING BEACON MAY BE USED IN LIEU OF HAZARD LIGHTS" with a small icon of a flashing beacon. At the bottom of the sign, it reads "THIS IS A DRUG AND ALCOHOL FREE SITE ALL PERSONS ON SITE MAY BE TESTED." and "SMOKING IS ONLY PERMITTED IN DESIGNATED AREAS" with a no-smoking symbol. In the background, there is a green building with a sign on its roof, and a conveyor belt system. The background is dominated by large, forested mountains under a clear sky.

# Organisational factors

- + Organisational structure
- + Governance and management
- + The workforce
- + Health and safety management

# Organisational structure

1. This chapter briefly describes Pike's organisational structure at the time of the explosion, including some of the changes that occurred to the structure in 2010. Later chapters include more detailed discussion of the roles introduced here.

## Board

2. Pike's board was responsible for 'overall corporate governance of the company including the strategic direction, determination of policy, and matters of finance, approval of significant contracts, capital and operating costs, and financial arrangements and investments.'<sup>1</sup> The board had overall responsibility for Pike's risk management and internal control system.

### Directors

3. At the time of the explosion the board comprised John Dow (chairman), Raymond Meyer, Stuart Nattrass, Antony Radford, Dipak Agarwalla and Arun Jagatramka. Gordon Ward was an executive director from July 2006 until 1 October 2010. It appears that none of the directors had underground coal mining experience.<sup>2</sup> Mr Dow's career was in metalliferous mining, Professor Meyer was a mechanical engineer, Mr Radford was the chairman of New Zealand Oil & Gas (NZOG) and Messrs Agarwalla and Jagatramka were nominees of the Indian shareholder companies, both of which were coke producers.

### Committees

4. There were three formally constituted board subcommittees: audit; health, safety and environment (HSE); and remuneration. There was also a less formal due diligence committee, meeting only when required, usually during large-scale projects such as capital raisings.
5. The audit committee reviewed and monitored Pike's financial affairs. Its members were Professor Meyer, Mr Nattrass and Mr Radford.
6. The HSE committee was responsible for ensuring Pike provided a safe workplace, monitoring compliance with environmental consents, permits and agreements, and reviewing projects. Its members were Mr Dow and Professor Meyer.<sup>3</sup>
7. The remuneration committee was to ensure Pike attracted and retained 'the right people' by offering competitive and fair remuneration packages.<sup>4</sup> Its members were Mr Dow, Professor Meyer and Mr Radford.

## Chief executive

8. As at 19 November 2010, Pike's management was led by the chief executive, Peter Whittall, who was based in Wellington. Before his appointment as chief executive at the start of October 2010, Mr Whittall was the general manager mines. Substantively, he had held this role since he was employed in February 2005. As general manager mines, Mr Whittall had reported directly to Mr Ward.<sup>5</sup>
9. Mr Ward was the chief executive from January 2007 to 1 October 2010. In his role as general manager of NZOG, Mr Ward was responsible from 1998 for 'all aspects of the Pike River coal project, taking it through to construction.'<sup>6</sup>

## Site general manager

10. Reporting to the chief executive was the site general manager, Douglas White. Mr White originally started at Pike as operations manager in January 2010. As operations manager, he reported to Mr Whittall and had four managers reporting to him: engineering, safety and training, coal preparation plant (CPP) and the underground mine manager. The remaining managers reported directly to Mr Whittall.
11. Around the time Mr Whittall was promoted to chief executive, the management structure at the mine was reorganised and some roles were reviewed.<sup>7</sup> Mr White became site general manager, which had previously been the general manager mines role, and the operations manager role was disestablished.
12. As site general manager, Mr White was based at the mine and had general responsibility for the mine's operations. Eight managers reported to him: human resources, environment, project and planning, technical services, underground mine operations, engineering, CPP and safety and training. McConnell Dowell Constructors Ltd also reported to Mr White. He understood his responsibilities as including guiding the mine safely through the project phase into development of hydro production.<sup>8</sup>
13. From 12 June 2010, Mr White was the statutory mine manager, which included supervising the health and safety of the underground operation. In the absence of a dedicated ventilation engineer, Mr White also took on overall responsibility for managing the ventilation system.

## Underground mine operations

### Underground mine manager/production manager

14. Responsibility for underground mine operations was effectively split between Mr White, as the statutory mine manager, and Stephen Ellis, as the production manager. The production manager role was created following the resignation in June 2010 of then underground mine manager, Michael Lerch. The role was initially filled by a temporary appointee and then by Mr Ellis in October 2010.
15. As production manager, Mr Ellis oversaw the operations underground and, in particular, development operations. He was expected to become the statutory mine manager once he obtained a first class coal mine manager's certificate of competence. That occurred in December 2010, with Mr Ellis appointed to an acting role on 24 December 2010 and then later as the permanent statutory mine manager in May 2011.

### Underviewers and deputies

16. There were three underviewers (or shift co-ordinators), one for each shift, and a dedicated hydro co-ordinator, who did not hold a coal mine underviewer's certificate of competence. The underviewers and hydro co-ordinator reported directly to Mr White, in his capacity as the statutory mine manager, rather than Mr Ellis, who was at the same level as them.<sup>9</sup>
17. The underviewers were responsible for co-ordinating activities, planning activities, managing employee attendance and issues, ensuring safety systems were implemented and maintained, and carrying out inspections and examinations.<sup>10</sup>
18. Responsibility for the hydro monitor crews' activities lay with the hydro co-ordinator who was responsible for overseeing and managing hydro production, including planning activities, ensuring safety systems were implemented and maintained and ensuring hydro production met or exceeded production targets.<sup>11</sup>
19. Beneath the underviewers were the deputies, with up to three working on each shift. The deputies carried out the inspections, examinations and reporting required by the company and by law and provided supervision and guidance to their crews.<sup>12</sup>

**Mining crews**

20. The mining crews comprised, in hierarchical order, senior miners, experienced miners, miners and trainee miners.<sup>13</sup> They operated the mining equipment, including the hydro-mining equipment.

**Contractors**

21. Pike used a number of contractors to support mining operations underground. They were involved in a range of activities, including shot-firing, in-seam drilling, electrical and mechanical work, pipe-laying and construction. Many of the contractors in the mine had not previously worked in an underground coal mine and were not miners by trade.

## Coal preparation plant

22. The CPP cleaned and separated coal from waste product, ready for transport to the coal handling facility near Ikamatua. The plant was managed by Johan Klopper. His staff included a process engineer, crews working shifts similar to the mining crews, and an Ikamatua crew.

## Engineering

23. The engineering department was responsible for maintaining commissioned fixed plant in the mine, mobile mining equipment and diesel vehicles. That included gas monitoring sensors, the electrical system, the surface fan and other auxiliary fans. It appears that handover of the equipment in the hydro panel to the engineering department had not occurred before 19 November 2010.
24. Robb Ridl was appointed engineering manager in August 2010. He had initiated a restructure of the engineering department, including the creation of new roles. Under the new structure, Mr Ridl would have had four staff reporting directly to him: an electrical engineer, a mechanical engineer, a maintenance engineer and a maintenance superintendent. Beneath them were a communications engineer, three co-ordinators and a maintenance planner and then shift engineers, with electrical and mechanical technicians below them.

## Technical services

25. Technical services was responsible for mine design (including underground ventilation, but not gas monitoring), surface and underground exploration, strata control, scheduling, surveying and geotechnical functions. Gas drainage, which evolved from in-seam drilling for exploration, was also a function of the technical services department.
26. Pieter van Rooyen had been the technical services manager since February 2009, but resigned effective from 3 November 2010. A new technical services manager had been recruited, but was not due to start at Pike until December 2010. In the meantime, the technical services co-ordinator, Gregory Borichevsky, an experienced mining engineer, was the most senior member of the technical services department.
27. Nine staff reported to the technical services manager: a technical services co-ordinator, a mining engineer, two geologists (including a graduate), a geotechnical engineer, three surveyors and a surveyor's assistant. The contractor carrying out in-seam drilling, VLI Drilling Pty Ltd, reported to the geologist.

## Project and planning

28. Underground infrastructure projects, such as building, installing and commissioning the hydro monitor and the main fan, were carried out by the project and planning department. The project/planning manager was Terence

Moynihan. The project and planning department also included a project engineer, a commissioning manager, a project supervisor, an electrical design and installation engineer, and a systems engineer. All but one were contractors.<sup>14</sup> Many of the small contractors working at the mine reported to members of the project team.

## Safety and training

29. The safety and training department was responsible for developing a health and safety system. Implementation of the system and associated plans were the responsibility of each of the operational departments.<sup>15</sup> The safety and training department was not responsible for ensuring the health and safety of the workforce; each department was responsible for its own health and safety.<sup>16</sup>
30. Following a reorganisation in 2010, the training function was removed from the safety and training department and placed with the human resources department. Neville Rockhouse, who had been the safety and training manager, became the safety manager. He was supported by two administrative assistants, one of whom was a contractor.<sup>17</sup>
31. Before the reorganisation, Adrian Couchman had reported to Mr Rockhouse as the training and safety co-ordinator. By 19 November 2010, Mr Couchman had moved to the human resources department and his role had narrowed to training co-ordinator. Mr Rockhouse was required to pick up the safety-related duties that Mr Couchman no longer performed.<sup>18</sup>

## Environment

32. The environmental department was responsible for all aspects of environmental compliance, including resource consents, access arrangements and subsidence. It was concerned primarily with surface operations. The environmental department had a total of seven staff, including the environmental manager, Ivan Liddell.

## Human resources

33. Human resources was responsible for recruitment, remuneration, employment relations and, following the reorganisation in 2010, training. Additionally, the other departments were responsible for training their own staff. Richard Knapp was the human resources manager. Two staff reported to him, a training co-ordinator and a human resources adviser.

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### ENDNOTES

<sup>1</sup> Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002/5.

<sup>2</sup> John Dow, transcript, pp. 4120–22.

<sup>3</sup> *Ibid.*, p. 3901.

<sup>4</sup> John Dow, witness statement, 23 November 2011, DAO.037.00001/22, para. 83(c).

<sup>5</sup> Peter Whittall, transcript, pp. 727–28.

<sup>6</sup> New Zealand Oil & Gas Ltd, Paper Phase One – Context, 25 May 2011, NZOG0067/55, para. 6.88.

<sup>7</sup> Compare organisational structure at June 2010 (Pike River Coal Ltd, Organisational Chart June 2010, DAO.003.06725/1) and at 19 November 2010 (Pike River Coal Limited Organisation Chart as at 19 November 2010, PW23a/1).

<sup>8</sup> Douglas White, transcript, p. 1118.

<sup>9</sup> Pike River Coal Limited Organisation Chart, PW23a/1.

<sup>10</sup> The description of the roles of the underwriters is taken from a 2008 draft company document and may not reflect their day-to-day practice: Pike River Coal Ltd, Roles and Responsibilities: Management Plan (Draft Document), 9 September 2008, DAO.002.00960/42.

<sup>11</sup> Pike River Coal Ltd, Pike River Coal Hydro Superintendent Job Role, INV.03.29025/1.

<sup>12</sup> Pike River Coal Ltd, Roles and Responsibilities, DAO.002.00960/50; Stephen Wylie, witness statement, 31 October 2011, WYL0001/4, para. 12.

<sup>13</sup> Peter Whittall, transcript, p. 725.

<sup>14</sup> *Ibid.*, p. 734.

<sup>15</sup> Neville Rockhouse, transcript, p. 4177.

<sup>16</sup> *Ibid.*, p. 4200.

<sup>17</sup> Neville Rockhouse, transcript, p. 4161; Michelle Gillman, witness statement, 10 November 2011, GIL0001/3, para. 1.

<sup>18</sup> Neville Rockhouse, transcript, pp. 4203–04.

# Governance and management

## Introduction

1. This chapter considers the governance of Pike by the board of directors and the consequential effects on health and safety at the mine. The chapter also deals briefly with the actions of executive managers. Their actions emerge in more detail in the subsequent chapters, which describe how the mine was managed.

## Composition of the board

2. At 30 September 2010 the Pike board comprised John Dow, as chair, and five other non-executive directors, as listed in Chapter 4, 'Organisational structure'.
3. Mr Dow had retired following an international career in the metalliferous mining industry. He became a director of Pike in February 2007 and chairman in May 2007. Work had started on constructing the stone drive into the mine and a share market float was imminent. At the time of the explosion, the board had been looking to replace retiring directors with people who had underground coal mining experience.<sup>1</sup> Mr Dow provided the commission with written and oral evidence.<sup>2</sup> Antony Radford, a non-executive director, provided written evidence. Gordon Ward, an executive director and chief executive, refused to provide written or oral evidence to the commission but had provided evidence to the joint investigation.<sup>3</sup> Mr Ward had been on the board since July 2006 and resigned in September 2010. He moved to Australia where he was effectively beyond the commission's reach.

## Executive management

4. For the purpose of its report the commission has found it useful to distinguish between 'executive management' and 'functional management' responsible for specific areas such as engineering or technical services. Executive management comprised the chief executive, the general manager and the operations manager. Those positions were filled at various times by Mr Ward, Peter Whittall and Douglas White, as explained in Chapter 4. Mr Ward and Mr Whittall played major roles in the company. Mr Ward was chief executive from January 2007 to September 2010. In his previous capacity as general manager of New Zealand Oil & Gas Ltd he had been responsible for the Pike River project since 1998. Mr Whittall was general manager from February 2005 until he succeeded Mr Ward in October 2010. Mr White was the operations manager from January 2010 and became general manager in October 2010.

## Legal obligations of directors

5. Under the Companies Act 1993, Pike's board of directors was responsible for managing the company's business or affairs, or directing and supervising that management.<sup>4</sup> Under the health and safety legislation the company, as employer, was required to take all practicable steps to ensure the safety of its workers.<sup>5</sup> The legislation places no specific duty on individual directors to ensure the safety of workers. Directors may be prosecuted if the company has committed an offence under the legislation but only when they have directed, authorised, assented to, acquiesced in, or participated in the company's failure.<sup>6</sup>



## Governance by the board

6. The commission adopts the following definition of governance: ‘setting the strategic direction of the company and appointing and monitoring capable management to achieve this.’<sup>7</sup> The key point is that directors must not only lead but also monitor management and hold it to account.
7. A range of external guidance on good governance practice was available to help the Pike board to govern effectively. Comprehensive guidance on good governance practices was available from the New Zealand Institute of Directors.<sup>8</sup> This included the need for the board to systematically manage all business risks, to hold management strictly and continuously to account, and to ensure the company complied with regulatory requirements. Best governance practice on health and safety was also available from the UK Health and Safety Executive (the equivalent of the New Zealand Department of Labour).<sup>9</sup>
8. Three Australia/New Zealand Standards guidelines were also available for directors on governance principles, both generally and in respect of health and safety.<sup>10</sup> Governance principles are discussed in more detail in Chapter 28, ‘Improving corporate governance’, when considering recommendations for the future.

## Pike’s governance documents

9. The corporate governance manual included the board charter, the charter of the audit committee and the charter<sup>11</sup> of the health, safety and environment (HSE) committee.

### The board charter

10. The charter described the responsibilities of the board. The ‘managing director’ was responsible for implementing strategy and managing operations. The board was responsible for ‘reviewing and ratifying systems of risk management and internal compliance and control, codes of conduct, and legal compliance’. According to the charter, the board had overall responsibility ‘for the company’s system of risk management and internal control, and has established procedures designed to provide effective control within the management and reporting structure.’<sup>12</sup>
11. The charter described three committees that oversaw aspects of governance on behalf of the board: the audit committee (essentially financial), the remuneration committee and the HSE committee. The use of such committees is commonplace. The allocation of health and safety oversight to the HSE committee is in line with international thinking on health and safety and follows good governance practice.<sup>13</sup> The responsibility remains with the board and committees must report back so that other directors can raise questions.<sup>14</sup>

### The corporate risk management policy

12. The board was responsible for annually approving the risk management policy<sup>15</sup> and monitoring the management of risks in the company.
13. In its corporate governance disclosure statement filed with the New Zealand Stock Exchange in September 2010, the company described its risk management in reassuring terms:

*Pike River has developed a framework for risk management and internal compliance and control systems which cover organisational, financial and operational aspects of the company’s activities. . .*

*Management is responsible for designing, implementing and reporting on the adequacy of the company’s risk management and internal control system. The board requires that management reports to it on a monthly basis as to whether material business risks are being effectively managed, and to the Audit Committee and the Health, Safety and Environment Committee. . .*

*The board has a Health, Safety and Environment Committee comprising two non-executive directors with mining and engineering experience... there is a strong safety culture which is fostered by management... detailed compliance programmes operate to ensure the company meets its regulatory obligations.<sup>16</sup>*

## Risk assessment

14. Risk assessment takes a number of forms and typically operates at different levels of a company. The basic concept is to identify risks faced by the company and assess their likelihood of occurring and their consequences if they do occur. To do this, the adequacy of the controls, or defences, intended to reduce likelihood or consequence have to be assessed and additional controls implemented if necessary. Finally, a decision is taken as to whether the risk is acceptable or not, and the risk is then managed. Risk assessment, which starts with the board, is an integral part of modern governance and a continuous process.
15. In Pike's circumstances, one could reasonably expect to see three interacting levels of risk assessment: corporate, mine site and specific proposal. The risk assessments at the corporate level, viewed by the board, should detail the major risks faced across the company, for example in the areas of finance, people and operations. At the mine, the major risks, such as ventilation, would be similarly documented and assessed by executive and middle managers and, depending on importance, would be summarised and included in the corporate-level risk assessment. Risks posed by specific processes or proposals, such as changes to the ventilation system, would be separately assessed at a detailed level by the relevant managers and experts, then summarised and included in the mine site assessment and, if necessary, the corporate assessment.
16. For a high-hazard activity such as underground coal mining, rigorous and continuous risk assessment, and subsequent management, are crucial at all three levels. According to Mr Dow, the board was 'keenly aware' of the risks posed by methane.<sup>17</sup> But the board had no effective framework for ensuring there was a systematic assessment of risk throughout the organisation. The board commissioned no third parties to carry out such an assessment.
17. The corporate risk management policy required an overall risk management committee but this was not established.<sup>18</sup> Mr Dow said Pike instead had committees that individually managed risk in specific areas. One was the HSE committee, which he chaired.

## The challenges facing the board and executive management

18. In 2010 the board and executive management faced serious challenges, some of which had been apparent for years. The company had a history of not delivering on its promises. Coal production was years behind schedule and previous estimates of production capacity had to be severely reduced. Lack of revenue was driving the company to seek further funding. There were major problems with the advent of hydro mining, the company's main production method.
19. It appears that no one on the board had experience in the local underground coal mining industry. The business was new, with the mine still under development, as were its systems, including health and safety.
20. There was a rapid turnover of statutory mine managers and middle managers. Many workers were inexperienced. Morale and absenteeism were of concern. The company relied heavily on contractors and consultants. It had purchased equipment unsuitable for the difficult strata conditions encountered. Some key equipment and systems were unproven when production began. There was no suitable second egress for use by workers in an emergency.

## Board meetings

21. The board met monthly, sometimes at the mine. The chief executive normally attended. Included in the monthly board papers was an operations report from the mine site, part of which was devoted to health and safety. Mr

Dow considered that 'quite a significant amount of the report focuses on the safety aspects of it and the board was getting quite a lot of good information'.<sup>19</sup>

22. The statistical information provided to the board on health and safety comprised mainly personal injury rates and time lost through accidents. Mr Dow was comfortable with the information provided to the board.<sup>20</sup> The information gave the board some insight but was not much help in assessing the risks of a catastrophic event faced by high-hazard industries. Pike had not developed more comprehensive measures which would have enabled the board and executive managers to measure what was being done to prevent catastrophes, such as the analysis of high-potential incidents (near misses which could have caused serious harm) and the steps taken to prevent their recurrence. The board appears to have received no information proving the effectiveness of crucial systems such as gas monitoring and ventilation. The nearest the board came to questioning management on such issues appears to have been on 15 November 2010, when the general manager, Mr White, attended his first board meeting and was questioned about safety systems.<sup>21</sup>
23. In describing his approach to governance, Mr Dow compared the difference between governance and management to the difference between 'church and state'.<sup>22</sup> The commission does not accept the analogy. Management operated under delegation from the board. Good governance required the board to hold management strictly and continuously to account.

## Meetings of the board's health, safety and environment committee

### Composition, mandate and meetings

24. The HSE committee, which was to report to the board, consisted of Mr Dow as chair and another director, Professor Raymond Meyer. According to its charter, the committee was to assess management's effectiveness in providing leadership in health, safety and environment matters; review with management the company's strategy and performance in these areas, 'including receiving reports on any significant incidents and measures arising from them to avoid future incidents'; consider and review the identification and management of health, safety and environmental risks as part of the company's overall risk management system; and 'monitor compliance with legal and statutory obligations'.<sup>23</sup>
25. The HSE committee was to meet every six months but by the time of the explosion it had not met for 13 months, with the exception of the board meeting of 15 November when it questioned the general manager on health and safety. Mr Dow said that this was because the board as a whole was taking more interest in health and safety.<sup>24</sup> No meetings of the HSE committee had been scheduled for 2011, in contrast to meetings of the board.<sup>25</sup>

### Obtaining information

26. In Mr Dow's view, health and safety were the responsibility of the health and safety manager,<sup>26</sup> who had charge of the corporate safety management plan, and the mine manager. The health and safety manager presented information to the committee when it visited the mine. Mr Dow did not consider the committee needed to obtain information from other managers.<sup>27</sup> If they wished to raise concerns with him they had the opportunity to do so, for example at company dinners or barbecues.<sup>28</sup> Mr Dow considered that neither the board nor the committee felt it necessary to obtain further information or seek independent advice on health and safety. The HSE committee recommended that third-party audits of the safety management systems should be done but did not require this when senior management considered they should be deferred until the systems had been bedded down.<sup>29</sup>

### Warning signals

27. In 2010 there were obvious warning signals that things were amiss. These included two third-party reviews that an alert chair and board would have found very revealing. The first review was a comprehensive risk survey by Hawcroft

Consulting International, commissioned by Pike's insurers. The second was a review of legislative compliance conducted by Minserv International Ltd (Minserv).

### The Hawcroft risk survey 2010

28. Hawcroft is a specialist risk assessor for the insurance industry, carrying out over 150 insurance risk surveys annually at over 150 mining/processing operations around the world. Their risk survey at Pike covered underground, coal processing and surface operations.
29. In its 2010 report on Pike, Hawcroft repeated its 2009 recommendations that a 'broad-brush' risk assessment of the operation was needed, in order to develop a risk register and determine core hazards.<sup>30</sup> The report also identified that a number of specific risk assessments were outstanding on such vital matters as windblast, gas ventilation and hydro mining. Hawcroft rated the risk of a methane gas explosion as 'possible'. The Hawcroft review also commented on the need for timely and effective action on incident reports.
30. Mr Dow said that although the board was aware of the review, he had not read the report and the board had neither considered it nor been briefed on it.<sup>31</sup> Mr Dow considered the matters raised would be appropriately dealt with by management at the mine.<sup>32</sup> The Hawcroft report was not, in his view, something that would normally come to the board or its HSE committee.<sup>33</sup>
31. Mr Dow added that the site managers were responsible for bringing the issues they considered important to the board's attention. These people were very competent and the board had every confidence in them.<sup>34</sup> There were plenty of opportunities for site managers to bring safety concerns to his attention in both formal and informal situations,<sup>35</sup> and he was surprised that they had not done so.

### The Minserv legislative compliance audit 2010

32. In the course of eight visits to the mine between February and April 2010, David Stewart, an experienced mining consultant and principal of Minserv, conducted a legislative compliance audit.<sup>36</sup>
33. In August 2009 Mr Dow had been approached by a professional colleague who expressed concern about aspects of the Pike River mine, including training and culture. Mr Dow discussed this with Mr Stewart. Mr Stewart said that Mr Dow was concerned about the turnover of senior managers, difficulties in recruiting good managers, morale and the failures to meet production targets.
34. Mr Stewart told Mr Dow that the management team needed help from someone entirely familiar with New Zealand regulations and conditions, and the starting point should be a legislative compliance audit.<sup>37</sup> Mr Dow referred Mr Stewart to Mr Whittall.
35. Mr Stewart's review identified serious problems with safety critical systems.<sup>38</sup> Among these he noted that:
  - the instrumentation of the main fan was not compliant with regulations;
  - there was no remote gas monitoring systems in the mine connected to the control room;
  - the ventilation structures (stoppings and doors) were inadequate and training on construction was needed;
  - the stoppings needed protection from blast damage caused by shot-firing;
  - there was a lack of information about ventilation air flow;
  - there were obstructions and debris in the main returns leading to the Alimak ventilation shaft;
  - there were no stone dust barriers;
  - the ventilation shaft was impractical as a second egress;
  - intershift reports by mine deputies were inadequate; and

- the methane gas drainage line alongside the main access road in Spaghetti Junction was at risk of damage by mobile equipment.
36. Mr Dow did not ask for Mr Stewart's reports. He did not require the board or the HSE committee to be briefed on them. He told the commission: 'Mr Stewart was engaged to help the management team deal with the issues. He was engaged by them, the reports went to them. I didn't consider that it was necessary for them to come to me as well and Mr Stewart testified that he didn't expect them to come to me either. I had a subsequent oral conversation with him to ask how it had gone.'<sup>39</sup> There does not appear to have been a comprehensive management response to all the issues raised in Mr Stewart's reports. The health and safety manager, Neville Rockhouse, did not see them.<sup>40</sup>

## Serious incidents at the mine

37. Mr Dow was asked to comment on a range of high-potential incidents at the mine in the month or so before the disaster.<sup>41</sup> A sample of these was summarised in schedules prepared by the commission.<sup>42</sup> Although Mr Dow was referred to only a few incidents, these were enough to show that over a five-day period in October 2010 there were six occasions when methane was over 5% of the air. Mr Dow viewed these as 'a series of operational incidents that are very much the prerogative of the onsite management team ... In due course I would expect the board to have been advised at its next meeting.'<sup>43</sup>
38. Mr Dow was then referred to a number of earlier incidents, including one on 23 June 2010 that concerned dangerous recirculation of air. A mine deputy had attributed this to inadequate ventilation, inadequate leadership and supervision, inadequate engineering, inadequate maintenance, safety rules not enforced and poor stoppings. When Mr Dow was asked, 'Would the committee not have wanted to verify for itself whether those matters had been remedied or not?', he answered, 'No, as I've said on a number of occasions these are operational issues on site ... it's a management issue to follow up.'<sup>44</sup>
39. Mr Dow accepted that the schedules presented to him showed many high-potential incidents were not reported to the board. But he did not accept that the systems were not working and said he was comfortable with the reporting.<sup>45</sup>

## Challenges facing executive management in 2010

40. The challenges faced by the executive management, and how they handled those challenges, are described in some detail in Chapters 7 to 12, but some general comments are made now. Although they are described in mining industry terms, the issues also relate to the generic management problems faced in other enterprises – strategy, planning, risks, systems, information and people.
41. Executive managers had to translate the board's strategic direction into operational plans but had difficulty in preparing a comprehensive, long-term operational plan because of continual changes in the mine design and production schedules.<sup>46</sup>
42. Executive managers, like the board, focused on production and earning revenue. As noted in paragraphs 14 to 17 of this chapter, risk management was undeveloped at Pike. The risk of catastrophe was not identified by executive management and was not reported to the board. The warnings in the Hawcroft reports that risk management needed improvement were not heeded. Similarly, there was no comprehensive response to the Minserv legislative compliance audit. A number of other reports from consultants on safety critical issues, such as methane management and ventilation,<sup>47</sup> were not properly addressed by the time of the tragedy.
43. The mine's health and safety management systems, including vital systems such as ventilation management, methane drainage, gas monitoring and hydro mining, were still under development at 19 November 2010, as discussed in Chapters 7 to 12.

44. The management information systems were also undeveloped and vital information was not brought together, summarised and analysed for executive managers. For example, as is clear in Chapter 7, 'Health and safety management', key information on health and safety incidents in the mine was available but was not handled systematically and so did not result in a comprehensive response.

## Conclusions

45. The board's focus on meeting production targets set the tone for executive managers and their subordinates. The board needed to satisfy itself that executive managers were ensuring that its workers were being protected. After all, the company was operating in a high-hazard industry. The board needed to have a company-wide risk framework and keep its eye firmly on health and safety risks. It should have ensured that good risk assessment processes were operating throughout the company. An alert board would have ensured that these things had been done and done properly. It would have familiarised itself with good health and safety management systems. It would have regularly commissioned independent audit and advice. It would have held management strictly and continuously to account.
46. Mr Dow's general attitude was that things were under control, unless told otherwise. This was not in accordance with the good governance responsibilities. Coupled with the approach taken by executive managers, this attitude exposed the workers at Pike River to health and safety risks.
47. Focused on production targets, the executive management pressed ahead when health and safety systems and risk assessment processes were inadequate. Because it did not follow good management principles and industry best practice, Pike's workers were exposed to health and safety risks.

## The future

48. In Chapter 28, 'Improving corporate governance', and Chapter 29, 'Improving management leadership', the commission discusses governance and executive management more generally, identifies the lessons that the Pike River tragedy holds for directors and executive managers in high-hazard industries, and makes recommendations for the future.

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### ENDNOTES

<sup>1</sup> John Dow, transcript, p. 3900.

<sup>2</sup> *Ibid.*, pp. 3891–4156.

<sup>3</sup> Gordon Ward, Police/DOL interview, 29 September 2011, INV.03.28891.

<sup>4</sup> Companies Act 1993, s 128.

<sup>5</sup> Health and Safety in Employment Act 1992, s 6.

<sup>6</sup> *Ibid.*, s 56.

<sup>7</sup> David Walker, A Review of Corporate Governance in UK Banks and Other Financial Industry Entities, 26 November 2009, p. 23, [http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/walker\\_consultation\\_261109.pdf](http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/walker_consultation_261109.pdf)

<sup>8</sup> Institute of Directors in New Zealand, Principles of Best Practice for New Zealand Directors: The Four Pillars of Board Governance, 2010, <https://www.iod.org.nz/Publications/TheFourPillarsOfGovernanceBestPractice.aspx>

<sup>9</sup> Institute of Directors and Health and Safety Executive, Leading Health and Safety at Work: Leadership Actions for Directors and Board Members, October 2007, <http://www.hse.gov.uk/pubns/indg417.pdf>

<sup>10</sup> Standards Australia and Standards New Zealand, Risk Management – Principles and Guidelines (AS/NZS ISO 31000:2009), 20 November 2009; Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – General Guidelines on Principles, Systems

and Supporting Techniques, (AS/NZS 4804:2001), 15 November 2001; Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001.

<sup>11</sup> Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002.

<sup>12</sup> *Ibid.*, DAO.037.00002/5.

<sup>13</sup> Health and Safety Executive (UK), Leading Health and Safety at Work, October 2007, <http://www.hse.gov.uk>

<sup>14</sup> Securities Commission New Zealand, Corporate Governance in New Zealand Principles and Guidelines: A Handbook for Directors, Executives, and Advisors, March 2004, p. 13, <http://www.fma.govt.nz/media/178375/corporate-governance-handbook.pdf>

<sup>15</sup> Pike River Coal Ltd, Corporate Risk Management Policy, DAO.001.09450.

<sup>16</sup> Pike River Coal Ltd, Corporate Governance Disclosure Statement, September 2010, NZX2292/6.

<sup>17</sup> John Dow, transcript, p. 4028.

<sup>18</sup> *Ibid.*, p. 4000.

<sup>19</sup> *Ibid.*, p. 3905.

<sup>20</sup> *Ibid.*, p. 4031.

<sup>21</sup> Pike River Coal Ltd, Excerpt from PRC Board Minutes, 15 November 2010, DAO.014.00448/1.

<sup>22</sup> John Dow, transcript, p. 3991.

<sup>23</sup> Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002/30.

<sup>24</sup> John Dow, transcript, p. 4012.

<sup>25</sup> Ibid., p. 3956.

<sup>26</sup> Ibid., p. 3984.

<sup>27</sup> Ibid., p. 3993.

<sup>28</sup> Ibid., p. 4080.

<sup>29</sup> Ibid., pp. 3947, 3992.

<sup>30</sup> Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710.

<sup>31</sup> John Dow, transcript, p. 4005.

<sup>32</sup> Ibid., p. 3983.

<sup>33</sup> Ibid., p. 3989.

<sup>34</sup> Ibid., p. 3984.

<sup>35</sup> Ibid., p. 3922.

<sup>36</sup> David Stewart, Pike River Compliance Audit – Ventilation, 11 February 2010, STE0004.

<sup>37</sup> David Stewart, transcript, p. 3324; John Dow, transcript, p. 3927.

<sup>38</sup> David Stewart, transcript, pp. 3326–34.

<sup>39</sup> John Dow, transcript, p. 4007.

<sup>40</sup> Neville Rockhouse, transcript, p. 4251.

<sup>41</sup> John Dow, transcript, p. 4034.

<sup>42</sup> For example: Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Limited Deputy Statutory Reports for March and October 2010, November 2011, CAC0115/15–17; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/10–30.

<sup>43</sup> John Dow, transcript, pp. 4035–36.

<sup>44</sup> Ibid., pp. 4037–38.

<sup>45</sup> Ibid., pp. 4040–41.

<sup>46</sup> Petrus (Pieter) van Rooyen, transcript, pp. 5181–83; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/54–55, paras 320–24.

<sup>47</sup> For example: Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811; Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System – History & Current Status, 31 March 2010, DAO.003.05885.



## Introduction

1. The labour market for mine workers is global, and demand for skilled and experienced workers is high. Many mines face shortages of experienced staff and therefore need to recruit new entrants to the industry. Their training and supervision are critical.
2. Training is a significant defence against major mining hazards: an inexperienced workforce is less likely to appreciate inherent risks and know how to mitigate them safely. Training requires a strong focus on health and safety and the teaching of safe practical mining skills. Quality ongoing supervision and mentoring are essential, as is supervisor training.
3. At the time of the explosion Pike employed 174 staff.<sup>1</sup> Several contractors also had their own staff and subcontractors onsite. Many members of this combined workforce were inexperienced in the hazards of underground coal mining.

## Workforce problems

4. In 2009 and 2010 Pike faced a number of problems with its workforce, at a time of significant change for the company and when pressure for coal production was increasing daily.

### High turnover of staff

5. Pike had a high turnover of miners underground,<sup>2</sup> and was unable to retain personnel in many key operational management roles.
6. As shown in Figure 6.1, from the time the mine was classified as a gassy coal mine in November 2008, Pike had six mine managers, two technical services managers and three engineering managers. In 2010 the mine had two production managers.
7. The high management turnover 'compromised [Pike's] functioning and continuity',<sup>3</sup> owing to inefficiencies, loss of institutional knowledge and the need for employees to adjust to differing management styles. There was no systematic handover process when staff changed; the exception was Pieter van Rooyen's handover when he left Pike in November 2010.<sup>4</sup>

### Problems in attracting and retaining experienced staff

8. Lack of experience was a significant problem at Pike. As at November 2010 three key operational specialists in the technical services department, and the data and communication systems specialist, had no prior experience working in gassy underground coal mines.<sup>5</sup>
9. On occasion, Pike hired, for specialised roles, individuals who required intensive on-the-job learning amid the pressure for coal production. An example is the hydro co-ordinator who had no previous hydro-mining experience and had made that clear when interviewed for the position. He was promised training and support and was confident he could up-skill. But he received no formal training and was 'a little out of my depth because of my lack of knowledge of the hydro-machinery and equipment'.<sup>6</sup> Other applicants with operational hydro-mining experience at West Coast mines applied for the role but were unsuccessful.<sup>7</sup>
10. It was also a 'struggle to obtain tradesmen with mining experience',<sup>8</sup> and Pike sometimes had to rely on contract tradesmen from Australia.

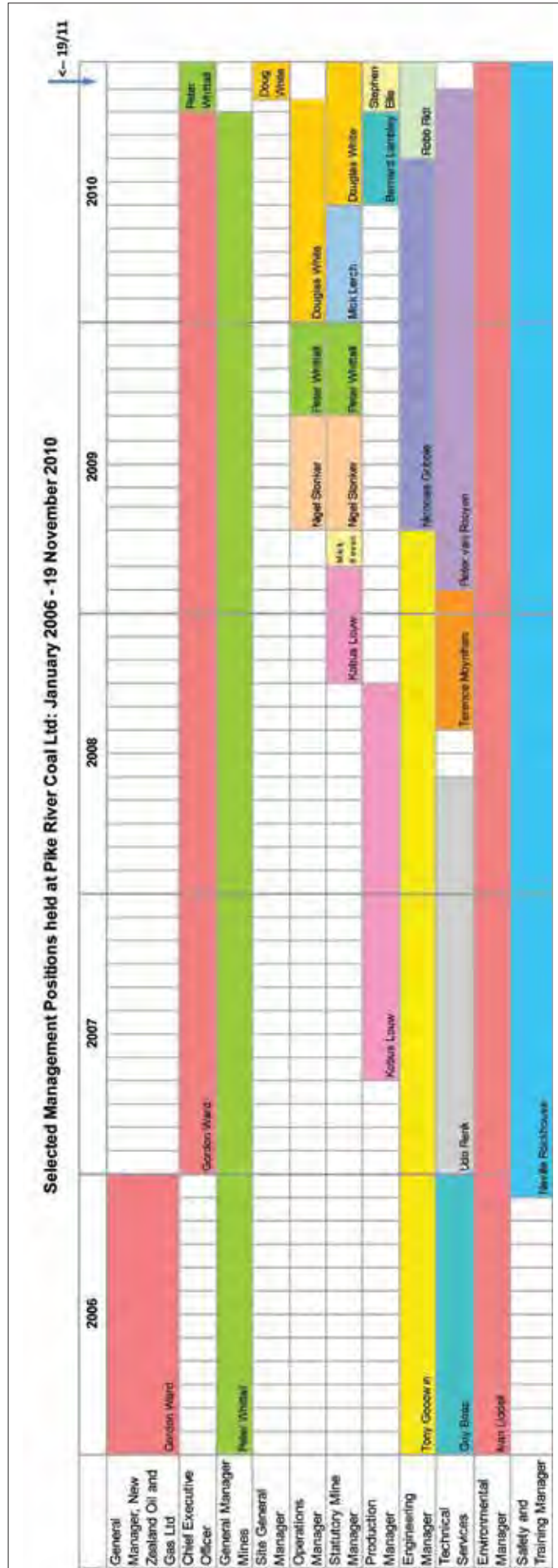


Figure 6.1: Selected management positions held at Pike River Coal Ltd, January 2006–19 November 2010<sup>9</sup>

### Underviewers and deputies

11. Pike had an ongoing shortage of underviewers and deputies, which occasionally led to those on shift covering multiple roles.<sup>10</sup> Among other problems, the shortage caused a delay in the training of the person identified as suitable to fill the role of ventilation officer, as the resignation of another underviewer left the mine short staffed at that level. Moving to a 24-hour production cycle in the hydro panel in October 2010, incorporating two 12-hour shifts, also meant that Pike could not have a deputy dedicated full time to the hydro production panel,<sup>11</sup> and there was no underviewer responsible for hydro mining.<sup>12</sup>

### Percentage of cleanskins

12. Cleanskins are workers with little or no underground mining experience. The prominence of cleanskins within Pike's workforce was described as 'the nature of the modern industry'.<sup>13</sup>
13. There is no set or absolute ratio of experienced to inexperienced miners, but Neville Rockhouse estimated that 40 to 50% of workers at Pike were working in their first underground mine.<sup>14</sup> To David Reece, an expert engaged by the Department of Labour (DOL), that level is a concerning 'sad reality' faced by the industry.<sup>15</sup> Experienced mining consultant David Stewart from Minserv International Ltd (Minserv) considered that the ratio at Pike was not favourable and there were too few experienced miners given the nature of the operation and the conditions,<sup>16</sup> which made it 'very difficult for [Pike] to maintain consistency and development and performance as so much of the work and skills were left to the experienced few'.<sup>17</sup>
14. The result of a high ratio of inexperienced miners is either reduced productivity or a lack of time for the experienced miners to 'actually teach and ... mentor all those people in the crews with them',<sup>18</sup> as 'you can't easily do both'.<sup>19</sup> Trainer/assessor George Colligan considered that the ratio at Pike was 'way [too] low' and slowed down the machinery certification process as experienced miners were required to supervise trainees.<sup>20</sup>
15. Some of the experienced miners working underground had real concerns:
 

*I have got to admit I've found it very hard here with the young men. They seem to have too much self-confidence, too quick. They've been underground maybe six months and they are a miner. But they can't have in those six months appreciated the dangers down there. ... Some of these young men have called me some serious names while I've been here ... I said, 'Look, I don't care. I've been in this game all my life and I'm not going to die here just because you don't understand where you are working.' And that's why I jacked it in.*<sup>21</sup>
16. Pike recognised the ratio of cleanskins 'was starting to get out of whack' after it employed all the new trainees who completed its second intake of the three-month trainee induction programme, discussed in paragraph 44. Pike decided not to run a third intake for some time.<sup>22</sup>

### Absenteeism

17. The experience ratio was not assisted by absenteeism. The difficult working conditions underground (the cold, wet environment and steep grades), frustrations with underperforming equipment and low morale were no doubt contributing factors.<sup>23</sup>
18. Reginald Matthews, a trainer/assessor at Pike in 2009 and 2010, described the level of absenteeism as 'very high': 'It was almost as if staff took the view that if you could get away with it, and there were no "consequences", then why not do it'.<sup>24</sup>
19. Adrian Couchman considered that while 'on paper' the ratios per shift were correct, on many occasions experienced staff would be absent but the shift would proceed with trainees under the supervision of the shift deputy.<sup>25</sup> The level of absenteeism sometimes had a direct effect on development<sup>26</sup> and Pike issued warnings and terminated some employees for absenteeism through 2009 and 2010.<sup>27</sup>
20. In July 2010 the hydro-mining start-up bonus discussed in Chapter 12, 'Hydro mining', was instituted, although the cause of the absenteeism problem was not clear to the board.<sup>28</sup> The bonus was reduced by \$200 for each non-attendance, defined as every day or shift on which an employee was rostered but did not work for any reason,

including sickness or lateness.<sup>29</sup> By November 2010, Pike considered that the bonus scheme had led to a 'reduction in sick leave usage'.<sup>30</sup>

### Diverse nationalities

21. Pike employed a diverse workforce. Mr Stewart's impression was that this diversity created a separation:<sup>31</sup>

*The workforce was further complicated by the mix of New Zealanders, Australians and South Africans scattered through all levels. In many operations this can be an advantage, but at PRC mine it appeared to add to the apparent dysfunctional nature of the organisation and communication within the mine and between underground and surface.*<sup>32</sup>
22. As well as difficulties with communication and managerial styles, the diversity also meant a lack of consistency in approach and style to decision-making and in operational planning and implementation. At management level there was a notable lack of local mining experience in the West Coast's unique conditions,<sup>33</sup> and many of the overseas staff were used to operating under and complying with much more prescriptive mining regulations than existed in New Zealand.
23. Neville Rockhouse considered that the integration of diverse backgrounds of Pike's staff and contractors was also 'not an ideal situation for generating effective health and safety in the mine' and led to differing levels of understanding of health and safety documents, including risk assessments, job safety and environmental analyses (JSEAs) and safe operating procedures (SOPs).<sup>34</sup>
24. In 2007 Pike had recognised that 'cultural diversity will certainly become an issue' as the company expanded,<sup>35</sup> and proposed training for the management team and employees. This had not occurred before the explosion.

## Training at Pike

### Obligations to workers

25. Under the Health and Safety in Employment Act 1992 (HSE Act) Pike was required to take all practicable steps to ensure that every employee had adequate supervision and training to work underground.<sup>36</sup>

### Industry qualifications

26. The mining industry in New Zealand has largely determined its workforce skill standards through the work of the Extractive Industry Training Organisation (EXITO). EXITO has set the curriculum and assessment requirements for regulated roles in mines, and worked with employers to develop national qualifications for the mining industry. DOL, as the regulator, has not been involved.
27. There are 24 extractives industry qualifications (national diplomas and certificates) available in New Zealand,<sup>37</sup> including several specific to the coal industry, all with a strong focus on health and safety in the workplace. All EXITO's national qualifications are made up of unit standards that set out short statements of what people need to know or be able to do to show that they are competent in a particular skill area.<sup>38</sup>
28. People carrying out specific roles, including first class coal mine manager, coal mine underviewer and coal mine deputy, must have certificates of competence (COCs), also known as tickets, permits or licences. These are different from EXITO qualifications but are obtained by completing some of the same unit standards, together with relevant experience. DOL delegated authority to EXITO to issue COCs.

### Recognition of overseas certificates of competence

29. The necessity to fill statutory positions with overseas workers led Pike to push for the development, through Tai Poutini Polytechnic and EXITO, of an industry programme known as professional conversation.
30. To qualify in New Zealand under this programme, workers holding COCs from other countries must obtain a

New Zealand gas ticket, complete New Zealand Qualifications Authority (NZQA) unit standard 7142 on legislative requirements,<sup>39</sup> and then appear before a panel comprising an educator, an EXITO moderator and an industry expert. The panel assesses each applicant to determine whether any further training is required before a New Zealand COC is issued.<sup>40</sup> Pike used this programme successfully for several of its overseas staff.

31. In 2009 an automatic process was established, under Part 3 of the Trans-Tasman Mutual Recognition Act 1997, allowing workers holding an Australian COC to obtain the New Zealand equivalent without further training, other than gaining their New Zealand gas ticket. Under this process applicants are not required to complete NZQA unit standard 7142, as long as the mine manager is satisfied that they understand New Zealand's mining legislation,<sup>41</sup> a requirement met by Pike by its site induction or specific onsite training.<sup>42</sup>
32. Peter Whittall was instrumental in establishing this process, suggesting to EXITO that those holding a COC from New South Wales or Queensland should not have to undergo the subjective professional conversation programme when the qualifications were mutually recognised.<sup>43</sup> EXITO and DOL eventually agreed. This means that no professional conversation is required,<sup>44</sup> and there is no objective assessment of an applicant's knowledge of New Zealand legislation.
33. Not everyone agrees with this approach. It is generally accepted in the industry that Australian mining qualifications are of a higher standard than their New Zealand equivalents and are more difficult to achieve,<sup>45</sup> yet the mutual recognition process also allows New Zealand COC holders to automatically qualify in Australia with limited further training required. This process leads to a perception that New Zealand can be a 'back door' way for Australian miners to more easily obtain their COCs.<sup>46</sup>
34. Alignment of training and qualification standards with Australia and involvement of the regulator are discussed further in Chapter 31, 'Qualifications, training and competence'.

### Resourcing of training

35. Organisation of formal training at Pike was the responsibility of the safety and training department. From 2007 Pike outsourced several aspects of its workforce training, including to Tai Poutini Polytechnic. But by late 2010 the increase in Pike's workforce meant those involved in health, safety and training had been overworked and under resourced for some time.<sup>47</sup>
36. Mr Couchman was employed in September 2008 as the training co-ordinator, reporting to Mr Rockhouse. He developed and managed staff induction and training programmes, and had a secondary safety role that included issuing personal protection equipment to miners, underground audits of safety equipment, maintenance of the incident/accident reporting system and random drug and alcohol testing. He also chaired the workforce health and safety committee. Mr Couchman had no previous mining experience and arranged to outsource some of the technical training.
37. From June 2009 to May 2010 Reginald Matthews, a workplace trainer/assessor with over 30 years' mining industry experience, was contracted by Tai Poutini and based at Pike to conduct training and assessments on mobile machinery, and surface and underground safety audits.<sup>48</sup> He was joined in November 2009 by George Colligan, another experienced miner and trainer/assessor with more than three decades of industry experience.<sup>49</sup> Together, they were responsible for training and assessing everyone at Pike, including contractors, on their competencies on the mine's machinery and equipment. Messrs Matthews and Colligan established a database or skills matrix that recorded and updated every individual crew member's skill level and certified competencies.<sup>50</sup>
38. After Mr Matthews left Pike, Mr Colligan became the sole trainer/assessor at the mine. Pike was employing more staff and commissioning more plant and equipment, leaving him 'run of [sic] my feet' trying to keep up with the workload.<sup>51</sup> Mr Colligan had either trained or assessed 28 of the 29 men who died in the mine on 19 November 2010 in various roles and on different mining equipment and plant,<sup>52</sup> and was confident that each had reached their respective certified skill levels and competencies in accordance with Pike's processes and procedures.<sup>53</sup>
39. From July 2008 the safety and training department also had a part-time contractor, Michelle Gillman, who assisted Mr Rockhouse in controlling the safety management documents and planning safety materials.<sup>54</sup> Mr Rockhouse

campaigned for more staff and was given some administrative support,<sup>55</sup> but after restructuring in September 2010 Mr Couchman ceased his safety role and moved into the human resources department as the training officer.<sup>56</sup> Neither Mr Couchman nor Mr Rockhouse considered the restructuring a positive move, and other commitments left Mr Rockhouse little time to conduct safety audits underground after Mr Couchman was transferred.<sup>57</sup>

## Training of workers

### Recognition of training needs

40. Pike's response to the difficulty in attracting and retaining experienced staff was to recruit 'suitable local people and to give them appropriate training'.<sup>58</sup> The company recognised that this meant a need for quality industry-based training, so it developed a number of training programmes from a basic induction through to specialised training for departmental staff.
41. For all its training programmes Pike used a consistent principle that 'three bodies of evidence of competency' were required: attendance at a training course, completion of a written assessment and an assessor's sign-off confirming competency.<sup>59</sup> Initially, each employee had performance appraisals when their individual training needs were identified by the head of department and signed off by the mine manager.<sup>60</sup> However, performance appraisals were 'overlooked' from mid- to late 2009, and Mr Rockhouse only had time to do 'a couple' of safety contacts (performance checks of staff underground) in 2010.<sup>61</sup>

### Basic induction

42. Everyone working or visiting underground was first required to attend Pike's basic classroom-based induction training, which had up to four levels, depending on where an inductee would be working. Underground workers had to complete a 'level 2 – general surface induction' and 'level 3 – underground induction', which together took about two hours and introduced the mine site, covered rules for working on the surface and underground, and included instruction on emergency procedures.<sup>62</sup> New employees had a more in-depth induction that initially took up to two and a half weeks, but was shortened to a week when employee numbers increased.<sup>63</sup> However, on occasion contractors were found working underground with no induction.<sup>64</sup>
43. Every person working underground at Pike also had to pass a medical examination and complete the New Zealand NZQA unit standard 7146.<sup>65</sup> This two-day course, delivered offsite by the Mines Rescue Service (MRS), required participants to describe and demonstrate the basic skills necessary for working in an underground mine.<sup>66</sup>

### Trainee induction programme

44. In 2009, in partnership with Tai Poutini Polytechnic, Pike developed a 12-week trainee induction programme designed for people new to the mining industry. The programme, based on NZQA unit standards, involved an initial two-week induction course at Pike, which included an underground tour and a walk out of the mine, then four weeks offsite completing training from the MRS and experienced consultant trainers. There was a further six weeks onsite at Pike when they were assigned to a crew, rotating around shifts. During that period trainees would work two to three shifts per week under supervision, and spend two days offsite on further theoretical and practical study.<sup>67</sup>
45. At the end of the programme, trainees completed a set of unit standards which gained them a Level 2 National Certificate in Extractive Industries (Introductory Skills). Then, if considered suitable, a trainee would be offered a job at Pike and, after one year underground as a trainee miner, could apply for miner status.
46. This trainee induction programme was described as 'ground breaking and extremely comprehensive', and the polytechnic received positive feedback from Pike management, experienced miners and the trainees themselves.<sup>68</sup>
47. Two intakes were run before November 2010 and 11 trainees completed the programme in each intake, and were offered employment at Pike.<sup>69</sup>



### Continuing workforce training in 2010

48. Management appreciated that targeted ongoing training was necessary for its workforce, and made efforts to address training gaps when they were identified. Sources of information on training requirements included the statutory reports, incident/accident reports and the *I Am Safe* booklets completed by workers.
49. The trainer/assessors frequently found 'non-trained or non-competent' people operating machinery underground, and provided specialised training to workers and licensed them for the operation of equipment and machinery.<sup>70</sup> Shortly after his arrival at Pike, Douglas White brought in a consultant to audit Pike's training packages against the equivalent NZQA unit standards. Mr Couchman had begun to update some of the training packages for mine machinery by the time of the explosion, but it was a time-consuming process.<sup>72</sup>
50. Pike's engineering department had developed a reputation for isolating itself and not being involved with the safety and training department's objectives and requirements. This changed when engineering manager Robb Ridl was appointed in mid-2010, and Mr Couchman was put in charge of engineering training. Specialist training programmes were designed, a specialist consultant was engaged to provide the training and sessions had begun before the explosion.<sup>73</sup>
51. In April 2010 Mr White made changes to the shift roster system that meant day and afternoon shifts were shortened and overlapped to allow continuous production and daily one-hour training sessions at the beginning of the afternoon shift. These sessions covered SOPs, where available, supplemented by each department delivering training modules on chosen subjects. Friday was also a designated training day for crews not in production, which usually coincided with a maintenance day for one of the development machines. This session was designed for more advanced or detailed training on specific topics.<sup>74</sup>
52. Mr White also initiated refresher training to be delivered within the Friday training session, targeting miners who had not had any follow-up training for some time. This session was designed to review policies and procedures, and to refresh staff knowledge in such areas as ventilation, use of self-rescuers and first aid training. Outside trainers were often brought in, and in September 2010 Mr Couchman arranged through the polytechnic for Harry Bell, a highly regarded and experienced West Coast miner, to conduct eight of these Friday refresher sessions on gas and ventilation management.<sup>75</sup>
53. However non-attendance at the Friday training sessions had increased throughout the year. On one occasion underwriters told Mr Couchman that they could not afford to release staff for training because they did not have enough staff on shift to continue production. By October and November attendance had fallen so significantly that Mr Bell's training was postponed after only two sessions, and Friday training was cancelled for the rest of the year.<sup>76</sup> Human resources manager Richard Knapp reported the reasons to the management meeting on 10 November 2010:

*The issue of Friday training being poorly attended has led to the decision to cancel the Friday training for the rest of this year (we also need the production). The reasons behind this are that it is costing the training budget over \$1000 per session to arrange this and when only 2 underground staff turn up to one session and on another occasion nobody turned up at all means that it is not good value for money to continue. This has been an ongoing issue and [sic] has been a struggle to get shift managers to release staff to participate in this process from the beginning.<sup>77</sup>*

## Some training issues

54. Despite Pike's efforts, there were some gaps in the training programme and some worker behaviour underground revealed training failures.

### Training gaps

55. The responsibilities of control room operators had become progressively more demanding as the mine developed but they had received only limited formal training. There had been no formal training on gas monitoring using the Safegas and SCADA programmes, with the exception of specific training from Mr White on a system he had put in

place for monitoring carbon monoxide levels.<sup>78</sup> After a meeting with the operators, management had agreed to provide more training but this had not occurred before the explosion.<sup>79</sup>

56. Specific training was given to the first hydro-mining crew who worked five days a week commissioning the hydro monitor and equipment in September 2010. When Pike moved to a 24-hour four-crew operation there was limited time to train the new crews. Stephen Wylie, a deputy assigned to one of the hydro crews, had some hydro-mining experience from Spring Creek but asked for training on Pike's set-up. None was given, which 'made it difficult, like especially since I was a supervisor on the panel'.<sup>80</sup>
57. There was also insufficient training in emergency preparedness at Pike. As discussed in Chapter 16, 'Search, rescue and recovery', training on the use of self-rescuers was inadequate. Many of the workers at the mine in November 2010 had not been involved in a mock underground evacuation, the last one having taken place in October 2009. There had been no training to test the practical implementation of the mine's emergency response management plan, which had not been reviewed since February 2009.<sup>81</sup>

#### **Lack of leadership training for supervisors underground**

58. There was no mentoring system for trainee miners once they were employed,<sup>82</sup> other than being assigned to a deputy or to an experienced miner. But deputies or leading hands were not given any specialised training in how to supervise, mentor and train the trainees.<sup>83</sup> At Mr White's request, Mr Stewart had provided some informal mentoring of the underviewers and deputies during his compliance audits, accompanying them underground for a shift and providing feedback and guidance,<sup>84</sup> but this had not continued after April 2010. Pike was working towards having a qualified workplace trainer/assessor on each shift to run the trainees, but this was not in place by November 2010.<sup>85</sup>
59. Comments made to Mr Couchman in November 2010 by some of the second intake of trainees indicated that the safety approach taught in the classroom was not always evident underground.<sup>86</sup> This concerned Mr White, who considered there was a 'direct leadership issue, especially with our senior miners and deputies'.<sup>87</sup> He discussed engaging a consultant to help improve supervision underground, but a proposal from an Australian consultant was declined on 18 November 2010 to give Stephen Ellis, the production manager, an opportunity to 'right things himself'.<sup>88</sup>

#### **Contraband**

60. Contraband incidents were reported and tool box talk safety advisory and newsflash notices were circulated throughout the Pike workforce.<sup>89</sup> Random searches for contraband began in late 2009,<sup>90</sup> and occurred frequently throughout 2010.<sup>91</sup> A process for searches was included in the mine manager's rules.<sup>92</sup> Contraband was also addressed in the NZQA unit standard training and in Pike's induction and in-house training, and Pike had signs around the site and at the portal entrance reminding of the prohibitions underground.<sup>93</sup> Although there are no completed incident/accident forms regarding contraband after April 2010, statements obtained from workers during the joint investigation suggested that the problem of workers taking contraband underground, intentionally or otherwise, continued.<sup>94</sup>

#### **Bypassing safety systems**

61. Analysis of the incident/accident reports exposed incidents of deliberate bypassing of safety systems and tampering with safety locks or covers, rendering them inoperable.<sup>95</sup> As discussed in Chapter 12, 'Hydro mining', a worker admitted briefly taping a plastic bag over a methane monitor on the morning shift on 19 November 2010.<sup>96</sup>

#### **Unsafe ventilation practices**

62. The commission received evidence of a number of incidents involving unsafe ventilation practices, including incidents where air was diverted away from a working face without workers being given prior notice,<sup>97</sup> where the ventilation had been shut down for over 40 minutes while maintenance work on machines underground continued and workers were overcome by fumes from machinery,<sup>98</sup> and where inexperienced workers showed a lack of regard for basic ventilation and gas practices and the need for set procedures.<sup>99</sup> These were the types of practices that Mr Bell had been hired to deal with before his training sessions were cancelled.

# Contractor problems

## Introduction

63. Under the HSE Act, Pike was required to take all practicable steps to ensure that no employee, contractor or subcontractor was harmed while working, and that no hazard in its workplace harmed people in the vicinity.<sup>100</sup> Pike had a contractor management system, but it was not fully implemented.

## Induction of contractors

64. Before working underground at Pike, contractors had to complete only the basic two-hour induction training, a medical examination and the NZQA unit standard 7146. Short-term contractors (fewer than five days on site) working underground had only to complete the two-hour induction training.<sup>101</sup> Other than delivering basic inductions and some on-the-job instruction, Pike was not involved in training contractors,<sup>102</sup> and it was hit and miss whether all contractors received Pike's safety information by way of tool box advisory notices, newsflashes and the minutes of the health and safety committee.<sup>103</sup>
65. Mr Couchman was concerned that Pike's standard of induction for contracted workers was deficient compared with that given to new employees.<sup>104</sup> To address the problem, in mid-2010 Mr Couchman designed a standardised five-day induction for employees and contractors, which he presented to Messrs White and Rockhouse. The programme was welcomed but he was told 'we would have to wait until we were in full coal production before it could be introduced.'<sup>105</sup> He understood that was because of the time needed to fully induct the large number of contractors on site, whereas by the time full coal production was reached (estimated for February 2011) there would have been a 'lot less reliance' on contractors.<sup>106</sup>

## Pike's policy on contractor management

66. Pike's policy and procedures for managing contractor health and safety were set out in its safety manual,<sup>107</sup> which included requirements for contractors to comply with the mine manager's rules, to report incidents or accidents using Pike's forms and to advise the company what risks they and/or their equipment would introduce into the mine.<sup>108</sup> Contractors were to operate under the supervision of Pike staff, usually the project manager who employed them,<sup>109</sup> and a contractor authority to work permit had to be issued by Pike before work started. This was to ensure contractors had the same level of understanding and experience of site operations and hazards as Pike employees.<sup>110</sup>

## Contractor health and safety systems

67. Pike required all contractors without their own site specific health and safety system to complete the contract specific safety management plan in Pike's 'SubbyPack<sup>TM</sup>'.<sup>111</sup> This was a suite of documentation designed to 'establish a minimum and auditable standard for the management of Occupational Health and Safety by contractors and sub-contractors',<sup>112</sup> and to ensure compliance by Pike and the contractor with their obligations under the HSE Act.
68. Both the large contractors, McConnell Dowell Constructors Ltd and VLI Drilling Pty Ltd (VLI), had their own extensive site-specific health and safety systems. McConnell Dowell had a health and safety officer at the mine who attended Pike's health and safety committee meetings and the daily production meetings.<sup>113</sup> Only some of the smaller contractors had their own health and safety systems, but not all of those were specific to Pike or even to underground coal mining.<sup>114</sup>

## Responsibility for contractor management

69. Some Pike staff directly managed contractors,<sup>115</sup> and consultants assisting Pike in 2010 were managed by the department staff who engaged them. But from 2009 responsibility for the general management of many of the smaller labour hire contractors (those brought in when necessary to provide labour for projects in the mine) was

given to Terence Moynihan, himself an independent contractor working as manager of the project team,<sup>116</sup> and two contractors he managed, Rem Markland and Matthew Coll. The project team managed the day-to-day work of their smaller contractors and were often underground checking on the workers and their tasks, but they did not see their role as including managing the contractors' health and safety, other than in a limited way during construction and installation activities.<sup>117</sup>

70. In early 2010 Mr Rockhouse learnt that Pike had begun to engage contractors on hourly hire contracts and in about July/August 2010 he asked Mr Moynihan for contractor documentation for the new faces he had noticed around the mine. But it did not exist because the project team was unaware of the health and safety documentation that Pike required from its contractors, or of their obligation to obtain that information before a contractor began work underground.<sup>118</sup> This meant many contractors had staff working underground at Pike without their own health and safety system in place, and without the alternative protection of having their staff inducted into Pike's health and safety system, as required by the company's safety manual.<sup>119</sup>
71. Since management were confident that any safety matters would be addressed by the project team, it was agreed that Pike would improve its safety management system for contractors over the following three months rather than delay the project work (the commissioning of the hydro panel and underground fan) to review each contractor. Those improvements had not occurred by 19 November 2010.<sup>120</sup>

#### **No auditing of contractor safety**

72. Although Pike's safety management system required regular audits of contractor safety performance,<sup>121</sup> there is no evidence to establish that Pike audited either McConnell Dowell and VLI or any of the smaller contractors who lost men on 19 November 2010.<sup>122</sup> As a result of this omission, Pike was missing vital information on its contractors and the hazards that their staff and/or equipment might introduce to the mine.<sup>123</sup>

#### **Supervision of contractors underground**

73. There was no formal system requiring Pike's deputies to regularly check the safety of contractors while working underground.<sup>124</sup> In practice that was left up to their discretion when checking their areas of responsibility within the mine.
74. There was also no system to keep track of the locations of contractors underground, although the project team had a weekly plan that included information on where their contractors would likely be working each day. Contractors were not restricted from moving around the mine and 'pretty much looked after themselves'.<sup>125</sup> Visitors and contractors were required to sign in and out but that sometimes did not happen,<sup>126</sup> and neither that system nor the portal tag board helped the control room or the deputies to keep track of contractors' whereabouts underground.<sup>127</sup>

## Conclusions

75. Recognising the training needs of its relatively inexperienced and diverse workforce, Pike set out to create and implement good training programmes. But the company struggled to always train its workforce adequately. This was partly due to underresourcing and work pressures preventing the release of miners from their crews to attend training sessions. Some worker conduct underground reflected inadequate training, inexperience and a lack of underground leadership.
76. Pike's induction training for new employees was comprehensive, but the quality of contractor induction was inadequate. These workers faced the same hazards and should have received the same level of induction.
77. The management of contractors got away from Pike in 2010 and these workers were often left to their own devices. No person or department took overall responsibility for contractor management, and Pike did not ensure sufficient health and safety training and awareness for its contracted workforce. Safety performance audits of contractors were required but did not occur.

## ENDNOTES

- <sup>1</sup> Peter Whittall, witness statement, 22 June 2011, PW0/3, para. 5.
- <sup>2</sup> Adrian Couchman, transcript, p. 3827.
- <sup>3</sup> David Stewart, transcript, p. 3344.
- <sup>4</sup> Pieter van Rooyen, Pieter van Rooyen Handover Notes, 2 November 2010, PVR002.
- <sup>5</sup> Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/243, para. 5.10.1.
- <sup>6</sup> George Mason, transcript, pp. 3638, 3663–64; George Mason, witness statement, 31 October 2011, MAS0001/5, para. 14.
- <sup>7</sup> Matthew Coll, witness statement, 20 November 2011, FAM00055/5, para. 19.
- <sup>8</sup> Pike River Coal Ltd, Minutes of a Meeting of Directors, 24 August 2010, DAO.007.28248/4.
- <sup>9</sup> Diagram adapted from: Peter Whittall, Selected Management Positions Held at Pike River Coal Limited, January 2005–19 November 2010, PW22/1.
- <sup>10</sup> Dene Murphy, witness statement, 2 December 2011, FAM00057/15, para. 84.
- <sup>11</sup> George Mason, transcript, p. 3653.
- <sup>12</sup> Stephen Wylie, transcript, p. 3708.
- <sup>13</sup> Peter Whittall, transcript, p. 2786.
- <sup>14</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/53, para. 189.
- <sup>15</sup> David Reece, transcript, p. 4699.
- <sup>16</sup> David Stewart, transcript, p. 3341.
- <sup>17</sup> *Ibid.*, p. 3344.
- <sup>18</sup> David Stewart, Police/DOL interview, 4 April 2011, INV.03.17291/15.
- <sup>19</sup> Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/12, para. 61.
- <sup>20</sup> Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/8, para. 42.
- <sup>21</sup> Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/8, paras 38–41.
- <sup>22</sup> Adrian Couchman, transcript, p. 3828.
- <sup>23</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 192.
- <sup>24</sup> Reginald Matthews, witness statement, 29 November 2011, MAT0001/15, p. 96.
- <sup>25</sup> Adrian Couchman, transcript, p. 3828.
- <sup>26</sup> An example occurred in August 2010 when three machines were in position ready to cut coal, but there was a lack of available operators to run them: Pike River Coal Ltd, Operations Meeting, 4 August 2010, DAO.002.14764/6.
- <sup>27</sup> Pike River Coal Ltd, Operations Meeting, 8 October 2009, DAO.002.14097/6; Pike River Coal Ltd, Operations Meeting, 1 September 2010, DAO.002.14860/7.
- <sup>28</sup> John Dow, transcript, p. 3934.
- <sup>29</sup> Letter, John Dow to all staff, 5 July 2010, DAO.011.22212/3.
- <sup>30</sup> Pike River Coal Ltd, Operations Meeting, 10 November 2010, DAO.002.14998/7.
- <sup>31</sup> David Stewart, transcript, p. 3369.
- <sup>32</sup> *Ibid.*, pp. 3341–42.
- <sup>33</sup> Matthew Coll, witness statement, 20 November 2011, FAM00055/6, para. 25.
- <sup>34</sup> Neville Rockhouse, witness statement, 1 April 2012, ROCK0031/8, paras 37–38.
- <sup>35</sup> Pike River Coal Ltd, Leadership Team Meeting – Minutes of the PRCL Leadership Management Team, 28 February 2007, DAO.025.43041/2.
- <sup>36</sup> Health and Safety in Employment Act 1992, s 13.
- <sup>37</sup> National qualifications are those approved and quality assured by the New Zealand Qualifications Authority. They feature in the National Qualifications Framework and levels of difficulty are assessed within this framework, with level 1 being the least difficult and levels 8 to 10 being university qualifications.
- <sup>38</sup> Each unit standard has a level and a credit value, which gives an idea of how long it is likely to take. One credit is roughly equivalent to 10 learning and assessment hours, although this varies depending on the skills and knowledge a candidate already possesses: Extractive Industry Training Organisation, Adding Value to Industry with On-Job Training and National Qualifications, [http://exito.org.nz/documents/cat\\_view/109-corporate-documents](http://exito.org.nz/documents/cat_view/109-corporate-documents)
- <sup>39</sup> New Zealand Qualifications Authority, NZQA Registered Unit Standard 7142, Version 7: Demonstrate Knowledge of the Application of Regulatory Requirements to Manage an Extractive Site, 2010.
- <sup>40</sup> Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, paras 7–10.
- <sup>41</sup> *Ibid.*, FAI0001/1, para. 12.
- <sup>42</sup> Email, Peter Whittall to Kevin Walker and others, 17 December 2009, DOL3000010036/1.
- <sup>43</sup> Emails between Peter Whittall, Kevin Walker and others, 8 December 2009–4 February 2010, DOL3000010032, DOL3000010036.
- <sup>44</sup> Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, para. 12.
- <sup>45</sup> Adrian Couchman, transcript, p. 3864; Robert (Gavin) Taylor, witness statement, 11 May 2012, DOL7770060001/2–3, paras 6–11.
- <sup>46</sup> Stephen Ellis, transcript, p. 2314. An example at Pike is a mine manager who failed three times to obtain a first class mine manager's COC in Queensland in 2009 and 2010, because he did not pass oral examinations. After arriving at Pike in September 2010, he completed the unit standard requirements and a professional conversation in November 2010, and obtained a New Zealand first class mine manager's COC: Stephen Ellis, witness statement, 17 April 2012, DAO.042.00036; Robert (Gavin) Taylor, witness statement, 11 May 2012, DOL7770060001.
- <sup>47</sup> Peter Fairhall, witness statement, 6 November 2011, FAI0001/2, para. 19; Michelle Gillman, witness statement, 10 November 2011, GIL0001/4, para. 17; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/13, paras 30–31; Reginald Matthews, witness statement, 29 November 2011, MAT0001/8, paras 45–48; Adrian Couchman, witness statement, 28 November 2011, COU0001/7, paras 29–34; Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/97, para. 40.
- <sup>48</sup> Reginald Matthews, witness statement, 29 November 2011, MAT0001/4–6.
- <sup>49</sup> Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/4–5.
- <sup>50</sup> *Ibid.*, COL0001/6–7, para. 38.
- <sup>51</sup> *Ibid.*, COL0001/7, para. 40.
- <sup>52</sup> Mr Colligan had not trained Joseph Dunbar, who was underground at the Pike River mine for the first time on 19 November 2010.
- <sup>53</sup> Alexander (George) Colligan, witness statement, COL0001/8, paras 45–46.
- <sup>54</sup> Michelle Gillman, witness statement, 10 November 2011, GIL0001/3, para. 1.
- <sup>55</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/6, para. 26.
- <sup>56</sup> *Ibid.*, COU0001/5, para. 18.
- <sup>57</sup> Adrian Couchman, transcript, pp. 3823–24; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/16, 42, paras 39, 41, 141–42; Michelle Gillman, witness statement, 10 November 2011, GIL0001/4, para. 14.
- <sup>58</sup> John Dow, transcript, p. 3933.
- <sup>59</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/10, para. 49; Adrian Couchman, transcript, p. 3780.
- <sup>60</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/55, para. 195.
- <sup>61</sup> Neville Rockhouse, transcript, pp. 4273–74; Pike River Coal Ltd, Corporate Safety Manual: Section 1.7, June 2008, DAO.001.08593.
- <sup>62</sup> Adrian Couchman, transcript, pp. 3762–63.
- <sup>63</sup> *Ibid.*, p. 3764.
- <sup>64</sup> Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/64–65, sch I.
- <sup>65</sup> Adrian Couchman, transcript, p. 3762; New Zealand Qualifications Authority, NZQA Registered Unit Standard 7146: Demonstrate Basic Knowledge and Ability Required to Work in an Underground Mine, Version 7, 2010, CAC0142.
- <sup>66</sup> Including knowledge and use of self-rescuers, cap lamps and personal protective equipment; safe measures for isolation of energy systems to machinery and equipment underground; knowledge of emergency procedures; personnel security issues (contraband, restricted zones and restricted materials) and accounting systems (tag, paper, cap lamp number); and the ability to describe basic ventilation principles and practices in an underground mine, and demonstrate basic knowledge of mine gases. Knowledge of the requirements of the HSE Act and relevant regulations was

also required.

- <sup>67</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/8, paras 36–39; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 190.
- <sup>68</sup> Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, para. 5.
- <sup>69</sup> Adrian Couchman, transcript, p. 3772.
- <sup>70</sup> Reginald Matthews, witness statement, 29 November 2011, MAT0001/6, para. 31.
- <sup>71</sup> Adrian Couchman, transcript, p. 3778.
- <sup>72</sup> *Ibid.*, pp. 3780–81.
- <sup>73</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/10, paras 50–51.
- <sup>74</sup> Douglas White, transcript, pp. 1119–20; Adrian Couchman, transcript, p. 3782; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 191; Email, Michelle Gillman to Neville Rockhouse and Douglas White, 7 March 2010, ROCK0027/1.
- <sup>75</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/9, para. 45; Adrian Couchman, transcript, pp. 3781–82, 3829–30.
- <sup>76</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/9, para. 47; Adrian Couchman, transcript, pp. 3829–30; Peter Fairhall, witness statement, 6 November 2011, FAI0001/2, para. 17.
- <sup>77</sup> Pike River Coal Ltd, Operations Meeting, 10 November 2010, DAO.002.14998/8.
- <sup>78</sup> Douglas White, transcript, p. 4923.
- <sup>79</sup> Daniel Duggan, transcript, p. 1609; Barry McIntosh, Police/DOL interview, 2 August 2011, INV.03.28697/33–34; Douglas White, transcript, pp. 4921–24.
- <sup>80</sup> Stephen Wylie, transcript, p. 3705.
- <sup>81</sup> Douglas White, transcript, p. 1263; Neville Rockhouse, transcript, p. 1451.
- <sup>82</sup> Adrian Couchman, transcript, p. 3776.
- <sup>83</sup> *Ibid.*, pp. 3776–77.
- <sup>84</sup> David Stewart, transcript, pp. 3343, 3360–61; Emails between Douglas White, David Stewart, Michael Lerch and Peter Whittall, 15–16 February 2010, CAC0138/4–5.
- <sup>85</sup> Adrian Couchman, transcript, p. 3777.
- <sup>86</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/8, para. 41; Adrian Couchman, transcript, pp. 3773–74; Pike River Coal Ltd, Trainee Miner Recommendations: August 2010 Intake, 9 November 2010, INV.04.00649/2–3.
- <sup>87</sup> Email, Douglas White to Richard Knapp and Stephen Ellis, 9 November 2010, INV.04.00691/3–4.
- <sup>88</sup> Emails between Douglas White and Ted Botham, 15–18 November 2010, INV.04.00661/4–7 and INV.04.00733/1.
- <sup>89</sup> See, for example, Tool Box Talk Safety Advisory notices issued on 31 March 2009 (DAO.001.11364), 15 December 2009 (DAO.001.11428) and 16 April 2010 (DAO.001.11947); and General Newflash notices on 5 January 2009 (DAO.001.08773), 30 April 2009 (DAO.001.08786), 17 September 2009 (DAO.001.08805) and 27 November 2009 (DAO.001.08820).
- <sup>90</sup> In 2009 one of the first searches by an undermanager of 25–30 miners about to go on shift produced an estimated 18–20 restricted articles, including cigarettes, matches and lighters, cans and two cellphones. Pike also had instances of cigarette lighters left in the back of driftrunners, cigarette butts in the tunnel, a miner wearing a battery-operated watch underground, and other restricted items such as aluminium and glass vessels found underground: Reginald Matthews, witness statement, 29 November 2011, MAT0001/13, para. 77; Adrian Couchman, witness statement, 28 November 2011, COU0001/22, para. 119; Neville Rockhouse, transcript, p. 4247.
- <sup>91</sup> Pike River Coal Ltd, Contraband Searches Conducted, DAO.004.00002; Brett Murray, transcript, p. 4426.
- <sup>92</sup> Pike River Coal Ltd, Mine Manager's Rules, 13 September 2010, INV.03.25773/24–25.
- <sup>93</sup> Pike River Coal Ltd, Training Module – Contraband Rules, May 2010, EXH0051/1; Brett Murray, transcript, p. 4423; Photograph, 'No Contraband Permitted Underground' sign, EXH0052/1.
- <sup>94</sup> David Reece, transcript, pp. 4668–69.
- <sup>95</sup> Royal Commission on the Pike River Coal Mine Tragedy, Summary of the Reports, CAC0114/20–24.

- <sup>96</sup> Police/DOL interview, 8 April 2011, INV.03.17556/1–22. (The commission decided, by majority, to withhold the name of the worker concerned. Commissioner Bell dissented.)
- <sup>97</sup> Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/9, paras 45–47.
- <sup>98</sup> Reginald Matthews, witness statement, 29 November 2011, MAT0001/11, para. 68.
- <sup>99</sup> Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/10, paras 50–51.
- <sup>100</sup> Health and Safety in Employment Act 1992, ss 16, 18.
- <sup>101</sup> Email, Adrian Couchman to Andrew Sanders, 19 May 2010, attaching Pike River Coal Ltd, PRCL Contractor Management Overview, DAO.003.01788/1–2.
- <sup>102</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/13, para. 71.
- <sup>103</sup> Department of Labour, Investigation Report, DOL3000130010/266, paras 6.14.1–8.
- <sup>104</sup> Adrian Couchman, transcript, p. 3768.
- <sup>105</sup> Adrian Couchman, witness statement, COU0001/14, para. 76; Adrian Couchman, transcript, p. 3768–69.
- <sup>106</sup> Adrian Couchman, transcript, p. 3769.
- <sup>107</sup> Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/1–5.
- <sup>108</sup> *Ibid.*, section 8.1, DAO.001.08536/3.
- <sup>109</sup> *Ibid.*, section 8.4, DAO.001.08548/2.
- <sup>110</sup> *Ibid.*, section 8.8, DAO.001.08287/1–3.
- <sup>111</sup> Pike River Coal Ltd, SubbyPack – Contractor's Site Specific Safety Management Plan, 2008, ROCK0011.
- <sup>112</sup> *Ibid.*, ROCK0011/7.
- <sup>113</sup> Department of Labour, Investigation Report, DOL3000130010/260, para. 6.10.5; Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/28, para. 124.
- <sup>114</sup> Department of Labour, Investigation Report, DOL3000130010/269–81.
- <sup>115</sup> For example, Douglas White (McConnell Dowell), Jimmy Cory (VLI) and Michael Scott (electrical contractors): Department of Labour, Investigation Report, DOL3000130010/260, para. 6.10.6.
- <sup>116</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/64, para. 246.
- <sup>117</sup> Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/25–33; Rem Markland, Police/DOL interview, 5 April 2011, INV.03.17730/31–34.
- <sup>118</sup> Neville Rockhouse, witness statement, ROCK0002/65–67, paras 253–55; Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/25–33; Matthew Coll, Police/DOL interview, 20 April 2011, INV.03.19129/14–16; Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/3.
- <sup>119</sup> *Ibid.*, DAO.001.08536/3.
- <sup>120</sup> Neville Rockhouse, witness statement, ROCK0002/66–67, paras 256–58; Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/26.
- <sup>121</sup> Pike River Coal Ltd, Pike River Coal Safety Audit Schedule V1, 12 August 2010, DAO.010.00316/2; Pike River Coal Ltd, Corporate Safety Manual: Section 8.5, June 2008, DAO.001.08557/1.
- <sup>122</sup> Department of Labour, Investigation Report, DOL3000130010/267–69, paras 6.15.1–15.
- <sup>123</sup> Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/3.
- <sup>124</sup> Department of Labour, Investigation Report, DOL3000130010/264, para. 6.13.9; Simon Donaldson, Police/DOL interview, 11 July 2011, INV.03.24207/7–8; Shaun Whitau, Police/DOL interview, 4 February 2011, INV.03.12950/21–22.
- <sup>125</sup> Rem Markland, Police/DOL interview, 5 April 2011, INV.03.17730/45; Craig Bisphan, Police/DOL interview, 12 July 2011, INV.03.24109/49.
- <sup>126</sup> One contractor working at Pike River since 2009 said he was not instructed to and did not sign in at the control room; instead he believed that a microchip access button he was provided registered his whereabouts. He had lost his tag for the board about four months before the explosion and had not been given a new one: Phillip Smith, Police/DOL interview, 20 October 2011, INV.03.31617/33–34.
- <sup>127</sup> Dene Murphy, Police/DOL interview, 28 January 2011, INV.03.18581/74.



# Health and safety management

## Introduction

1. Employers must take all practicable steps to ensure the safety of employees. In coal mining and other high-hazard industries best practice is to manage the significant risks involved through a health and safety management system that provides a mechanism for identifying hazards and the risks associated with them, and managing those risks.
2. This chapter introduces the systems concept and its basis in law and practice. It then discusses Pike's approach to planning, implementing, monitoring and reviewing its system.
3. The focus is on the people most involved in developing and managing the health and safety system and what was needed to put it into practice.
4. There is further analysis in other chapters on critical mine systems and organisational factors. Workplace safety is multi-faceted. In mining it is the product of good ventilation and gas control, effective hazard management, ongoing worker training and supervision, and a commitment by managers and directors to worker safety.

## Health and safety management systems

5. A health and safety management system is 'that part of the overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the OHS policy, and so managing the risks associated with the business of the organization'.<sup>1</sup> It integrates a range of safety management tools and functions including 'senior management commitment, hazard identification, risk management, safety reporting, occurrence investigation, remedial actions and education'.<sup>2</sup>
6. A health and safety management system provides a framework or structure for the development, implementation and review of the plans and processes necessary to manage safety in the workplace.<sup>3</sup> The influences that shape the system and the main elements for an underground coal mine are illustrated in the following diagram.

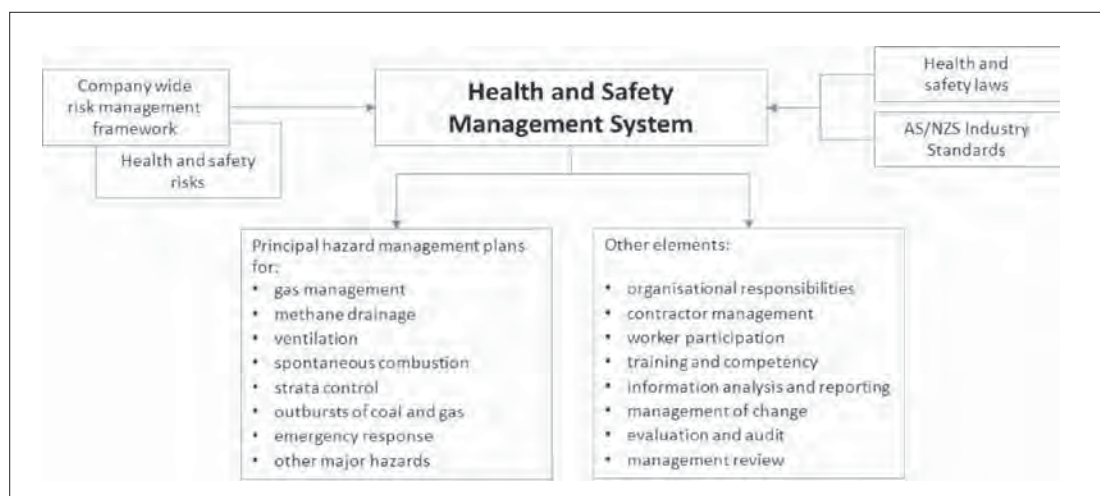


Figure 7.1: Elements of a health and safety system

## Requirements of the Health and Safety in Employment Act 1992 (HSE Act)

7. The act's objective is to advance worker safety by 'promoting excellence in health and safety management, in particular through promoting the systematic management of health and safety'. Employers have a general duty to 'take all practicable steps to ensure the safety of employees while at work',<sup>4</sup> through providing a safe environment, work facilities and plant and ensuring that workers are not exposed to hazards.<sup>5</sup> Employers must identify and assess hazards,<sup>6</sup> then implement a hierarchy of controls to eliminate, isolate or minimise those that might cause serious harm.
8. Other obligations on employers include informing employees about hazards to which they might be exposed and the steps to be taken to avoid being harmed by those hazards; ensuring worker health and safety representatives have access to information about health and safety systems; ensuring that employees are properly trained and supervised; and involving workers in health and safety matters.
9. Employees must take all practicable steps to keep themselves safe and not harm others.

## The elements of a health and safety management system

10. Two Australasian industry standards provide guidance on health and safety management systems.<sup>7</sup> These recommend that an organisation:
  - defines its health and safety policy and ensures commitment to the system through leadership and allocation of resources. This is a board and executive management function;
  - develops a management plan to control specific hazards;
  - implements the plan by involving people at all levels in the organisation. Implementation includes allocating resources, assessing training needs, making sure information is communicated, establishing incident/accident and hazard reporting systems, documenting the system and changes, and setting up procedures for continued assessment and control of hazards;
  - measures and evaluates health and safety performance, through inspections, monitoring, incident reporting, investigations and audits; and
  - reviews the system at the executive management level to ensure it is operating effectively and remains appropriate. 'Management review is the cornerstone of the system'.<sup>8</sup>
11. The design of a health and safety management system should be tailored to the circumstances of an organisation and its stage of development. Pike's system, for example, had to recognise that the company was in development and early production mode, mining in difficult conditions, reliant on a growing and diverse workforce, and planning to establish a high-production operation based on hydro mining. Hazard identification and control needed to take account of all these challenges.
12. The commitment of everyone in the organisation, from the chair of the board to trainee miners, is vital to a properly functioning health and safety management system. There must be attention to detail in all aspects of the operation, from design of the mine, procurement of plant and equipment to mining activities – all tasks that affect workplace safety, directly or indirectly.

## The Pike approach

### An integrated approach

13. Pike recognised the need for an organisation-wide, integrated approach to safety management. The corporate

health and safety policy stated that creating a safe work environment is 'both the individual and shared responsibility of all PRCL employees, management and board' and 'that people at all levels' must be committed to achieving high health and safety standards.<sup>9</sup> Documentation shows that all aspects of the operation were seen as part of the health and safety management system and that responsibilities were dispersed across the organisation as depicted in this diagram.



Figure 7.2: Pike safety management systems and management plan<sup>10</sup>

### Role of the board

14. In its charter, the board's health, safety and environment (HSE) committee acknowledged that the board was ultimately responsible for health and safety and environmental policies and compliance with relevant laws. Responsibility for implementation rested with executive management. The actions of this committee and the board more generally are evaluated in Chapter 5, 'Governance and management'. The HSE committee and the board did not properly identify and manage the major health and safety risks facing the company.
15. Implementation of the health and safety management system was made more difficult because there were no clear objectives and targets during the development phase. Pike relied on having a fully externally auditable health and safety management system by the time 'steady-state production' was reached, which meant that 'virtually ... all of your infrastructure is in place, all of your plant and equipment has been ... fully commissioned and you are a coal mine producing coal'.<sup>11</sup>
16. This goal was understandable if it meant the system would mature in pace with development of the mine. Workplace safety is a work in progress, and the identification and management of hazards ongoing. But it is critical that health and safety management begins at the planning, design and mine development stages and remains relevant to the stage the mine has reached. At Pike River the drive to produce coal in 2010 led to a view that management of some hazards could await the implementation of a long-term solution, when for example a suitable second egress and a usable fresh air base (FAB) should have been high-priority safety requirements.

### The safety and training department

17. High-hazard and complex organisations generally employ specialist health and safety officers. Their existence does not remove the responsibility from directors or managers to manage health and safety in the same way as they manage other risks facing the organisation, such as those relating to production and finance.
18. The functions of Pike's safety and training department included developing the health and safety management system, developing and managing the incident and accident reporting system, conducting underground and medical equipment audits and inducting and training workers. Neville Rockhouse was the safety and training manager. He joined Pike in 2006. Mr Rockhouse had a post-graduate qualification and experience in health and

- safety and, earlier in his career, some mining experience. However, at the job interview he impressed upon Peter Whittall that his mining work experience was distant, was not in a gassy mine and did not extend to hydro mining.<sup>12</sup>
19. Mr Rockhouse twice gave evidence to the commission. This posed special difficulties for him: he lost one son in the tragedy and another was one of the two survivors who escaped from the mine.
  20. Mr Rockhouse had a heavy workload, sometimes working between 60 to 80 hours per week. He sought more staff for his department, but was largely unsuccessful.<sup>13</sup> He found it difficult to get co-operation from other managers. Although Mr Rockhouse was the architect of most of the health and safety documents, he depended on technical input from the managers or staff of other departments. He had no authority over the managers and staff and there was no central oversight of the way departments managed health and safety other than Mr Rockhouse who was 'chasing them constantly to get stuff done'.<sup>14</sup>
  21. The commission is satisfied that Mr Rockhouse needed significant support and guidance in developing Pike's health and safety management system, and direction on priorities. This was lacking. And when Mr Rockhouse was vocal in raising safety concerns, for example the absence of a second means of egress and the need for a refuge chamber,<sup>15</sup> his concerns were not addressed. Generally, his department struggled for credibility alongside the more production-focused departments.
  22. The resourcing of the safety and training department, including the staff members who assisted Mr Rockhouse, has been discussed in Chapter 6, 'The workforce'.

## Implementing the system

23. Mr Rockhouse began in 2006 with 'pretty much a blank sheet of paper' and was told 'go for it'. He had previous experience in designing a system 'from scratch', but not for a coal mine. However, Mr Rockhouse saw it as 'an exciting project'.<sup>16</sup> He drew on Australian and New Zealand industry standards and had access to management systems from other mines, mainly in Australia, which he adapted to Pike's circumstances. The system was to be computer-based, and was intended to be 'world class'.<sup>17</sup>

### Documentation

24. The documented system was developed mainly by Mr Rockhouse.<sup>18</sup> The main document was the *Corporate Safety Manual: Safety in the Pike River Coal Workplace*,<sup>19</sup> which covered the employer commitment to safety management practices; planning, review and evaluation; hazard identification; information, training and supervision; incident/accident reporting and investigation; employee participation; emergency planning; and contractor management.
25. Beneath the manual was a hierarchy of documents, including departmental management plans, safe operating procedures (SOPs) to assist in managing known hazards, trigger action response plans (TARPs) to define the response to specific events, and job safety and environment analyses (JSEAs) for specific tasks.
26. A permit to work system operated to define the boundaries for specific work activities. Other documents included the mine manager's rules, an induction handbook, a SubbyPack™ (for contractors) and a hazard register.
27. By November 2010 there were over 398 documents in the electronic system.<sup>20</sup> Of these 227 were in draft as they were not signed off by two managers, although they were still used in the meantime. The number, and length, of the documents posed a challenge to the credibility of the system.
28. Although many of the documents were helpful, there were problems, not only with the sheer volume of material, but also with some of its content. For example, in 2010 two consultants and a Pike manager assessed the ventilation management plan and concluded it needed a complete review.<sup>21</sup>

### Communication of health and safety issues

29. Informing workers, the board and the regulator about health and safety issues is an important component of any system.
30. Employees must be provided with a range of health and safety information, including about 'identified' hazards to which they may be exposed or that they may create. They may refuse to do work they believe is likely to cause them serious harm. That belief may be based on the advice of health and safety representatives, who must have access to sufficient health and safety information to enable them to perform their functions. Work cannot be refused because it carries an 'understood risk' of serious harm; the risk must have materially increased beyond the understood risk.<sup>22</sup> These rights depend on access to accurate information.
31. Pike had a number of mechanisms for providing health and safety information to employees and contractors, including inductions, training, news flashes and tool box talk safety advisories. While these were no doubt of benefit, two problems are apparent.
32. First, it seems some known information, bearing on hazards and increased risk, was not widely published. For example in late October 2010 a high reading of methane occurred at the ventilation shaft. A ventilation expert, John Rowland, said 'I would assume that such an event would be of sufficient importance that subsequent investigations and remediation strategies would be widely publicised to at least all site personnel, as a matter of very urgent priority.'<sup>23</sup> Mr Rockhouse agreed but said 'I didn't even know about it so no, no it wasn't done.'<sup>24</sup>
33. Prior to the tragedy Mr Rockhouse was not aware of methane readings of 5% reported by deputies during October 2010. When asked whether they received publicity or were notified to site personnel he stated 'No they didn't. You can't trust people can you.'<sup>25</sup> Methane readings were also not being properly reported in daily production or weekly operations meetings, nor through the health and safety system.<sup>26</sup>
34. The hazard was not only that of a potentially explosive methane incident in the workplace, but also that the mine lacked the capacity to prevent that, and further potentially explosive methane levels.
35. Second, this and subsequent chapters identify hazards and risks, some at a systemic level, which it seems were not fully identified or assessed by Pike. Without Pike having accurately identified them and their nature, it is unlikely that workers were informed of them.
36. Board health and safety communication was mainly via executive management's monthly operations report. Direct contact between the safety department and the board was rare. There was a weak link between the board HSE committee and the safety and training department. The committee met Mr Rockhouse infrequently and he did not always receive its minutes.<sup>27</sup> There was what Mr Rockhouse termed 'a cursory look at what was going on' by the HSE committee.<sup>28</sup>
37. Notification of health and safety information to the Department of Labour (DOL) was also inadequate. Employers must notify serious harm and other incidents prescribed by regulation 10 of the Health and Safety in Employment (Mining – Underground) Regulations 1999. These include an explosion or ignition of coal dust or gas, fire or spontaneous heating, unplanned outbursts of gas or water, loss of control of a vehicle, employees being trapped, structural failures, unplanned falls of ground, major collapses of part of the workings, uncontrolled accumulations of flammable or noxious gas, and failures of a main ventilation fan for more than 30 minutes.
38. Pike's incident and accident reporting procedure required serious harm notification, but did not capture and notify all matters required by regulation 10. Many notifiable incidents were not reported to DOL, including high methane readings of about 5% in October 2010.<sup>29</sup>
39. To Mr Rockhouse's knowledge Pike did not review or take legal advice regarding whether it was notifying the matters it was required to notify.<sup>30</sup>

### The workers site health and safety committee

40. The site committee was of the kind envisaged in the HSE Act. It had the power to make recommendations about health and safety matters which an employer had to adopt, or give written reasons for not doing so.
41. The committee's function was defined as monitoring health and safety, but 'focused on injury prevention' and significant hazard identification and management because 'this process is the key to all of our injury prevention initiatives'. Its role was to gather information from workers, table that information and develop controls to 'manage risk and prevent harm'.<sup>31</sup> The committee was to comprise an elected chair, a manager, a representative from each department and a union representative,<sup>32</sup> although no union involvement eventuated.<sup>33</sup> The committee did not have a budget or authority over workers, although departmental managers had access to funds.<sup>34</sup> Later, membership of the committee was increased to include contractor representatives from McConnell Dowell Constructors Ltd and trucking company TNL Group Ltd.
42. The committee met monthly. Minutes were taken and widely circulated, including to the chief executive, general manager and Mr Rockhouse, who sometimes attended meetings. The minutes were also made available to workers by email and by placing copies on notice boards and on smoko tables. However, Adrian Couchman, the chair of the committee, said there was never any feedback from workers.<sup>35</sup>
43. The committee maintained an 'action sheet' that recorded required actions, the person responsible for implementing them and an assignment and completion date. The sheets show that attention to completing actions varied. Ordinarily, simpler matters were attended to promptly, but actions assigned to some departments were routinely left unresolved. Mr Rockhouse stated, 'some department heads took little notice of action points arising from the meetings.'<sup>36</sup>
44. Attendance at committee meetings was an ongoing problem. For example, only five of the 10 representatives attended the final meeting on 8 November 2010.<sup>37</sup> The engineering department was consistently unrepresented, and had still not appointed someone to the committee as at November 2010.<sup>38</sup> Sometimes, there were more managers than workers at meetings, which concerned Mr Couchman, given that the committee was intended to be a workforce forum for health and safety concerns.<sup>39</sup>
45. Despite these problems the committee remained the voice of the workforce. Following the November 2010 meeting it raised numerous concerns, including the return to service of an unrepaired Jugernaut that had caused a back injury, poor underground management of fire hoses, the unavailability of a drifrunner underground at shift changeover periods and at other times when an evacuation could be declared, a shortage of fans and vent cans underground, the location of a toilet 1.2km away from the working faces, and the inability of miners to contact the control room by digital access carrier (DAC) or phone.<sup>40</sup> When Mr Couchman conveyed these concerns to Douglas White, Mr Rockhouse and Stephen Ellis, Mr White responded immediately, saying, 'my patience is wearing rather thin on some of these issues.'<sup>41</sup> These were clearly recurrent problems.
46. The most significant obstacle the committee faced was its inability to make progress on the major issues it raised. On 3 March 2010 Mr Couchman, as chair, wrote to Mr Rockhouse asking 'if there has been any further progress made on reaching a resolution in regards to the 2nd means of egress.'<sup>42</sup> On 17 March 2010 Mr Rockhouse replied, noting that, following a significant risk assessment, the Alimak section of the ventilation shaft would not be used as a second emergency egress if the drift was impassable. Instead a FAB was to be constructed in the slimline shaft stub. But a proper FAB was not completed by the end of June. There was only a pull-down brattice stopping to isolate the slimline shaft stub. This was an interim measure while the FAB was designed and ventilation surveys undertaken.<sup>43</sup>
47. When the committee met on 13 September 2010, and noted that development of a second means of egress was planned 'sometime in the coming months', it resolved 'that this was not adequate and requested a firm plan be made available to identify when the 2nd means of egress would be actioned.'<sup>44</sup> Mr Couchman was designated to



action this. The matter was raised at the next meeting, on 11 October, when in the absence of any response from the company, it was reassigned to Mr Ellis to 'chase it up for us'.<sup>45</sup> At the November meeting it was noted that Mr Ellis would report 'next month'.<sup>46</sup>

48. Hence, by the date of the explosion little progress had been made. There was a plan to establish a walkout second egress, but its construction was at least 12 months off. The interim safeguard of a proper FAB had not eventuated either. A fundamental concern of the workforce remained unaddressed – eight months after it was first raised.

## Evaluation and monitoring

49. Ongoing evaluation of available information is an important component of a health and safety management system. It identifies emerging issues and risks and opportunities for improvements. This requires monitoring and reporting mechanisms, management analysis of the resulting information and a response to any warning signs, including effective feedback to the workforce.
50. As well as information from the site health and safety committee, numerous records and reports provided information about problems at the mine. Deputies and underviewers completed reports every shift. Control room operators prepared shift, daily and event reports. Engineers, electricians and machine operators regularly inspected and reported on diesel engines, fans, pumps, sensors and electrical equipment.<sup>47</sup>
51. The safety and training department, assisted by the Mines Rescue Service, audited rescue and medical equipment; the New Zealand Fire Service undertook audits and prepared reports on surface facilities.
52. Later chapters consider the effectiveness of monitoring of specific systems such as those relating to methane, ventilation, strata and mining practices. This section looks at other reporting mechanisms and the company's general response to safety information from within the mine.

### Incident/accident reporting and investigation

53. Pike had an incident/accident reporting and investigation system in place. Workers were required to report events on a report form.<sup>48</sup> These forms went to the safety and training department. Mr Rockhouse investigated some serious matters himself. Otherwise investigations were undertaken by a manager or staff member from the appropriate department. Some events were investigated by a team, which could include the mine manager.
54. The workers reported many incidents and accidents. The commission analysed 1083 reports and summarised a selection of 436 in a schedule.<sup>49</sup> The schedule groups events by type, including methane spikes, ventilation, strata, bypassing, equipment sparking and a number of others. The numbers suggest that the workforce, including contractors, were committed to reporting events, though the extent of non-reporting is unknown. The reports certainly contained a wealth of information which, if properly analysed, revealed much about the systems and conduct underground.
55. However, there were problems with the investigation process. Many reports were assigned to an investigator, but no investigation was completed. This was evident from the report forms filed with the commission. Mr Couchman described the extent of this problem. Some departments would have only a handful of investigations outstanding, while the engineering and production departments sometimes had up to 70 uncompleted investigations and some were over a year old. Measures to deal with the backlog were unsuccessful. When the backlog was discussed with Mr White in October 2010 he decided that they should be cleared and a fresh start made 'with a new management and a new mine manager'. This meant that the incidents were never properly investigated.<sup>50</sup>
56. The site health and safety committee reviewed a selection of incident/accident reports at its monthly meetings. Approximately six of these were selected at random, and a committee member assessed whether stipulated remedial actions had been carried out.<sup>51</sup> If not, the incidents were reopened and followed up.
57. There was some trend analysis of, and action was taken on, some issues, such as contraband. But because reports were not analysed systematically for recurring safety problems, or weaknesses in control measures, many matters

were not discovered. In this way potential information about safety and emerging risks was lost, and information that could have been obtained from completed investigations was not put to best use. The extent of this deficit was most apparent when Mr Rockhouse described his reaction to seeing the schedules prepared by the commission: 'Mr Wilding, when you spent that three days with me and you showed me that stuff you had me reduced to tears. I know there was no analysis like you've done with that [information] at Pike River.'<sup>52</sup>

58. There was also a breakdown in providing feedback to the report writers. Mr Couchman considered there was no established system for providing feedback.<sup>53</sup> Mr Rockhouse understood that when an investigation was completed, there should have been feedback to the reporter but this 'didn't happen.'<sup>54</sup>

### Use of lead and lag data

59. An additional problem was the way overall safety performance was being measured at Pike. The health and safety management system and reporting to management and the board was based mainly on lag, rather than lead, data. Lead indicators 'are measures of pre-emptive actions or initiatives that assist in preventing workplace injury,'<sup>55</sup> for example, the percentage of hazards rectified and near miss investigations. They enable trends and weaknesses in processes to be identified before serious incidents occur. Lag indicators measure events and impacts after the event.
60. In the early days of the mine there was discussion of using lead indicators as key performance measures for managers,<sup>56</sup> though lag indicators (lost time injuries and later medical treatment injuries) were used.<sup>57</sup> Lag rather than a mixture of lag and lead data was also reported to the operations meetings and to the board.<sup>58</sup> There is no sign that the board of directors appreciated the importance of using both types of data.

## Management review

61. Periodic management review of the health and safety management system is essential to ensure it remains relevant and to plan improvements. Beyond an audit of statutory compliance in early 2010,<sup>59</sup> there was no systematic attempt to review the health and safety management system initiated by Pike management.
62. The closest to a review was an insurance risk survey conducted by Hawcroft Consulting International. This established risk ratings that influenced the premiums Pike paid for insurance cover. The company's health and safety management systems were rated as average or above, save in one respect – risk management. This received an average rating in 2009, but a below average/low standard rating in 2010.<sup>60</sup> The commentary to the survey explained that 'Over the next 12 months Pike River Coal will be in a transition phase from development to steady state coal production from the monitor panels. A number of risks exist associated with methane (gas drainage efficiency), wind blast potential (monitor panels only), goaf falls in monitor panels and actual behaviour of the immediate massive strata.' And, as at July 2010, 'management had not conducted a broad brush risk assessment or formal operational risk assessments into these principal hazards, therefore some risks may remain unknown.'<sup>61</sup>
63. Mr Rockhouse was alive to this problem. Aware of Hawcroft's recommendation for a broad-based assessment, he raised the matter at various managers' meetings. Mr Whittall responded that the issue should be 'taken offline,' to be discussed 'at a later date outside of this forum.'<sup>62</sup> There was no discussion and no broad assessment of risks before hydro mining began.
64. A review of the whole health and safety management system would have identified anomalies, many of which could have been readily rectified. For example, the mine manager's rules required people to go to 'a ventilated place' when gas concentrations exceeded 'safe levels,'<sup>63</sup> whereas regulations prescribe a 'flammable gas' level of 2% by volume, or more' as the trigger point for withdrawal.<sup>64</sup> Management plans referred to compliance with codes of practice, when these did not exist in New Zealand. These errors probably resulted from using overseas materials when drafting the Pike documents.
65. There was also a gap between the documented system and actual practices underground. The ventilation management plan provided a glaring example of this. In accordance with best practice it required the appointment

of a ventilation engineer, whose critical role was to oversee the ventilation system. But no one was appointed to this position (see Chapter 8, 'Ventilation', paragraphs 89–101). The plan also contemplated the installation of a tube bundle monitoring system, but the mine did not have one.

66. More generally, when referred to numerous examples of conduct and practices that were contrary to the procedures described in the documented system, Mr Rockhouse lamented that 'the purpose of their creation was to actually be used and be followed to keep everyone safe. Clearly that has not occurred across a lot of departments.'<sup>65</sup>

## Hazard recording

67. Pike had a suite of documents that enabled the reporting and recording of hazards and associated information. This included accident and incident forms and 'I am safe' booklets which workers could use to report hazards and a 'baseline risk assessment significant hazard register' (register), which listed hazards rated for their risk and probability and their controls. However, that system was not effective. Four examples illustrate why.
68. First, new information gathered by Pike was not always incorporated into the register. When hazards were reported on the accident and incident forms or in 'I am safe' booklets there would be a check to ensure those hazards were listed in the register. If not, they would be included. But multiple occurrences of the same hazard, and reporting of an accident or incident, did not result in re-evaluation of the probability and consequence of the hazard.<sup>66</sup> The concerns raised in the Hawcroft report did not flow into the register.<sup>67</sup>
69. Second, the register dealt with hazards discretely, for example hazards relating to vehicles, water management, working at heights and ventilation management. The register did not reflect the increased risks resulting from a combination of hazards. Those risks should have become apparent had there been a broad brush risk assessment of the type raised by Hawcroft.
70. Third, many of the controls listed in the hazard register were dependent on compliance with Pike's management plans and operating procedures, and the proper training and assessment of, and operation of equipment by, workers. Yet, as seen elsewhere, there were significant problems with those aspects, which suggest that many of the 'controls' did not exist or could not be relied on.
71. Finally, to Mr Rockhouse's knowledge the register was not used for management-level operational planning.<sup>68</sup>

## Conclusions

72. The company did not have a clear strategy from the board that set out its vision, objectives and targets for health and safety management. It did not treat health and safety as a key corporate risk and prioritise the development of an integrated health and safety management system.
73. The executive management team therefore did not always prioritise safety matters. Mr Rockhouse, without a strong mandate, found it difficult to influence and involve others. The safety and training department at Pike appears to have been marginalised.
74. The Pike health and safety management system was never audited internally or externally. If it had been, deficiencies would have been identified, including the gap between the standards and procedures laid down in the Pike documents, and the actual mine practices. Examples of this are highlighted throughout Chapters 8 to 12, on the critical mine systems.
75. Pike generated a lot of information about the safety of critical mine systems and practices underground. This included information about contraband, bypassing of safety devices, ventilation problems, methane spikes, sensor

failures and information on numerous other topics. But much of the information was not analysed and responded to. If it had been, some of the problems discussed in this report would have been highlighted, and a number of warning signs that pointed to the risk of an underground explosion would have been noticed.

76. The appointment of a specialist health and safety adviser does not alleviate the need for an organisation-wide acceptance of responsibility for health and safety management.

## ENDNOTES

- <sup>1</sup> Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – General Guidelines on Principles, Systems and Supporting Techniques, (AS/NZS 4804:2001), 15 November 2001, p. 4.
- <sup>2</sup> Civil Aviation Authority of New Zealand, Safety Management Systems Policy, [http://www.caa.govt.nz/SMS/SMS\\_Policy.htm](http://www.caa.govt.nz/SMS/SMS_Policy.htm)
- <sup>3</sup> David Cliff, The Management of Occupational Health and Safety in the Australian Mining Industry, 2012, International Mining for Development Centre, p. 5, [http://im4dc.org/wp-content/uploads/2012/01/UWA\\_1698\\_Paper-03.pdf](http://im4dc.org/wp-content/uploads/2012/01/UWA_1698_Paper-03.pdf)
- <sup>4</sup> Health and Safety in Employment Act 1992, ss 5(a), 6.
- <sup>5</sup> To ensure there is broad coverage, and reflect the variety of workplaces, similar duties are imposed on those who control workplaces, the self-employed, principals to contracts and suppliers of plant.
- <sup>6</sup> The definition of hazards is broad. It can include 'physical, chemical, biological, psychosocial and mechanical factors': Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/8, para. 23.
- <sup>7</sup> Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001; Standards Australia and Standards New Zealand, AS/NZS 4804:2001.
- <sup>8</sup> Standards Australia and Standards New Zealand, AS/NZS 4801:2001, p. 40.
- <sup>9</sup> Pike River Coal Ltd, Health & Safety Policy, DAO.001.09556/1.
- <sup>10</sup> Pike River Coal Ltd, Strata Control Management Plan: Management Plan (Final Document), 21 October 2010, DAO.025.38374/4.
- <sup>11</sup> Neville Rockhouse, transcript, p. 4200.
- <sup>12</sup> *Ibid.*, pp. 4197–98.
- <sup>13</sup> *Ibid.*, pp. 4340–41; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/13, para. 30.
- <sup>14</sup> Neville Rockhouse, transcript, p. 4253.
- <sup>15</sup> *Ibid.*, pp. 4290–91.
- <sup>16</sup> *Ibid.*, pp. 4209, 4278, 4361.
- <sup>17</sup> *Ibid.*, p. 4365.
- <sup>18</sup> Before Mr Rockhouse began work, Pike had a documented system that he considered would not meet AS/NZS 4801: Neville Rockhouse, transcript, p. 4209.
- <sup>19</sup> See table of contents: Pike River Coal Ltd, Corporate Safety Manual: Safety in the Pike Coal Workplace, 2008, DOL7770030013/1–7.
- <sup>20</sup> Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/235, para. 5.5.2.
- <sup>21</sup> Andrew Sanders, Pieter van Rooyen and John Rowland, see Chapter 8, 'Ventilation', paras 39–42.
- <sup>22</sup> Health and Safety in Employment Act 1992, ss 12, 28A.
- <sup>23</sup> John Rowland, witness statement, 25 November 2011, ROW007/1, para. 4.
- <sup>24</sup> Neville Rockhouse, transcript, p. 4244.
- <sup>25</sup> *Ibid.*
- <sup>26</sup> *Ibid.*, pp. 4224–25, 4244–45.
- <sup>27</sup> *Ibid.*, p. 4235.
- <sup>28</sup> *Ibid.*, p. 4366.
- <sup>29</sup> *Ibid.*, pp. 4266–67.
- <sup>30</sup> *Ibid.*
- <sup>31</sup> Pike River Coal Ltd, Corporate Safety Manual: Section 1.8, 26 November 2008, DAO.001.08360/1–2.
- <sup>32</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/37–38, paras 125–26.
- <sup>33</sup> Adrian Couchman, transcript, p. 3811.
- <sup>34</sup> Neville Rockhouse, transcript, pp. 4231–32.
- <sup>35</sup> Adrian Couchman, transcript, pp. 3818–19.
- <sup>36</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/38, para. 126.
- <sup>37</sup> Pike River Coal Ltd, Health and Safety Committee, Meeting Minutes, 8 November 2010, DAO.002.08159/1.
- <sup>38</sup> Email, Adrian Couchman to Douglas White, Neville Rockhouse and Stephen Ellis, 9 November 2010, DAO.002.08157/1.
- <sup>39</sup> Adrian Couchman, witness statement, 28 November 2011, COU0001/20, para. 109.
- <sup>40</sup> Email, Adrian Couchman to Douglas White, Neville Rockhouse and Stephen Ellis, 8 November 2010, DAO.002.08157/1–2.
- <sup>41</sup> Email, Douglas White to Adrian Couchman, Neville Rockhouse and Stephen Ellis, 9 November 2010, DAO.002.08157/1.
- <sup>42</sup> Email, Adrian Couchman to Neville Rockhouse, 3 March 2010, DAO.002.08049/1.
- <sup>43</sup> Letter, Neville Rockhouse to Adrian Couchman, 17 March 2010, DAO.002.08049/2–3.
- <sup>44</sup> Pike River Coal Ltd, Pike Health and Safety Committee, Meeting Minutes, 13 September 2010, DAO.002.08125/2.
- <sup>45</sup> Adrian Couchman, transcript, p. 3817.
- <sup>46</sup> Pike River Coal Ltd, Health and Safety Committee, Meeting Minutes, 11 October 2010, DAO.002.08138/2.
- <sup>47</sup> Karyn Basher, witness statement, 10 November 2011, CAC0117.
- <sup>48</sup> Pike River Coal Ltd, Incident/Accident Form for All Accidents, Near Accidents, Incidents and/or Property Damage Incidents, DAO.001.08685.
- <sup>49</sup> Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, 7 November 2011, CAC0114.
- <sup>50</sup> Adrian Couchman, transcript, pp. 3803–04.
- <sup>51</sup> *Ibid.*, pp. 3814–15.
- <sup>52</sup> Neville Rockhouse, transcript, p. 4227.
- <sup>53</sup> Adrian Couchman, witness statement, 26 November 2011, COU0001/17, para. 97.
- <sup>54</sup> Neville Rockhouse, transcript, p. 4257.
- <sup>55</sup> Department of Employment, Economic Development and Innovation, Queensland Mines and Quarries: Safety Performance and Health Report, 1 July 2009–30 June 2010, p. 63.
- <sup>56</sup> Neville Rockhouse, transcript, p. 4207.
- <sup>57</sup> Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/28, para. 87.
- <sup>58</sup> Neville Rockhouse, transcript, p. 4206.
- <sup>59</sup> David Stewart, Pike River Compliance Audits, February–April 2010, STE0004.
- <sup>60</sup> Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710/17, 21.
- <sup>61</sup> *Ibid.*, DAO.003.08710/11.

<sup>62</sup> Neville Rockhouse, transcript, p. 4238.

<sup>63</sup> Pike River Coal Ltd, Safe Operating Procedure, 13 September 2010, DAO.002.06949/19, para. 8.3.

<sup>64</sup> Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 21.

<sup>65</sup> Neville Rockhouse, transcript, p. 4276.

<sup>66</sup> Ibid., pp. 4256, 4269.

<sup>67</sup> Ibid., p. 4270.

<sup>68</sup> Ibid.





# Mine systems

- + Ventilation
- + Methane drainage
- + Gas monitoring
- + Electrical safety
- + Hydro mining



## CHAPTER 8

# Ventilation

## Introduction

### The purpose of mine ventilation

1. All underground coal mines require adequate ventilation. A mine's ventilation system must deal with the hazards of gas and dust, keep the temperature and humidity within acceptable limits, and ensure there is sufficient air for workers to breathe.<sup>1</sup> The ventilation system should form part of an overall gas management system, including gas monitoring, electrical safety procedures, measures to avoid sources of ignition and, in some cases, pre-drainage of methane.<sup>2</sup>
2. Poor ventilation is a serious hazard that creates a risk of a major explosion and loss of life. Multiple disasters over more than a century have shown the importance of robust ventilation, which has rightly been described as 'the life-blood of any operational mine'.<sup>3</sup>

### Basic description of a ventilation circuit

3. The basic design of a ventilation system consists of an intake, which draws in fresh air, and a return, which expels contaminated air. This creates a ventilation circuit, with air flowing in, across a working face to collect gas and other contaminants, and out through the return. Mining consultant David Reece referred to the following diagram to explain the concept of a ventilation circuit:

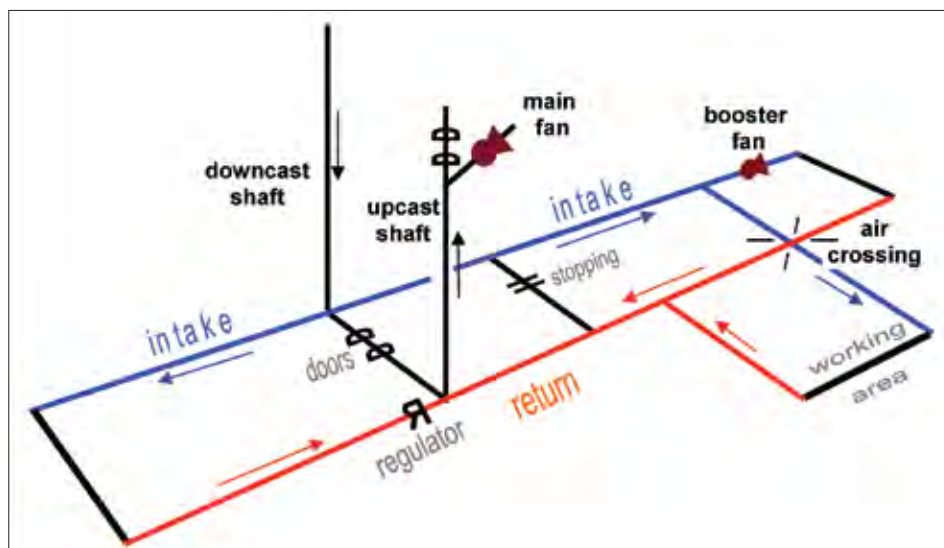


Figure 8.1: Typical elements of a main ventilation system<sup>4</sup>

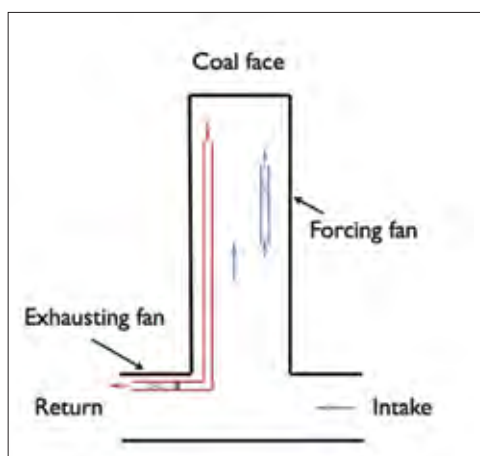
4. Fresh air is drawn in through a downcast shaft, continues along the blue intake roadways, then across the mining faces shown in black. Contaminated air travels through the return airways, shown in red, and out the upcast shaft through the main fan. At Pike River, the intake was the 2.3km drift, and the main fan was at the base of the upcast shaft rather than on the surface, but the principle of a ventilation circuit was the same.
5. To create a ventilation circuit it is essential to direct air along the correct roadways and in the right direction. This is achieved with ventilation control devices. These consist of stoppings (solid barriers), overcasts or air crossings (which send air over a roadway) and other devices designed to direct or control the flow of air. Any leakage of air, through a poorly constructed stopping, for example, will make the ventilation circuit less effective.

6. The simplest ventilation circuit involves a U shape with the intake and return completely separated by solid walls. However, during development there will frequently be sections of one-way road, as well as dead-end stubs and other areas, that do not naturally fall within a circuit. One solution to ensure these areas are properly ventilated is to use an auxiliary fan, such as the one in the photograph.



**Figure 8.2: Auxiliary fan**

7. An exhausting auxiliary fan draws contaminated air away from the end of a stub or working face through a tube. A forcing fan may also help to send intake air in the correct direction towards the face. This is shown in the diagram, which shows an exhausting auxiliary fan drawing air away from the face through a ventilation tube, in red, with an additional forcing fan, in blue, on the right to help push fresh air up to the face.



**Figure 8.3: Right-hand diagram exhausting system with force overlap<sup>5</sup>**

8. In order to function safely and effectively, an auxiliary fan must itself be located in sufficient air to keep it cool and to prevent recirculation of contaminated air. A standard requirement, which applied at Pike River, is that the main ventilation system must provide at least 30% more air to the auxiliary fan than the fan itself draws.

## Who designed the Pike River ventilation system?

9. It was clear from an early stage that the Pike River ventilation system would need to deal with significant quantities of methane. As the next chapter describes in more detail, estimates of the methane content in the coal seam varied, and the Minarco Asia Pacific Pty Ltd ventilation report in June 2006 predicted a 'medium to high gas content throughout the resource area, particularly within close proximity to the Brunner fault.'<sup>6</sup> As a result, Pike River was expected to need about twice the ventilation of a typical high-production longwall mine.<sup>7</sup> Given the gassiness of

the coal seam, and the other challenges facing the design of the ventilation system, including the rugged surface terrain and complex geology, Pike should have had a dedicated ventilation officer<sup>8</sup> to oversee the system's design.<sup>9</sup>

10. However, no one person assumed responsibility for designing the ventilation system. When Peter Whittall was asked who designed it, he referred to four different ventilation consultants providing specific advice at different times.<sup>10</sup> It was appropriate for Pike to obtain advice from independent consultants, but the company did not establish clear responsibility and accountability for the overall design of the ventilation system.

## Location of the main fan

### Suggestions for an underground fan

11. On 31 October 2006 Pike invited four contractors to tender for the design, supply and installation of its main ventilation fans. The invitation stated that the fans were to be located on the surface. That is standard practice in the industry for a number of reasons, including the need for ready maintenance access, a secure power supply and access in an emergency. However, Pike faced significant challenges in installing fans on the surface. The proposed location was in mountainous conservation land, the only access was on foot by a bush track or by helicopter, there was no surface electricity supply and weather conditions on the surface were often harsh.
12. Two contractors ultimately proposed underground fans in addition to the conventional surface fans. It is unclear how the idea of underground main fans originated,<sup>11</sup> but Pike decided in favour of and developed the idea jointly with the preferred tenderer, Fläkt Woods Fan (Australia) Pty Ltd, in late 2006.<sup>12</sup>

### Unique in the world

13. Pike ultimately decided to install its main fans underground, with a back-up fan on the surface. That situation is unique. Although underground booster fans are common in many countries, there is no evidence of any other coal mine in the world with a main fan underground.

### The hazards of underground installation

14. Three main risks arise from locating a main fan underground.<sup>13</sup> First, it is more difficult to re-establish ventilation after an explosion, which could compromise the survival chances for anyone underground. Second, an underground fan is more likely to be damaged by an explosion. Third, an underground fan is closer to explosive material such as methane and coal dust, and a malfunction of the fan or its motor can be a source of ignition.
15. No doubt for these reasons, legislation in other countries either expressly bans main underground fans in coal mines,<sup>14</sup> or assumes they are installed on the surface and that only booster and auxiliary fans are installed underground.<sup>15</sup> The International Labour Organisation (ILO) code of practice issued in 2006 also assumes main ventilation fans are installed on the surface.<sup>16</sup> New Zealand law does not specifically prohibit the installation of main fans underground, and there is no mention of the location of main fans in the guidelines issued by the national health and safety council for the New Zealand minerals industry (MinEx), in October 2009.
16. Given the risks and the unique nature of the proposal, Pike should have insisted on a robust risk assessment and decision-making process to assess the proposal for an underground main fan. Three aspects of the process adopted by Pike are worthy of analysis: the risk assessment process, the level of oversight by Pike's board and the management's response to concerns raised.

### Underground fan risk assessment

17. At the time of the tender process, Pike intended the ventilation shaft would be in stone measures, at a location east of the Hawera Fault. In February 2007 Pike held a professionally facilitated risk assessment into the placement of main fans underground. The risk assessment was led by two facilitators from Platinum Safety Ltd. Their role was specifically confined to facilitation of the assessment process as they had limited experience and knowledge of any

elements of mining.<sup>17</sup> The expert group comprised Pike's engineering manager (Tony Goodwin), technical services manager (Udo Renk), mechanical co-ordinator (Robb Ridl), senior mine engineer (Guy Boaz) and health and safety manager (Neville Rockhouse). The group also included a representative from Fläkt Woods, and Jim Rennie, an Australian ventilation consultant engaged by Pike. Mr Whittall participated in scoping the risk assessment.<sup>18</sup>

18. The group noted that installing main fans underground required a rigorous risk assessment process because of the risks to employee safety and business continuity.<sup>19</sup>
19. The scope of the risk assessment was described as 'high level', and the facilitators described the process as 'very challenging' and difficult to maintain within the agreed scope and context because people continually left and returned to the meeting. A large number of 'unknown factors' required further analysis by Pike.<sup>20</sup>

#### **Problems with the underground fan risk assessment**

20. In common with other risk assessments at Pike, the process rated the risks of various events and identified proposed controls. The risks were re-evaluated, and often reduced, in light of the controls.
21. For example, the hazard identified as '[b]oth main fans destroyed by explosion' involved the risks of 'destroyed fans', 'employee injury', 'business interruption' and 'suffocation from methane in the mine'. Two of these risks were initially rated as high in the 'red' or 'unacceptable' area, but revised into the 'green' or 'low' risk category in light of various controls, namely:
  - *design and layout of the installation with built in explosion proofing*
  - *protection of equipment by servicing and maintenance*
  - *design consideration of the doors*
  - *limit the sources of ignition*
  - *installation of blast panels to protect the surface fan*
  - *implement detailed Emergency Response Plans*
  - *require supervisors to monitor specific hazardous processes and the installation*
  - *install temperature and vibration sensing equipment*
  - *site in a solid rock housing.*<sup>21</sup>
22. Some of these proposed controls never eventuated. For example, Pike did not install explosion proofing for the main underground fan, did not site the fans in rock and the blast panels on the surface fan proved inadequate during the explosion.

#### **Relocation of the ventilation shaft**

23. In September 2007 Pike moved the location of the ventilation shaft from stone into coal, west of the Hawera Fault, as discussed in Chapter 3, 'The promise of Pike', paragraph 47. The fan site moved with it, and despite material changes in the risks, there was no further risk assessment. Commissioning engineer Andrew Sanders, who began work at Pike as a consultant, drew this to Pike's attention in March 2010,<sup>22</sup> and listed three questions for the company:
  - Was the risk assessment report ever finalised?
  - Have resulting actions been followed up and signed off?
  - Would it be appropriate to conduct another risk assessment on the latest proposed design and installation?

#### **Mr Sanders' questions were never answered.**

24. The risk assessment report was not finalised. There were four versions of the draft report, but despite attempts by Platinum Safety between March and July 2007, Pike never finalised the report. In June 2007 Neville Rockhouse apologised to Platinum Safety for Pike's 'unprofessional conduct with regard to this project',<sup>23</sup> after a third version

circulated to management to provide content had not been completed. The fourth version was distributed to managers in early July 2007 for completion,<sup>24</sup> but Platinum Safety had no further communication with Pike.<sup>25</sup> Mr Renk described trying several times with Mr Rockhouse to finalise it, but said Mr Whittall disagreed 'with some of the risk ratings and wording of the report and we were not able to finalise it.'<sup>26</sup> Mr Whittall does not recall any such approaches. He said he was not on the risk assessment team and it could finalise the assessment without reference to him.<sup>27</sup>

25. The failure to finalise the risk assessment, whatever the reasons, meant Pike had no adequate basis for deciding whether to proceed with the underground fan in light of the risks. That decision was critical, and should have been informed by a proper and final risk assessment.

### Board oversight

26. Other than approving the expenditure required to enter into a contract with Fläkt Woods to manufacture and install the fans in July 2008,<sup>28</sup> neither the Pike board nor its health, safety and environment (HSE) committee took steps to ensure management had properly assessed the health and safety consequences of placing the main ventilation fans underground.
27. The board was informed in general terms of the underground fan risk assessment, but neither saw, nor asked for any audit of, the risk assessment report. The operations report to 23 February 2007 simply told the board there was 'no legislative or technical barrier to locating these fans underground with engineering solutions available to identified problems.'<sup>29</sup> From the board minutes, that advice appears to have been accepted without question.
28. Board chair John Dow was unaware of any other coal mine in the world with a similar arrangement,<sup>30</sup> but he said it was not a matter of particular concern for the board's HSE committee (which he chaired) to review the risks associated with having a main fan underground. He said he remembered having conversations about the location of the fan, but he saw it as a management issue.<sup>31</sup>

### Management response to concerns

29. From early 2007, when the operational decision was made, numerous people at Pike raised concerns about locating the main fan underground.
30. In June 2007 Mr Rennie emailed Mr Whittall and proposed a forcing fan at the portal instead of an underground fan. He identified many advantages, including:
  - ease of installation;
  - immediate access to the fan for maintenance;
  - power to the fan would not have to be routed underground and no secondary fan/generator system was required;
  - minimal facilities would need to be maintained at the remote ventilation shaft surface with less environmental impact; and
  - the long-term escapeway via the ventilation shaft would not be needed.

Mr Rennie stated that while his proposal for a forcing fan was 'somewhat unusual', it was 'by no means rare'.<sup>32</sup>

31. Mr Boaz was a participant in the February 2007 risk assessment. He left Pike later that year. He did not agree with the idea of putting fans underground and thought that the decision to do so was taken without full consideration of the risks involved.<sup>33</sup> Describing the concept as 'ground breaking', because he had not 'heard of it ever occurring in any other underground coal mine in the world', he raised his concerns with Mr Whittall.<sup>34</sup> However, Mr Whittall has 'absolutely no recollection' of this conversation.<sup>35</sup>
32. Mr Renk, the technical services manager from January 2007 to May 2008, emailed Mr Whittall in October 2007 to say he 'strongly believe[d]' a forcing fan at the portal was preferable to an underground fan and quoted a number of economic arguments to support his case.<sup>36</sup> Mr Renk says he was told it was too late as the decision had already

been made.<sup>37</sup> Mr Whittall does not recall saying this and also said that in any event a forcing fan was ruled out as impracticable at Pike River.<sup>38</sup>

33. Concerns continued to be expressed in 2009. Technical services manager Pieter van Rooyen recalled that in about February or March that year Mr Rennie expressed concerns about the placement of the main fans underground. Mr van Rooyen spoke to Mr Whittall, who said the decision had already been made, and one fan was already in New Zealand and the other partially constructed but on hold.<sup>39</sup>

### Oversight by the regulator

34. Michael Firmin, the Department of Labour (DOL)'s health and safety inspector responsible for liaison and inspections of Pike River mine from 2007 to mid-2008, recognised that an underground main fan was unusual and would give rise to more hazards than a surface installation.<sup>40</sup> Mr Whittall told him, at a meeting on 13 February 2007,<sup>41</sup> that 'he looked at the regulations. And there was nothing that would stop Pike River doing this, and that's basically what he said.'<sup>42</sup> Pike's risk assessment meeting on placement of the main fans underground occurred two days later.
35. Mr Firmin checked the New Zealand regulations and concluded they did not appear to prevent the main fan being installed underground.<sup>43</sup> He was concerned enough to conduct internet research into the regulatory regimes in other countries but said he did not find any regulation preventing an underground installation.<sup>44</sup>

## The ventilation management plan

36. Pike had a ventilation management plan, which was signed off by mine manager Kobus Louw and Mr Rockhouse on 18 November 2008, soon after the main drift struck coal.<sup>45</sup> The ventilation management plan was a 78-page document, with 48 pages of appendices. It dealt with 11 major topics:
  - ventilation design, plans and reports;
  - ventilation fans;
  - ventilation structures;
  - underground environmental monitoring;
  - mine inspections;
  - prevention of ignitions;
  - respirable dust;
  - management of heat underground;
  - wind blast;
  - administration of the ventilation management plan; and
  - responsibilities under the plan.
37. The plan required a ventilation engineer, a tube bundle system, explosion barriers, a permit to work system involving detailed sign-off by the ventilation engineer, and a full risk assessment to determine the non-restricted zone – none of which existed as contemplated by the plan.
38. The plan contained detailed and prescriptive responsibilities attached to 14 different roles at the mine. The mine manager was required to appoint a ventilation engineer,<sup>46</sup> and to receive reports from the ventilation engineer dealing with any defects in the ventilation or personnel.

### Criticisms of the ventilation management plan

39. A number of staff members and contractors at Pike voiced concerns about the ventilation management plan. Mr Sanders produced a report dated 31 March 2010, which noted that the ventilation management plan was out of



date and contained numerous references to standard operating procedures that did not exist or had not been approved. He listed 54 items that required follow-up before the main ventilation fan was commissioned and hydro-monitor operations began. These included:<sup>47</sup>

- the appointment of a ventilation engineer;
- the lack of a tube bundle system;
- the risk of wind blast due to hydro mining;
- clarifying the various responsibilities under the plan;
- ensuring consistency between the ventilation management plan, the emergency response management plan and other plans and procedures at the mine;
- addressing inconsistencies in the definition of the restricted zone;
- confirming assumptions underlying the plan;
- completing an annual ventilation audit by an independent ventilation engineer;
- reviewing the actions to be taken when methane levels rose above set limits;
- creating a hydro monitor panel gas management plan;
- establishing special controls during initial operation of the hydro monitor;
- planning for safe access to the surface ventilation fan in the event of an emergency;
- reviewing of the ventilation management plan;
- carrying out a risk assessment before monitor start-up; and
- training and communication on the ventilation management plan.

40. Mr White accepted that he received a copy of Mr Sanders' report,<sup>48</sup> although he said he was not aware of the list of 54 things to be addressed before hydro-monitor extraction.<sup>49</sup> There was no process to check whether the items had been completed,<sup>50</sup> and many of them were not.
41. Mr van Rooyen, who arrived at Pike in February 2009, realised the ventilation management plan would need to be reviewed because it contained information he considered irrelevant and was sometimes 'too detailed and impracticable'.<sup>51</sup> As a result, he asked ventilation consultant John Rowland to review the plan.
42. Mr Rowland did so and reported: 'to be honest I don't like it either!!' He described it as an all-encompassing plan covering ventilation management, explosion suppression, monitoring and other topics. It was 'gargantuan to be blunt and far too specific in my opinion in a lot of areas'. It would be difficult for him to adjust the plan in isolation: he would need to review the other management plans to see how they dovetailed together, and he would need to see a risk assessment. In his view the plan should be split up into various documents and this would take considerable thought. He said, 'It is ugly and will require far more discerning thought from you guys than you possibly realise'.<sup>52</sup> Mr Rowland received no further instructions in relation to this matter.

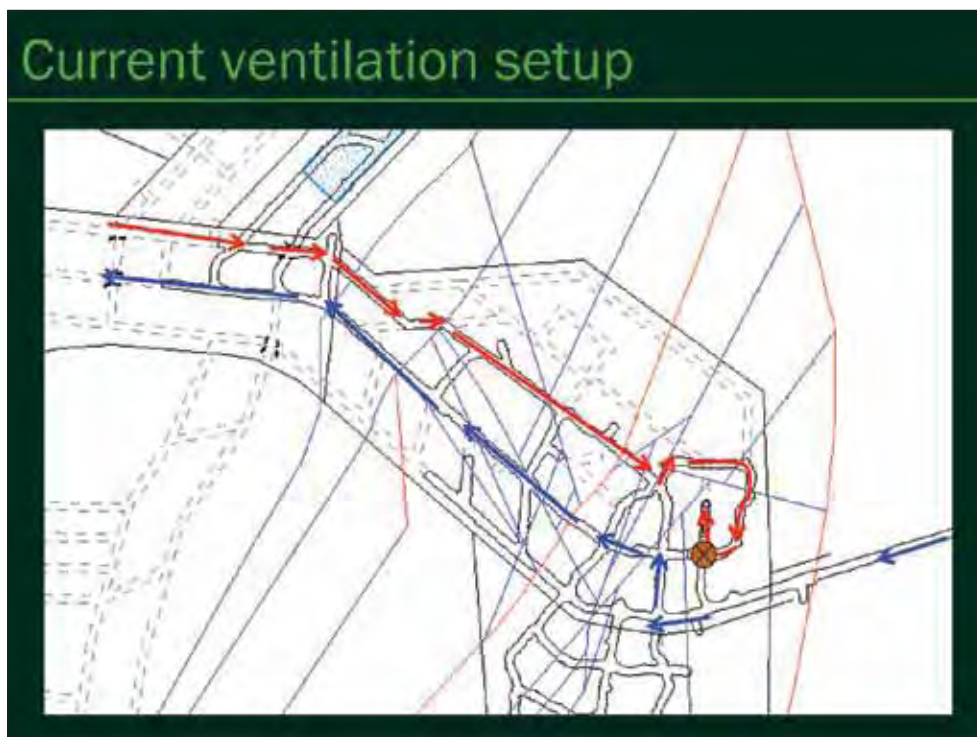
### Compliance auditing

43. Australian and New Zealand Standard 4801 provides for safety management systems to be regularly audited.<sup>53</sup> There was no process at Pike to audit compliance with the ventilation management plan, and no external auditing.
44. Mr Rowland was not asked to audit compliance with the ventilation management plan.<sup>54</sup> When David Stewart of MinServ International carried out a series of compliance audits at Pike in February to April 2010, he did not look at the ventilation management plan. Indeed, he 'deliberately stayed away from looking at the documentation as such',<sup>55</sup> because he believed the plan was to be reviewed and updated. Mr Stewart said it is not easy for any mine to ensure that management plans are complied with, and he expected Pike was typical in this respect.<sup>56</sup>

45. Mr Dow said the HSE committee did not consider asking to see evidence of compliance with the ventilation management plan.<sup>57</sup> He said those were 'onsite activities',<sup>58</sup> and he did not accept that the HSE committee of the board should have ensured that the things required by the ventilation management plan were in fact happening at Pike River.<sup>59</sup>

## The Pike ventilation system as built

46. Pike's early planning contemplated multiple intakes beyond the first year of development.<sup>60</sup> In November 2010 the Pike River ventilation system was still a one intake and one return system, as shown in the following diagram:



**Figure 8.4 : Current ventilation setup<sup>61</sup>**

47. The blue arrows depict fresh air entering through the intake (main drift), circulating through the workings and exiting through the return, shown in red. The main underground fan is depicted as a circled X towards the bottom right of the diagram, at the base of the ventilation shaft. Mr van Rooyen presented this simplified diagram of the Pike ventilation system to the Pike board in August 2010.
48. Mr Reece told the commission a single intake and return system is quite unusual for a mine with four or five working areas extending from it.<sup>62</sup> The DOL experts' report states that a one intake and one return system is not uncommon in New Zealand coal mines but would not be considered acceptable for anything but initial development in Australia. The report notes that Pike did plan to establish a second intake but it appeared that the mine would always be restricted to a single return system. The report said this might be acceptable, given the difficult geographical environment, but from a ventilation perspective it left no room for error. Any compromise to the main return would become a very serious event.<sup>63</sup>
49. The second intake was still planned. Mr van Rooyen presented the Pike board with a number of options in August 2010.<sup>64</sup> He estimated that it would have taken about a year for Pike to reach the recommended location of the second intake from the time he left in November 2010.<sup>65</sup>

# The surface fan

## Design and installation

50. Pike installed the surface back-up fan at the top of the ventilation shaft in June 2009. The exhaust structure (evasé) for the surface fan is on the left in the photograph, and the larger evasé is for the main underground fan.



Figure 8.5: The surface back-up fan

51. Fläkt Woods designed, built and installed the surface fan. It was powered by a 132kW electric motor with a capacity of 90m<sup>3</sup>/s air flow at 0.4kPa (kilopascals) pressure.<sup>66</sup> The fan acted as the primary fan until the first main fan was commissioned underground.
52. The diagram below shows a bird's-eye view of the surface fan as installed. In the centre was the main underground fan evasé, designed to direct the air flow horizontally and prevent rain or snow entering the ventilation shaft.<sup>67</sup> The surface fan impeller (blades) and motor were to the right. To the left was an airlock entrance allowing access to the fan housing. Anyone climbing the ladder in the ventilation shaft would also exit through the airlock.

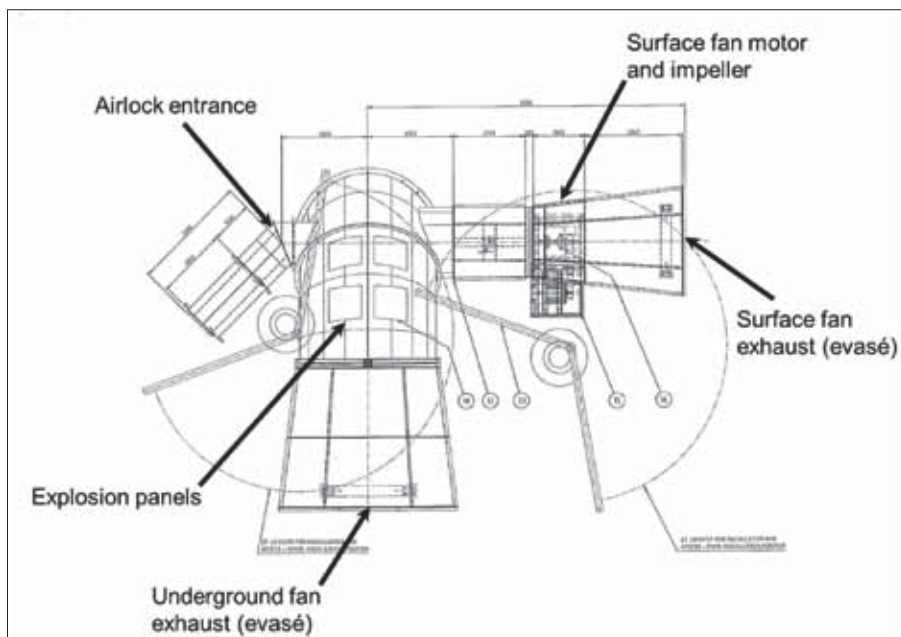


Figure 8.6: Surface fan as installed<sup>68</sup>

53. On the top of the housing were four explosion panels, designed to allow a pressure wave of air and debris following an explosion to go straight through the top of the housing and minimise damage to the fan. The explosion panels are seen in black in Figure 8.5.
54. Because both the surface fan and main underground fan were connected to the same ventilation shaft, a system was needed to block off air flow through one or other easé, depending which was in use. Initially Fläkt Woods designed a butterfly damper for that purpose, but this was damaged and not repaired for 12 months or more.<sup>69</sup> During commissioning of the underground fan a few weeks before the explosion, Pike installed a set of louvres at the end of the main fan easé as shown below. These were designed to close if the main fan stopped and the surface fan started up to ventilate the mine.



**Figure 8.7: Easé showing louvres being installed**

55. The surface fan was powered by electrical cabling that ran from the portal substation up the main drift and then to the surface via the shaft. This was unusual. It meant that if power was tripped to the main fan at the portal, for example because of methane in excess of 0.25% in the vicinity of the fan motor, power would also be unavailable to the surface fan. Accordingly, diesel generators were installed to start automatically if the main fan stopped, enabling the surface fan to operate.<sup>70</sup>

#### Surface fan failures

56. On the evening of 5 October 2010, about three weeks before the commissioning of the underground fan, the surface fan failed after a blade sheared off.<sup>71</sup> Methane levels rose, power tripped to the underground workings and all personnel underground were evacuated from the mine. The mine gassed out, and on 6 October drops in barometric pressure and temperature caused methane levels in pit bottom to rise to such a level that Pike was unable to send a Mines Rescue Service (MRS) team underground to degas.<sup>72</sup> The daily volume of methane make peaked at 102,000m<sup>3</sup> during degassing on 7 October.<sup>73</sup> Pike conducted a risk assessment together with MRS personnel,<sup>74</sup> and repaired and ran the surface fan using the damper door to 'gradually introduce ventilation underground diluting the gas levels until normal historical gas levels were reached'.<sup>75</sup>
57. A similar event had occurred in July 2009 due to vibration.<sup>76</sup> Project manager Terence Moynihan believed that changes to underground ventilation and surface conditions meant the fan sometimes operated within the stall zone, leading to high levels of vibration and causing fan blade failure.<sup>77</sup> Given the changes from the original



ventilation shaft design, including the smaller Alimak raise installation, and based on an April 2010 ventilation survey conducted by Mr Rowland indicating high pressure losses between the shaft collar and the fan itself,<sup>78</sup> Mr Moynihan considered the surface fan was operating at significantly higher pressures than the instrumentation was recording. He felt that with the mine expanding, and increasing resistance, the surface fan would not have been able to meet its objective as a back-up ventilation fan.

58. Pike reviewed the surface fan failure in a meeting on 7 October.<sup>79</sup> The reason for the failure had yet to be determined by the engineering department,<sup>80</sup> and the review did not focus on preventing a repeat event. Rather, the meeting identified a number of improvements required to Pike's immediate response.<sup>81</sup> It is unclear how many of the identified improvements had been achieved by 19 November 2010.<sup>82</sup>
59. This failure occurred when the surface fan was about to take on a crucial back-up role to the underground main fan. Pike's ability to reventilate the mine in the event of a gassing out or an explosion underground was dependent on the surface fan, as the main ventilation fan could not be restarted in high methane levels. This incident was a near miss that should have led to more robust investigation and action.

## The main underground fan

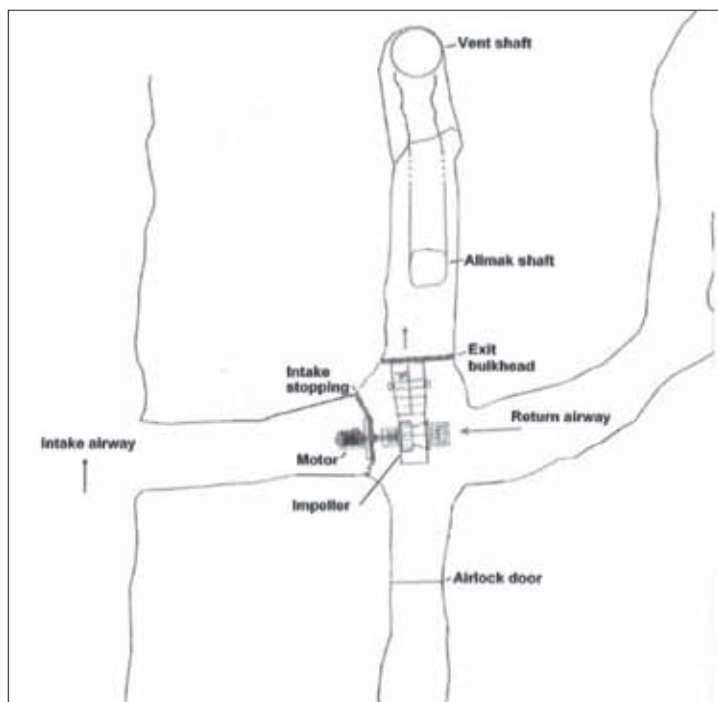
### Installation of the fan

60. Pike's first main underground fan was installed in August and September 2010. Its size and configuration are shown in the photograph below. The fan motor (grey) is in the foreground, with the drive shaft (orange) connecting to the fan impeller (white).



**Figure 8.8: Underground fan being assembled in factory**

61. The bird's-eye diagram below shows the orientation and operation of the underground fan.



**Figure 8.9: Orientation and operation of underground fan**

62. Air entered from the return airway to the right of the diagram, then passed through the impeller and up the Alimak shaft. The non-flameproof motor was in fresh air on the intake side and sealed off from the fan impeller by a stopping, through which the drive shaft passed. The exit bulkhead was partly fitted with louvres, which were closed when the fan was working, but opened when it tripped. This enabled the surface fan to draw air more easily up the ventilation shaft to maintain mine ventilation. The airlock doors prevented return air from entering the mine intake system.
63. The main fan was designed to shut down in the event of a methane concentration in excess of 0.25% near the fan motor or when temperature or vibration cut-off points were reached, at which point the back-up surface fan was designed to start automatically.
64. The fan's maximum capacity was  $128\text{m}^3/\text{s}$ ,<sup>83</sup> from the 375kW motor that was controlled by a variable speed drive (VSD) located about 94m away in pit bottom south.<sup>84</sup>

#### Commissioning and operation of the fan

65. The main fan was first operated on 4 October 2010, but sparks came from the fan shaft at the junction with the intake stopping through which it passed.<sup>85</sup> To resolve the problem Pike removed a brass bush, which formed a seal between the drive shaft and the stopping.<sup>86</sup> This left a gap which Mr Sanders estimated was at least 20mm.<sup>87</sup> Mr White accepted there was potential for methane-contaminated air to leak through the gap if the fan was not operating.<sup>88</sup>
66. Further testing continued and on 22 October 2010 the underground main fan came online and the surface fan switched to standby duty.<sup>89</sup> Almost immediately the main fan suffered problems associated with the VSD power supply and other issues. At first neither the supplier, Rockwell Automation (NZ) Ltd, nor the installer, iPower Ltd, could identify the problem. In late October Rockwell agreed to replace the liquid-cooled 700L VSD with an air-cooled and larger capacity 700H model.<sup>90</sup> Problems continued as the new model was installed in the same VSD cabinet but had a different thermal requirement, and to avoid rising temperatures tripping the power, the mine installed ducting to direct air over the VSD. An air conditioning unit was also ordered, but had not arrived at the time of the explosion.<sup>91</sup>



67. Testing of the fan was completed on 10 November 2010 and the fan was finally commissioned for operation.<sup>92</sup> After installing the replacement 700H VSD, the main fan ran continuously until the explosion, apart from one problem caused by an auxiliary fan motor.<sup>93</sup>

## Explosion protection of the fans

### The proposed explosion path and explosion proofing of the underground fan

68. In 2007 Mr Renk designed twin underground fans to be housed in a separate heading, offset at 90° from the main return.<sup>94</sup> This was an attempt to create an explosion path to mitigate the risk of damage to the underground installations in an explosion.<sup>95</sup>
69. When the ventilation shaft was relocated into coal west of the Hawera Fault, Mr Renk redesigned the fans to remain offset from the shaft, with stoppings designed to fail in a pressure concussion event so a blast overpressure would bypass the fan and go directly into and up the shaft to the surface. He intended to install additional explosion-proof standard stoppings reinforced with steel to protect the fans.<sup>96</sup>
70. After the collapse of the ventilation shaft and the installation of the Alimak raise, the technical services department had to review and redesign the underground fan installation, and Mr Renk's earlier explosion path design was no longer possible.<sup>97</sup> By that time he had left Pike and no one in the department, including the new manager Mr van Rooyen, had prior experience with the concept. In June 2009 Mr van Rooyen looked at trying to maintain an explosion path to protect the fan but, after some research,<sup>98</sup> that issue, and the decision over design of a second connection to join the ventilation shaft, were deferred until further geological information was available. It was noted the mine would be without an explosion path until the second connection to the shaft was completed, but the surface fan was considered to be a sufficient contingency, along with other methods, including installation of explosion barriers 'to reduce the potential damage of an explosion'.<sup>99</sup>
71. Discussions in June 2009 (including with Jim Rennie and another consultant Steve Beikoff)<sup>100</sup> and again in September 2010 led to a consensus that explosion paths would not necessarily work as intended in an underground explosion,<sup>101</sup> and were not proven to be effective.<sup>102</sup>
72. The 2007 underground fan risk assessment had identified 'built-in explosion proofing' and protection as a control for placement of the main fan underground,<sup>103</sup> and Pike told insurance risk assessors in 2010 the underground fan would be located in 'explosion protected panels',<sup>104</sup> but no protection was in place.
73. This was described as 'somewhat deficient' by the joint investigation expert panel, who noted protection was a standard requirement in underground booster fan installations 'albeit in the form of a bypass mechanism'. Installation of explosion protection by means of a bypass in the underground workings near the fan 'may have contributed to reducing the extent or even the level of damage to the mine; as well as providing potential survivability of the ventilation system for later operation'.<sup>105</sup>

### Stone dusting

74. Stone dusting helps to mitigate the effect of an explosion by mixing an inert limestone dust, also known as stone dust, with the coal dust on the floor, roof and ribs of the mine.
75. New Zealand regulations require employers to take all practicable steps to ensure the roof, floor and sides of every accessible part of the mine were treated with stone dust so combustible matter did not exceed 30%.<sup>106</sup> Pike's ventilation management plan set out a stone dust monitoring plan, and required the production deputy and undermanager to ensure that stone dusting was maintained daily in all roadways to within 10m of any working heading.<sup>107</sup>
76. Pike's stone dusting was inconsistent. When Mr White implemented a process in mid-2010 to test the standard of roadway dust, all samples failed the standard in Pike's draft standard operating procedure.<sup>108</sup> Although Pike was a

relatively wet mine, which would have mitigated the risk, the stone dusting was below standard and the problem had been raised during inspections and in writing twice by the DOL mines inspector in 2010.<sup>109</sup>

### Explosion barriers

77. Regulations also require employers to take all practicable steps to ensure water or stone dust barriers were erected at suitable sites to limit the effects of an explosion.<sup>110</sup>
78. The ventilation management plan stated that 'stone dust barriers of the bag type will be used',<sup>111</sup> and Pike advised the Hawcroft Consulting International insurance risk assessor, in 2009 and 2010,<sup>112</sup> that explosion barriers would be installed to 'provide added defences in the event of a gas ignition, preventing development of a coal dust explosion'. However, as at 19 November 2010, Pike had not installed any explosion barriers underground. The equipment had been purchased and was stored on site from mid-2009.<sup>113</sup>
79. Deputies were required to complete a report every shift, and answer the query 'Are explosion barriers in order?' Deputies regularly answered 'no' or 'N/A [not applicable]'. Some Pike employees were concerned about the lack of explosion barriers and said so.<sup>114</sup>
80. Mr Stewart noted the absence of stone dust or water barriers in any of the roadways, in contravention of the regulations. When he spoke to the engineering staff and underviewers he was told there were no plans for barriers to be erected and they were waiting for a stone dusting machine.<sup>115</sup>
81. The expert panel considered that stone dust explosion barriers would have been useful.<sup>116</sup> Mr Reece accepted that stone dust barriers are not proven to extinguish a flame front from a methane ignition, but they can reduce the intensity of an explosion. Noting the common use of stone dust barriers within development panels of between 100 and 200m, and the relatively small size of the mine at the time of the explosion, Mr Reece said a stone dust barrier may have been appropriate in the main return to give some protection to the fan.<sup>117</sup>

### The failure of explosion proofing of the surface installation

82. The surface fan failed in its vital back-up role. As shown in the photograph below, the explosion panels failed to divert the explosive air flow and debris from the first explosion, which damaged the fan, fan housing, shaft access doors, power generator and control infrastructure. Subsequent explosions propelled the fan and housing from their fixed positions.<sup>118</sup>



Figure 8.10: The surface fan after the first explosion

83. Gregory Borichevsky and an electrician examined the damage to the surface fan on 22 November 2010, before the second explosion on 24 November damaged it further. The airlock doors in the fan housing and the louvres installed on the evasé had been blown open and damaged. The fan was intact but three of the fan blades were damaged. The control panel had been blown over by the force of the blast coming out of the airlock doors and had fallen onto the emergency stop button of one of the generators.<sup>119</sup> The DOL investigation report concluded that the surface fan did not start at all, but it appeared that at least one of the diesel generators had started, since some fuel had been used.<sup>120</sup>
84. Mr Borichevsky believed the surface fan could and should have been restarted. Although damaged, his 22 November examination found the fan was intact, the second generator was running, the airlock doors could have been secured, the main cabling to the control panel appeared to be intact and could have been made safe to restart, the fan cowling, shutters and belts were slightly damaged but repairable, and the drive belts and motor on the fan appeared to be undamaged.<sup>121</sup> He says he told the production manager, Stephen Ellis, of his inspection and his view that the fan could be repaired and restarted to ventilate the mine, but that did not occur. Mr Ellis does not recall this, but comments that effecting repairs would have been too dangerous and restarting the surface fan was a decision for the mine manager Mr White.<sup>122</sup> Reventilating a mine following an explosion is an option that should always be available but can be dangerous and requires a risk assessment.
85. It is evident from the damage to the surface fan installation that the explosion panels could not cope with the explosion. The fan was too close to the ventilation shaft because of the limited space available at the site. The damage suffered meant the surface fan could not reventilate the mine.
86. Neither New Zealand or Australian mining legislation prescribes or provides guidance on the design of explosion panels. Pike provided no specifications to Fläkt Woods Fans. Fläkt Woods designed the explosion panels in accordance with a standard issued by the United States National Fire Protection Association (NFPA standard 68).<sup>123</sup> This standard requires complex calculations depending on analysis of several variables.<sup>124</sup> Fläkt Woods followed the design approach in this standard after it was specified for use by a Queensland mine for a surface fan installation Fläkt Woods completed in 2008, without comment from the Australian regulator.<sup>125</sup>
87. The commission considers that best design practice is reflected in the United States Code of Federal Regulations for underground mining. These regulations require explosion panels to have a cross-sectional area at least equal to that of the area (in Pike's case the ventilation shaft) through which an explosion would pass.<sup>126</sup> Under that approach, Pike's explosion panels were less than half the size they should have been to operate effectively.
88. The US regulations also provide that a main fan must be 'offset by at least 15 feet [5m] from the nearest side of the mine opening unless an alternative method of protecting the fan and its associated components is approved in the ventilation plan'.<sup>127</sup> Although the Pike surface fan was a back-up fan, a similar level of protection was necessary. However, the surface installation site was congested and the fan blades were installed only approximately 2.3m from the edge of the ventilation shaft. This site layout made it much more likely they would be damaged by explosion overpressure and debris.

## Responsibility for ventilation at Pike

### A dedicated ventilation officer

89. Since 1999 it has been a requirement for underground coal mines in Queensland and New South Wales to have a dedicated ventilation officer. That requirement arose from a recommendation of the inquiry into the 1994 Moura No. 2 mine disaster. The officer's functions are defined by statute and by regulations. They include ensuring adequate ventilation in the mine, ensuring proper ventilation measurements are taken and ensuring all ventilation control devices at the mine are properly constructed and maintained.<sup>128</sup> In New Zealand, a committee headed by the chief inspector of coal mines reviewed the Moura No. 2 recommendations in 1996, but did not recommend the

creation of a statutory ventilation officer position in this country because at that time only the largest company, Coal Corporation of New Zealand Ltd, had the economy of scale, or need, for such a person.<sup>129</sup>

90. In Australia, the ventilation officer's role is a full-time position. Queensland legislation does permit a ventilation officer to hold another role at the mine, but only if he or she can still carry out the functions of a ventilation officer. Mr Reece said a ventilation engineer would be 'constantly' looking into any methane issues in the mine and going underground every second or third day.<sup>130</sup>
91. In New Zealand, there is no statutory requirement for an underground mine to have a ventilation officer. Non-binding industry guidelines established by MinEx recommend that the mine manager appoints someone to carry out certain functions concerning ventilation, but they are much less exacting than the Queensland requirements.<sup>131</sup> Whereas in Queensland the ventilation officer must 'ensure' adequate ventilation and 'ensure' properly constructed ventilation control devices, the MinEx guidelines recommend that the relevant person carry out 'planning and design of ventilation systems and appliances' without reference to any particular standard.
92. From 2008 Pike's ventilation management plan required the mine to have a ventilation engineer, fulfilling the same role as a ventilation officer. However, no full-time ventilation engineer was ever appointed at Pike.
93. Mr Whittall said the role was subsumed within the mine manager's responsibilities. He thought Pike too small for a dedicated ventilation engineer and it might have been several years before the mine was large enough to merit a dedicated position.<sup>132</sup> Mr Whittall also said that the mine manager's responsibility for ventilation was 'supplemented by having a full-time, on-call ventilation or a designated on-call ventilation consultant available to us and they acted in that capacity'.<sup>133</sup> In particular, he indicated that Mr Rowland filled that role.<sup>134</sup>
94. However, Mr Rowland said he was never a 'full-time, on-call ventilation consultant' for the mine. He said he would not, under any circumstances, have accepted the ventilation engineer's responsibilities under the ventilation management plan as he was not permanently at the mine. Mr White accepted that Mr Rowland was not carrying out the role of ventilation engineer. He said it was never the intention to use Mr Rowland as a ventilation engineer but rather 'to seek his advice and have certain jobs done by him'.<sup>135</sup>
95. Mr White said that when he started in February 2010 he did not think Pike required a ventilation engineer. However, he accepted in hindsight it would have been desirable to have had a full-time person in this role from an early stage, even from the design phase.<sup>136</sup>

### Concern at the lack of a ventilation engineer

96. A number of people at Pike raised the need for a ventilation engineer. Mr van Rooyen said that when he was appointed in February 2009 he assumed there would be a ventilation officer at the mine. He thought one was needed, particularly since he had very little ventilation experience. He suggested to Mr Whittall that Pike should send one of its engineers to New South Wales to complete a ventilation officer qualification. Mr Whittall said a ventilation officer was not required under New Zealand legislation, and not necessary owing to the size of the mine. Mr van Rooyen also raised this matter with Mr White.<sup>137</sup>
97. Mr Sanders raised the lack of a ventilation engineer among the 54 matters in his March 2010 report.<sup>138</sup> The following month, he prepared another report documenting key aspects of the ventilation system and detailing how it was to be controlled and operated. The draft document contained dozens of queries and gaps on critical issues. No final document seems to have been created, and responsibility for the ventilation system and ventilation management plan was never clarified. Mr Moynihan wrote on his copy of the report, 'Who is the ventilation engineer?', 'Who "owns" the ventilation management plan?' and 'Who "maintains" the ventilation management plan and its requirements?'.<sup>139</sup>
98. The subject was perhaps most stridently raised by Dene Murphy, one of the Pike deputies.<sup>140</sup> On 24 June 2010 he noted a problem with the ventilation system in an area containing two electrical substations. Mr Murphy filled out an incident form, noting, among other things, in capital letters, 'Who is the mine ventilation engineer?'. He went on to write, 'Ventilation engineer required', and 'Require immediate feedback within four days – or I will write a formal

letter to the mines inspector.<sup>141</sup> Mr White signed off the incident on 7 July 2010, with the comment, 'This has been discussed with Dene. Vent structures being organised to be made permanent.'

SECTION 4: Identify the Potential Root Causes			
Immediate Causes (tick and describe)		Basic Causes (tick and describe)	
<b>Substandard practices</b> <input type="checkbox"/> Operating equipment without authority <input type="checkbox"/> Unaware of hazard <input type="checkbox"/> Failure to secure <input type="checkbox"/> Operating at improper speed <input type="checkbox"/> Not following procedure <input type="checkbox"/> Removing safety devices <input type="checkbox"/> Using defective equipment <input type="checkbox"/> Failing to use PPE <input type="checkbox"/> Improper loading <input type="checkbox"/> Improper placement <input type="checkbox"/> Improper lifting <input type="checkbox"/> Improper position for task <input type="checkbox"/> Servicing equipment in operation <input type="checkbox"/> Horseplay <input type="checkbox"/> Under influence of alcohol/drugs <input type="checkbox"/> Making safety devices inoperable	<b>Substandard conditions</b> <input checked="" type="checkbox"/> Inadequate guards or barriers <input type="checkbox"/> Inadequate protective equipment <input type="checkbox"/> Defective tools, equipment or materials <input type="checkbox"/> Congestion/restricted action <input type="checkbox"/> Inadequate warning system <input checked="" type="checkbox"/> Fire & explosion hazards <input type="checkbox"/> Poor housekeeping, disorder <input type="checkbox"/> Noise exposure <input type="checkbox"/> Radiation exposure <input type="checkbox"/> High or low temperature exposure <input type="checkbox"/> Inadequate or excess illumination <input checked="" type="checkbox"/> Inadequate ventilation <input type="checkbox"/> Weather	<b>Personal factors</b> <input type="checkbox"/> Lack of knowledge/training <input type="checkbox"/> Lack of skill/inexperience <input type="checkbox"/> Lack of concentration <input type="checkbox"/> Stress <input type="checkbox"/> Misconduct <input type="checkbox"/> Language difficulties <input type="checkbox"/> Inadequate capability <input type="checkbox"/> Improper motivation	<b>Job factors</b> <input checked="" type="checkbox"/> Inadequate leadership/supervision <input checked="" type="checkbox"/> Inadequate engineering <input type="checkbox"/> Inadequate purchasing <input checked="" type="checkbox"/> Inadequate maintenance <input type="checkbox"/> Inadequate tools, equipment, materials <input type="checkbox"/> Inadequate work standards <input type="checkbox"/> Abuse <input type="checkbox"/> Wear and tear <input checked="" type="checkbox"/> Inadequate procedure <input checked="" type="checkbox"/> Safety rules not enforced <input type="checkbox"/> Insufficient staff numbers <input type="checkbox"/> Sub standard/no training <input checked="" type="checkbox"/> Substandard work practice
What was the ROOT CAUSE of this event? <b>VERY INADEQUATE VENTILATION, POOR STOPPINGS: POOR VENTILATION MANAGEMENT. VENTILATION LEAKAGE HIGH PERCENTAGE</b>			
SECTION 5: Remedial Actions Recommended, Including Any Injury Prevention & Training if Required			
Follow up of Event: What investigation/action has or will be taken to prevent a recurrence			
<b>VENTILATION ENGINEER REQUIRED</b>			
<b>CONSTRUCT PERMANENT STOPPING ETC TO CONTROL VENTILATION</b>	By Whom	By When	Date Completed
<b>THIS</b>			
<b>REQUIRE IMMEDIATE FEED BACK WITHIN 4 DAYS - OR I WILL WRITE A FORMAL LETTER TO THE MINES INSPECTOR</b>			
New Hazard Identified - has this been added into the Hazard Register?			No <input type="checkbox"/>
New Controls Implemented - Have these been recorded in the Hazard Register?			Yes <input type="checkbox"/> No <input type="checkbox"/>

Figure 8.11: Extract from Dene Murphy's 24 June 2010 Incident/Accident Form

99. In the absence of a ventilation engineer, Mr White said he adopted the role of 'de facto ventilation engineer', adding he had 'no choice' because nobody else was available.<sup>142</sup> The ventilation management plan allocated more than 90 duties to the mine manager and ventilation engineer, and Mr White could not have fulfilled those while working as general manager.
100. Hydro-mining consultant Masaoki Nishioka said that when he arrived at Pike in July 2010 he found that 'nobody' was really taking care of ventilation at the mine.<sup>143</sup>
101. After Mr van Rooyen raised the lack of a ventilation officer with Mr White, it was agreed that Dean Jamieson, an underviewer, would be an appropriate person to train as a ventilation officer.<sup>144</sup> However, Mr Jamieson's training was delayed because of the resignation of another underviewer,<sup>145</sup> and he had not started formal training before November 2010.

### Ventilation control devices

102. In any mine ventilation circuit it is essential that fresh air is delivered to the correct locations and in the right quantities, and that contaminated air is kept isolated from intake air and from any potential sources of ignition.<sup>146</sup> For that reason, ventilation control devices, including stoppings, overcasts, regulators and other devices, are used to ensure ventilation air continues on the correct path.
103. A stopping is a solid barrier that prevents air travelling through a roadway. A permanent stopping may be constructed from masonry, concrete blocks, fireproofed timber blocks or steel.<sup>147</sup> As a short-term measure, stoppings may be constructed from timber and brattice (a fire-resistant, anti-static cloth). The photograph below shows a low-pressure stopping constructed from timber and brattice.





**Figure 8.12: Board and brattice stopping**<sup>148</sup>

104. Stoppings must be constructed to a suitable standard to avoid leakage, which can compromise the performance of the ventilation system. Stoppings should also be built to withstand the pressures that may follow a roof fall or windblast within the mine.<sup>149</sup>

#### Construction standards

105. In Queensland and New South Wales the law requires stoppings to be 'rated', that is, built to withstand identified pressures. This followed a recommendation of the Moura No. 2 inquiry dealing with the design and installation requirements for seals. A seal is used to isolate a worked-out area of a mine from the rest of the mine infrastructure. It may consist of two or more stoppings, 5–10m apart, with the space between occupied by sand, stone dust or other non-flammable material.<sup>150</sup> The Moura No. 2 inquiry recommended that the chief inspector of coal mines should determine and enforce minimum requirements for the design and installation of seals.<sup>151</sup>
106. That recommendation is reflected in the current Queensland coal mining safety and health regulation, which requires the ventilation officer to ensure ventilation control devices are installed in compliance with specified ratings. For example, a stopping installed as part of the main ventilation system must be capable of withstanding an overpressure of 35kPa.<sup>152</sup>
107. Neither New Zealand law, nor the industry guidelines produced by MinEx, provide for stoppings to be built to any rated standard. The guidelines suggest temporary ventilation stoppings can be as many as four cross-cuts or 250m backbye of development headings.<sup>153</sup> Mr Reece told the commission this was 'significantly less of a standard' than Queensland regulators would accept.<sup>154</sup>

#### The ventilation control devices at Pike River

108. In 2006 the Minarco ventilation report noted there were no specific construction requirements in New Zealand for ventilation structures, except that they be constructed from non-flammable material. The ventilation devices nominated for Pike River included roadway stoppings of a 'nominal 14kPa rating'.<sup>155</sup> The suggested 14kPa rating was only 40% of the equivalent standard in Queensland and New South Wales of 35kPa. The 2006 report did not offer any justification for the proposed lower standard at Pike River. Ultimately, Pike did not implement even the lower standard.



109. Appendix 5 of the Pike ventilation management plan set out a procedure for the construction of ventilation structures.<sup>156</sup> The ventilation engineer was to advise the undermanager on standards for ventilation stopping construction, and stoppings were to be built to standards set out in the 'Pike River Mine Manager's Ventilation Rules'. Whereas Minarco's ventilation report in 2006 had contemplated stoppings with a nominal rating of 14kPa, the ventilation management plan left the issue of standards for ventilation control devices to the 'Pike Mine Manager's Ventilation Rules'. No such documentation was created.
110. When Mr Stewart carried out a statutory compliance audit in early 2010 he referred to stoppings being 'badly constructed and leaking hugely', contaminated air recirculating back into the ... working place and overcasts with 'significant leakage'.<sup>157</sup> Improvements were made as a result of the audit, including the rebuilding of some stoppings. One report noted that an underviewer had been asked to develop designs for all the stopping types to form part of a construction template for Pike River. Mr Stewart also spoke to mechanical engineer Matthew Coll about stopping standards and gave him a copy of design and procedures for stopping construction for training purposes.<sup>158</sup>
111. When he left Pike in April 2010 Mr Stewart was not satisfied with the stoppings. Some had been improved, and he had done 'very basic things', for example, pushing stoppings to see whether they rocked.<sup>159</sup>
112. Responsibility for advising on standards for the construction of stoppings and other ventilation control devices rested with the ventilation engineer. When he arrived at Pike Mr White recognised that there were no permanent ventilation control structures, and he began organising a standard for building temporary stoppings and 'set about starting to talk to contractors in Australia with respect to the supply of equipment for building permanent stoppings'. Mr White added that it was 'difficult to nominate positions for permanent stoppings' because the mine plan changed so frequently.<sup>160</sup>
113. In May 2010 Pike issued a standard operating procedure document entitled 'Underground Standards', which set out the standard for both temporary and permanent stoppings.<sup>161</sup> The basic construction method was the same for both, namely board and brattice construction, as depicted in the diagram below and in Figure 8.12.

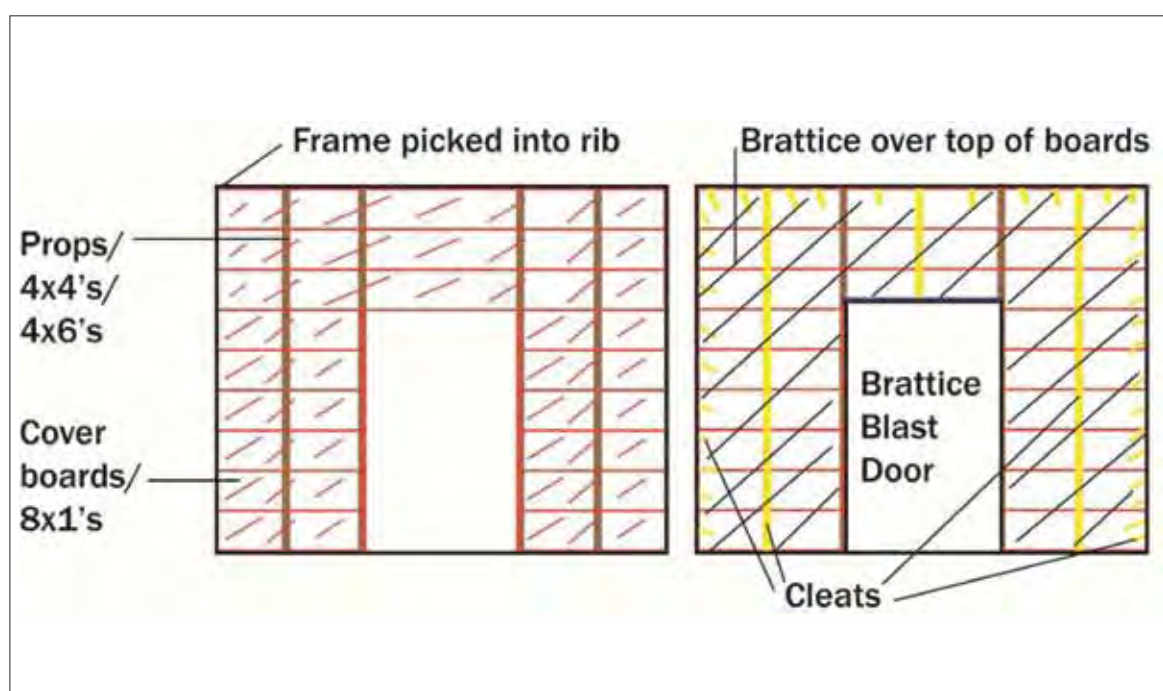


Figure 8.13: Board and brattice construction method<sup>162</sup>

114. The construction method was essentially to use standard timber covered by brattice. The main difference with permanent stoppings was that these were covered in mesh and sprayed with shotcrete (this is concrete or mortar

projected through a hose at high velocity). The underground standards document made no reference to pressure ratings.

115. Despite the underground standards document, problems with stoppings continued. On 20 September 2010 Mr Nishioka noted repeated problems with methane levels in the hydro panel. The hydro operation was stopped, and on investigation it was discovered that the ventilation stopping in the hydro panel was leaking air so badly that recirculation of air was allowing methane to accumulate in the explosive range.<sup>163</sup> The board and brattice system used to construct the stopping was not robust enough to prevent leakage, and this was the type of issue that would have been raised with the ventilation officer if there had been one at Pike.<sup>164</sup>

### Roof fall on 30 October 2010

116. On 30 October 2010 there was a large roof fall in the goaf in the hydro panel. The roof fall generated a pressure wave that knocked over the stopping at cross-cut one in the hydro panel, marked in the diagram below.

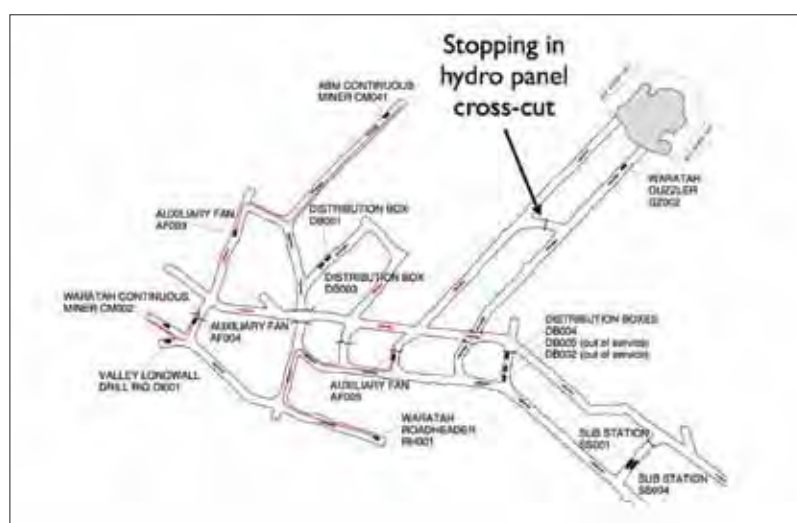


Figure 8.14: Stopping in hydro panel cross-cut<sup>165</sup>

117. The incident occurred around 4:00am on 30 October 2010. Steve Wylie was the deputy on duty. Just before the roof fall the crew had been cutting to the left of a stump of coal in the goaf. Slabs of coal had been falling from the side of the stump, most likely as a result of downward pressure from the roof of the goaf. Mr Wylie heard the roof collapse and saw that it had fallen in, covering the front of the monitor.<sup>166</sup>
118. He did not recall a significant windblast down the intake road, but the debris from the roof had blocked off the heading to the goaf and cut off ventilation. When he checked the stopping at cross-cut one he saw it had completely fallen over towards the intake roadway.<sup>167</sup> This indicated that a windblast had travelled down the return roadway and knocked the stopping over.<sup>168</sup> A gas reading showed greater than 5% methane in the return roadway at the intersection with cross-cut one.<sup>169</sup> Because his gas detector was not capable of reading greater than 5%, Mr Wylie could not tell the actual methane concentration, but there was clearly an explosive quantity of methane in the return.
119. Mr Wylie completed an incident report.<sup>170</sup> He attached a hand-drawn diagram showing the effects of the roof fall, including the blocked heading at the entry to the goaf and the damaged stopping in cross-cut one, with the words 'stopping blown over'.

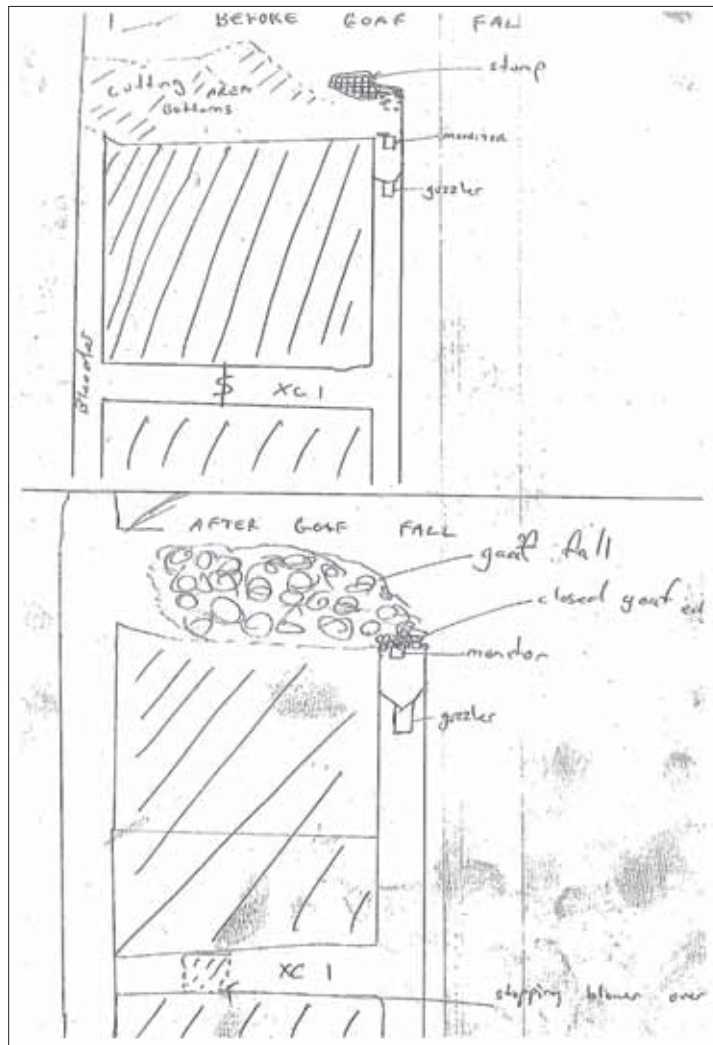


Figure 8.15: Effects of roof fall on 30 October 2010<sup>171</sup>

120. Mr Ellis signed off the incident form as 'closed' on 19 November 2010. The form stated the chance of this type of event happening again was 'occasional', and there had been 'extensive investigation and recovery'.<sup>172</sup> The commission has not been able to locate any evidence of that investigation. Mr Ellis said he would have expected the investigation to have been carried out by Mr Wylie or George Mason, but neither can recall it.<sup>173</sup> In a supplementary statement to the commission, Mr Ellis said he searched the company's electronic and hard copy records but had not been able to locate any material relating to the investigation. He said he would not have signed off the incident as closed without reading a report.<sup>174</sup> There is no evidence of such a report, other than a short, five-sentence note prepared shortly after the event.<sup>175</sup>
121. This incident provided a warning of a major hazard. It demonstrated the vulnerability of the mine's stoppings, as well as the potential for a roof fall in the hydro goaf to damage the ventilation system and lead to an explosive accumulation of methane.
122. Three aspects of the mine's response are significant. First, the incident was primarily categorised as property damage rather than as a safety issue. The original incident form noted that the incident had damaged a stab jack on the hydro monitor. The discussion at the weekly operations meeting focused on the cost of repair to the hydro monitor and the loss of production.<sup>176</sup> There is no indication that the broader significance of the event was discussed. When Mr Ellis signed off the incident on 19 November 2010 he did not answer the question whether any new hazard had been identified or new controls implemented, and he ticked the 'no' box in response to the question about a possible systematic failure.

123. Second, the incident highlighted the vulnerability at the mine caused by Pike's lack of a full-time ventilation engineer. The complete failure of a ventilation control device was a significant issue. Mr Rowland said he 'would expect the total failure of a ventilation appliance in a panel face area to be widely communicated to all persons on the site'.<sup>177</sup> Mr Reece agreed that, for a prudent mine operator, the roof fall would have signalled the urgent need to assess the integrity of all stoppings.<sup>178</sup> This task would have been the responsibility of the ventilation engineer, had there been one.
124. Third, the incident was not formally reported to DOL, despite the fact there was an uncontrolled accumulation of more than 5% methane. DOL inspector Kevin Poynter visited Pike three days after the roof fall, on 2 November 2010. Mr Ellis stated he discussed the roof fall with Mr Poynter, although he could not recall the specifics of the conversation.<sup>179</sup> Despite the seriousness of the incident, there was no formal notification and no investigation by the regulator.

### The standard of ventilation control devices at Pike River in November 2010

125. The DOL investigation team carried out a detailed analysis of the ventilation control devices at Pike River, and concluded their quality was 'extremely variable'.<sup>180</sup> The stoppings near the main ventilation fan were made of steel and concrete, and rated to 35kPa. A number of stoppings were constructed using 'pogo sticks', expandable poles with an internal spring often used to hold up cables within the mine. Mr Reece described pogo sticks as 'very temporary arrangements',<sup>181</sup> not intended for any type of permanent construction. The mine was attempting to achieve a number of permanent stoppings in the months leading up to November 2010, although these would not necessarily be rated.<sup>182</sup> The stoppings in November 2010 would not have complied with Queensland standards.<sup>183</sup>
126. The DOL investigation stressed the significance of the stopping at cross-cut 3, marked with an arrow below.

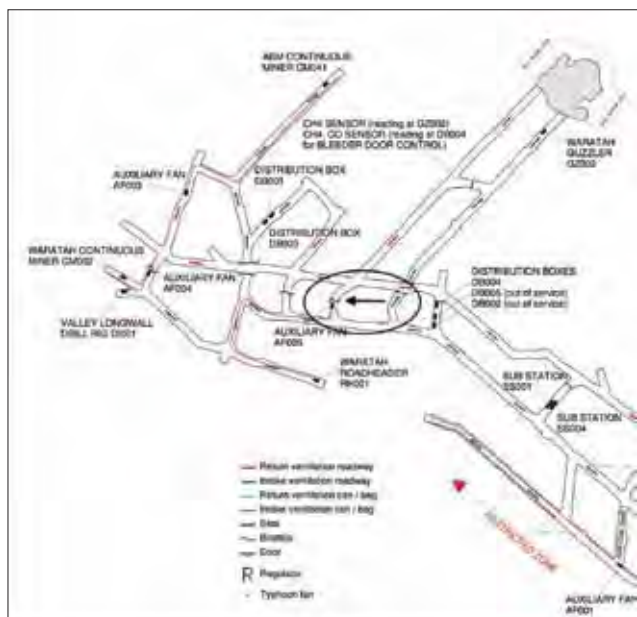


Figure 8.16: Hydro panel and cross-cut 3<sup>184</sup>

127. That stopping was directly in line with the return from the hydro-monitor panel. Any significant roof fall in the hydro goaf would create an overpressure down the return, and the stopping would need to withstand that pressure.
128. Despite that risk, the stoppings at cross-cuts 3 and 4 remained in a temporary state on 19 November 2010. The collapse of the stopping at cross-cut 1 in the hydro panel on 30 October 2010 had served as a warning of this vulnerability, but Mr White said it was 'not likely' any consideration was given to the matter, even following the 30 October incident.<sup>185</sup>
129. Mr van Rooyen agreed with the criticism of the stopping at cross-cut 3, and said it 'should have been made permanent preferably before or certainly early on in the excavation of the hydro panel'.<sup>186</sup> He agreed that the

increasing size of the goaf created a greater risk of a roof fall, resulting in damage to the temporary stopping in cross-cut 3, which could allow the short circuiting of air away from the inbye faces, and might also allow methane to enter the intake roadway.<sup>187</sup>

130. Mr White said the intention was to make that stopping permanent after a panel move, which took place from Friday 12 November to Monday 15 November 2010, but this was not done.<sup>188</sup>
131. There were three main problems with the ventilation control devices at Pike River in November 2010. First, there were too many temporary stoppings in light of the mining activity taking place. Second, with a few exceptions, the permanent stoppings that did exist were not rated to any particular standard. Third, there was insufficient oversight of the construction and maintenance of stoppings. The variable quality of stoppings at Pike River compromised the effectiveness of the ventilation system, and increased the risk of a catastrophic event. Rated stoppings may have assisted in an emergency, especially if combined with a functional surface fan, because they may have helped to re-establish a ventilation circuit to remove hazardous gases from the mine.

## Sufficiency of ventilation at Pike River

132. Evidence before the commission indicated that Pike River had a 'serious lack of ventilation quantity for the number of faces being worked'.<sup>189</sup> At best the system was stretched to capacity, with no room for error.<sup>190</sup>
133. Mr Ridl, by then the engineering manager, said the ventilation was 'pretty shit' before the main underground fan began operating in October 2010.<sup>191</sup> Then 'there was a significant increase in ventilation and people were a lot happier'.<sup>192</sup> However, Mr Rowland advised the mine in early November 2010 it needed more ventilation capacity 'relatively urgently' because the total amount of air available (120m<sup>3</sup>/s) was sufficient to run only four auxiliary fans on full speed while allowing standard margins for safety.<sup>193</sup> As at November 2010, the mine was running four auxiliary fans, with a fifth out of service. Mr Rowland's intention was to emphasise the importance of increasing the quantity of air available as soon as practicable and not 'resting on the apparent laurels of the new circuit capacity' provided by the underground fan.<sup>194</sup>
134. The DOL investigation included detailed ventilation modelling of the mine based on the available data. That modelling indicated there was less than 25m<sup>3</sup>/s available for each place requiring ventilation, not allowing for leakage. That information, together with reports from mine officials, showed the ventilation system was struggling to cope with the gas quantity and the extent of mining operations.<sup>195</sup> DOL concluded that Pike had a ventilation shortfall, and should have been working one fewer place in the mine.<sup>196</sup> Pike considered the work was being managed within the limits of the ventilation system. As noted in paragraphs 139–144 methane problems persisted.
135. Ventilation inbye of the monitor panel was particularly fragile and struggling to cope with the extent of mining operations and gas load in the mine.<sup>197</sup> Those areas had a small amount of pressure (14Pa) and quantity (49m<sup>3</sup>/s) available to ventilate the three working places and two standing places inbye of panel 1. That area is shaded yellow in the following diagram.



Figure 8.17: Ventilation inbye of the monitor panel<sup>198</sup>



136. DOL concluded that, given the gas make in the mine and the number of faces being worked, it should have been apparent that the ventilation system was stretched to its limit. Pike's approach allowed no factor of safety to deal with predictable hazards.<sup>199</sup>
137. Mr Reece also noted other deficiencies with the ventilation system, for example, the placement of an auxiliary fan (AF003) immediately next to a stopping,<sup>200</sup> which meant the fan did not have the necessary 30% of fresh air passing over it to ensure it did not overheat. The fan can be seen towards the left-hand side of the following diagram.

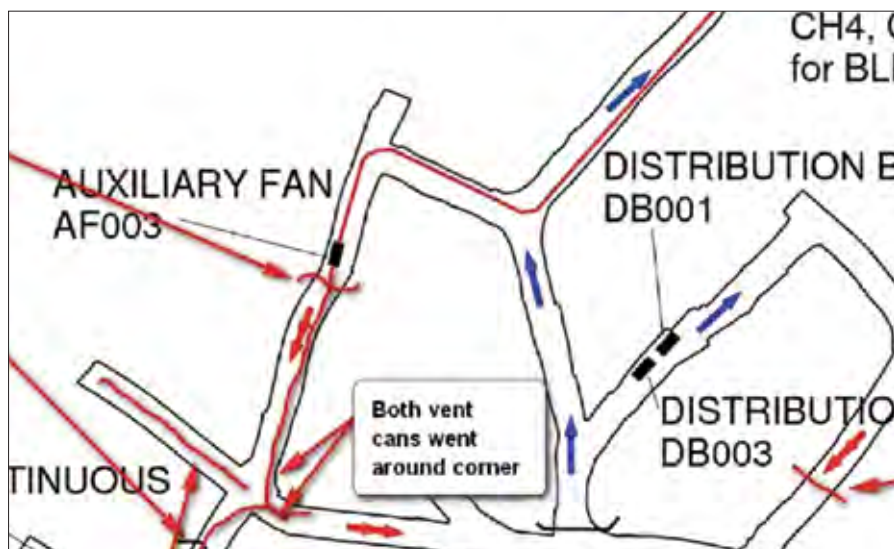


Figure 8.18: Location of the auxiliary fan<sup>201</sup>

138. Mr White accepted that the evidence used by DOL in its modelling was correct, but considered that there was sufficient air to run the number of faces being mined.<sup>202</sup> He said Pike managed the amount of work done within the ventilation available and did not work all faces at the same time.<sup>203</sup> However, Pike's own records, including incident reports and deputies statutory and production reports, show there were serious ventilation problems.

SPECIFIC PRODUCTION ISSUES, IMPROVEMENTS OR SUGGESTIONS						
IMPROVEMENT: GET THE DAM VENTILATION SORTED OUT SO WE CAN CUT COAL. THIS VENTILATION ISSUE HAS DRAGGED ON FOR 2 1/2 BLOODY YEARS!!!						
SHIFT ANALYSIS						
Shift start time: [ ] 14						
Shift start time (Hours:Min:Sec)	Target meters	Actual meters	Out	Back	Down	Comments
1	7:00					<ul style="list-style-type: none"> <li>✗ THE SHIFT STARTING - TRAVEL - LOAD POGO STUCK BRATIDE</li> <li>✗ TRAVEL</li> <li>✗ TRAVEL</li> <li>✗ INSPECTION - UNLOAD GEAR FOUND DAMAGED AIR MANIFOLD</li> </ul>
2	8:00					<ul style="list-style-type: none"> <li>✗ DEVELOPMENT WABLE SIGGODRON NOT REPEATED</li> <li>✗ TO PROVIDE VENTILATION TO MOUNTAIN FACE, WHEN ARE YOU GOING TO GET THIS SHIT SORTED!!!</li> <li>✗ IF YOU RUN A PRIVATE MINE LIKE THIS YOU WOULD BE SHUT DOWN A WEEK!!!</li> </ul>
3	9:00					

Figure 8.19: Extracts from Dene Murphy's 21 October 2010 Deputies Production Report<sup>204</sup>

## Recorded methane spikes

139. Evidence before the commission indicated a large number of methane spikes in the weeks and months before the explosion, many in the explosive range of greater than 5% methane. Mr White agreed that any instance of 5%



methane or more within a mine, even in the return, would be classified as a high-potential incident.<sup>205</sup> The evidence indicates that methane greater than 2% were almost a daily event, both before and after the commissioning of the main underground fan.

### Deputy statutory reports

140. Deputies' shift reports noted if they found greater than 1.25% methane in the general body of air. The reports between 3 October 2010 and 19 November 2010 contained recorded gas levels of 2% or higher on 48 occasions over 48 days. Concentrations of 5% were recorded within the mine 21 times during that period.<sup>206</sup> The gas detectors used by Pike were not capable of reading higher than 5%, so it is not possible to know the actual level of gas on these occasions. Pike should have notified DOL of these events, but did not. This was supported by accident/incident reports.

### Masaoki Nishioka's work record

141. Hydro consultant Masaoki Nishioka kept a daily work record. He noted methane levels on 14 days between 20 September and 15 October 2010, and on nine occasions methane levels exceeded 5% in the return airway.<sup>207</sup> It was a safety hazard to continue monitor extraction with gas concentrations at that level.<sup>208</sup> On 1 October Pike agreed to stop the hydro-monitor operation until the main fan became operational.<sup>209</sup> During commissioning of the main fan, gas spikes in the hydro-monitor panel continued and Mr Nishioka's work record contained numerous references to methane levels above 5% and the 'poisoning' of the methane detectors.
142. When asked about these instances, Mr White said he believed the plugs of methane from the monitor panel would have been diluted below the explosive range in the main return.<sup>210</sup> Similarly, Mr Ridl's understanding was that the spikes of greater than 5% were present only in the hydro panel.<sup>211</sup> However, the sensor at the top of the ventilation shaft was not capable of generating a reading higher than 2.96% methane, and it is not possible to be sure about levels in the main return. For that reason Mr White accepted that levels of methane may have remained in an explosive state all the way to the top of the ventilation shaft.<sup>212</sup>

### The gas monitoring system

143. DOL examined the records from the gas monitoring system for the period 25 October to 19 November 2010. Spikes over 1.25% were recorded 12 times. One of those spikes could be attributed to the calibration of the ventilation shaft gas detector, and a second to the restart of the main fan on 27 October 2010. Of the remaining 10, four events were of methane over 2.5% and a further two events were of methane over 1.8%. These were significant plugs of methane, and each one may have represented an explosive mixture if exposed to a source of ignition before dilution in the main return.<sup>213</sup> When asked about those conclusions Mr White said that number of spikes was a concern and, in hindsight, each should have been formally investigated.<sup>214</sup>
144. In a report written shortly after the explosion, Gregory Borichevsky noted that potentially explosive levels of methane would have been present in the mine workings on a number of occasions, because methane levels in the ventilation shaft routinely exceeded 1%, regularly exceeded 1.5%, occasionally exceeded 2% and had exceeded 3% more than once in the weeks before the disaster.<sup>215</sup> Mr White was asked whether, in light of the number of methane spikes coming through the ventilation shaft, there was a risk that this situation had become normalised. He said he would hesitate to say 'normalised', but it was 'certainly something that was happening frequently, more frequently than would be desired'.<sup>216</sup>

### Accident/incident reports

145. Pike's accident and incident reports show other ventilation issues were reported often by workers. For example in October 2010 a typhoon fan ventilating a drill stub was not operating – the air hose had been disconnected and connected to other machinery. In June 2010 there was a higher pressure on the return side of a stopping near an electrical sub-station, leading to recirculation when the stopping door was open and the possibility of potentially flammable air in the presence of the substation. In January 2010 a blower fan was found on the floor 40 metres

from its original location, with the air hose disconnected. It was thought to have been hit by a passing vehicle. In April 2009 ventilation ducting was found damaged, resulting in an accumulation of flammable gas.

146. The reasons given for such incidents included lack of knowledge and training; lack of skill and experience; being unaware of hazards; inadequate work standards; safety rules not enforced; inadequate leadership/supervision, poor housekeeping and poor ventilation management.<sup>217</sup>

## Ventilation monitoring

147. The effectiveness of a mine's ventilation system should be measured in a number of ways, including manual pressure and quantity surveys. Pike used hand-held anemometers (Kestrels) to measure ventilation quantity. These instruments are necessary to verify ventilation speeds underground, and essential in the degassing process.<sup>218</sup>
148. On at least 10 occasions during October 2010, deputies noted a lack of Kestrels underground. For example, on 20 October 2010 one deputy wrote: 'no Kestrel available for vent readings (5 wks now Hurry up and get em). Can't do job without the tools Bro'.<sup>219</sup>
149. When asked about this, Mr White said that 'as far as I was aware we had an adequate supply of Kestrels',<sup>220</sup> and that he would certainly have liked to have known this was an issue. He said it is not possible to start an auxiliary fan underground without measuring the air with a Kestrel, and he was disappointed to learn that someone had to wait five weeks to be given one.<sup>221</sup>
150. The commission received further evidence that Pike lacked appropriate equipment for ventilation measurements. On 12 October 2010 the Pike project manager Mr Moynihan emailed the Spring Creek mine's ventilation officer Robin Hughes and invited him to come to Pike. Mr Moynihan wanted someone to check air flow and pressure measurements for the underground fan. He said, 'Pike still does not have a [hand-held] electronic manometer and a good quality anemometer'.<sup>222</sup> A manometer is a pressure measuring instrument that should be available at an underground coal mine.<sup>223</sup>

## Three key decisions

151. The initial plan for the development of the Pike River mine envisaged a two-intake/single return ventilation system powered by two main forcing fans located on the surface. Three separate decisions put paid to this plan:
- In late 2006 a proposal was made to locate the main fans underground, but in stone measures to the east of the Hawera Fault, and this was decided on after a risk assessment in February 2007.
  - In late 2007, however, the location of the main ventilation shaft was moved from east of the Hawera Fault to its eventual position in pit bottom in coal. This meant also changing the location of the main fans so they would be adjacent to the shaft.
  - In early 2010 Pike obtained approval to locate a bridging panel near pit bottom, which meant that hydro mining began before the development of a second intake.

Hence, as at 19 November 2010, Pike had a single intake/single return ventilation system, powered by an underground main fan at a time when hydro coal extraction had begun.

## Conclusions

152. The ventilation system at Pike River was inadequate:
- The ventilation management plan was incomplete, largely ignored in practice and required the appointment of a ventilation engineer to be responsible for the ventilation system. No one was

appointed to the role and the mine manager became the de facto ventilation engineer, without the time or resources to carry out the role adequately.

- The opportunity to improve ventilation capacity was lost when development of a second intake was deferred to accommodate the commencement of hydro mining in the bridging panel.
- The placement of the main fan underground was a major error, aggravated by the failure to adequately protect the fan motor against methane ingress.
- Aside from permanent stoppings erected at the location of the main fan, the mine stoppings were of variable quality and were not built to any rated standard. They compromised the effectiveness of the ventilation system, and created a safety hazard.
- The mine had a ventilation shortfall, with no factor of safety to meet foreseeable hazards, and one less mining or development area in the mine should have been worked.
- On 19 November 2010 the main and back-up fans were both damaged during the explosion, and the ventilation system failed. The mine was unventilated.

## ENDNOTES

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<sup>2</sup> United Nations, Economic Commission for Europe, Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines (ECE Energy Series No. 31), 2010, p. 17, [http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide\\_MethDrain\\_es31.pdf](http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf)

<sup>3</sup> Douglas White, Submissions on Behalf of Doug White, 24 March 2012, WHI003//6, para. 4.4.

<sup>4</sup> Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/88, ch. 4.2.1.

<sup>5</sup> Ibid., CAC0158/110. (Labels added by the commission)

<sup>6</sup> Minarco Asia Pacific Pty Ltd, Pike River Coal Company Ventilation Report, June 2006, DAO.012.02277/10.

<sup>7</sup> Ibid., DAO.012.02277/27.

<sup>8</sup> In this section, the terms 'ventilation engineer', as used in the Pike River ventilation management plan, and 'ventilation officer' are used interchangeably.

<sup>9</sup> David Reece, transcript, p. 4563.

<sup>10</sup> Peter Whittall, transcript, pp. 872–73.

<sup>11</sup> Ibid., p. 890; Letter, Michael Zeitoun to Royal Commission on the Pike River Coal Mine Tragedy, 1 June 2012, FWF0001/1.

<sup>12</sup> Email, Ian Miller to Tony Goodwin, 16 November 2006, DAO.012.02253/3–4; Fläkt Woods Fans (Australia) Pty Ltd, Mine Ventilation Tender, 15 December 2006, DAO.025.27141.

<sup>13</sup> Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/101, para 3.8.6.

<sup>14</sup> In the United States: Code of Federal Regulations, Mandatory Safety Standards for Underground Coal Mines, 30 CFR § 75.310; in Canada: Coal Mining Occupational Health and Safety Regulations SOR/90–97, regs 2, 114(b).

<sup>15</sup> In Queensland: Coal Mining Safety and Health Regulation 2001, Part 11 Ventilation, Division 5, cls 353–58; in New South Wales: Coal Mine Health and Safety Regulation 2006, Part 4, Division 3, Subdivision 4, cls 118–22.

<sup>16</sup> Clause 1.3.3. of the code of practice provides that in the absence of national laws and regulations on a particular occupational safety and health issue, guidance should be drawn from the code of practice, as well as from other relevant nationally and internationally recognised instruments. The ILO is a specialised agency of the United Nations of which New Zealand is a member state.

<sup>17</sup> Platinum Safety Ltd, Institutional Report, 22 May 2012, PSL0001/4, para. 14.

<sup>18</sup> Ibid., PSL0001/5, para. 16.

<sup>19</sup> Platinum Safety Ltd, Risk Assessment Report: Underground Ventilation Fan Installation – Prepared for Pike River Coal Ltd, 27 February 2007, DAO.012.02318/4.

<sup>20</sup> Platinum Safety Ltd, Institutional Report, 22 May 2012, PSL0001/5, para. 17.

<sup>21</sup> Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318/21.

<sup>22</sup> Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System – History and Current Status, 31 March 2010, DAO.003.05885/8.

<sup>23</sup> Email, Neville Rockhouse to Paul Coleman, 15 June 2007, PSL0002/1.

<sup>24</sup> Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318; Email, Neville Rockhouse to Paul Coleman, 12 July 2007, PSL0004/1.

<sup>25</sup> Platinum Safety Ltd, Institutional Report, 2007, PSL0001/6, para. 28.

<sup>26</sup> Udo Renk, witness statement, 18 May 2012, RENK7770010001/9, para. 41.

<sup>27</sup> Peter Whittall, witness statement, 31 August 2012, p. 2, paras 5–7.

<sup>28</sup> Pike River Coal Ltd, Minutes of a Meeting of Directors, 30 July 2008, DAO.013.11707/4.

<sup>29</sup> Pike River Coal Ltd, Operations Report, 23 February 2007, DAO.007.00608/8.

<sup>30</sup> John Dow, transcript, p. 4028.

<sup>31</sup> Ibid., p. 4029.

<sup>32</sup> Email, Jim Rennie to Peter Whittall, 21 June 2007, INV.04.01153/1.

<sup>33</sup> Guy Boaz, Police/DOL interview, 12 July 2011, INV.03.24596/14.

<sup>34</sup> Ibid., INV.03.24596/16.

<sup>35</sup> Peter Whittall, witness statement, 31 August 2012, p. 2, paras 9–10.

<sup>36</sup> Email, Udo Renk to Peter Whittall, Kobus Louw and Les McCracken, 2 October 2007, DAO.025.46674.

<sup>37</sup> Udo Renk, Summary of Telephone Conversation with Udo Renk, 4 October 2011, DOL3000150034/1.

<sup>38</sup> Peter Whittall, witness statement, 31 August 2012, p. 3–4, paras 11–20.

<sup>39</sup> Petrus (Pieter) van Rooyen, transcript, p. 5199; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/33, paras 187–88.

<sup>40</sup> Michael Firmin, transcript, p. 2863.

<sup>41</sup> Discussed further in Chapter 15, 'Regulator oversight at Pike River', paras 22–25.

<sup>42</sup> Michael Firmin, transcript, p. 2898.

<sup>43</sup> Michael Firmin, witness statement, 19 October 2011, DOL7770040002/7, para. 26.

<sup>44</sup> Ibid., DOL7770040002/7, para. 29; Michael Firmin, transcript, p. 2899.

<sup>45</sup> Pike River Coal Ltd, Ventilation Management Plan, 2008, DAO.003.07114.

<sup>46</sup> Ibid., DAO.003.07114/54.

<sup>47</sup> Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System, DAO.003.05885/13.

<sup>48</sup> Douglas White, transcript, pp. 4900, 4879.

- <sup>49</sup> Ibid., p. 4879.
- <sup>50</sup> Ibid., p. 4883.
- <sup>51</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/32, para. 179.
- <sup>52</sup> Email, John Rowland to Pieter van Rooyen, Terence Moynihan and Douglas White, 23 September 2010, INV.04.00238.
- <sup>53</sup> Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001, p. 12, para 4.5.4.
- <sup>54</sup> John Rowland, witness statement, 22 October 2011, ROW001/11, para. 40.
- <sup>55</sup> David Stewart, transcript, p. 3362.
- <sup>56</sup> David Stewart, witness statement, 3 November 2011, STE0001/22, para. 42.2.
- <sup>57</sup> John Dow, transcript, p. 4024.
- <sup>58</sup> Ibid.
- <sup>59</sup> Ibid., p. 4026.
- <sup>60</sup> Minarco Asia Pacific Pty Ltd, Ventilation Report, DAO.012.02277/22–26.
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- <sup>62</sup> David Reece, transcript, p. 4486.
- <sup>63</sup> David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/44.
- <sup>64</sup> Petrus (Pieter) van Rooyen, transcript, p. 5207.
- <sup>65</sup> Ibid., p. 5213.
- <sup>66</sup> Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.19.
- <sup>67</sup> Fläkt Woods Fans (Australia) Pty Ltd, Drawing of General Arrangement VP-2000 Auxiliary Fan Surface Ventilation, 26 February 2008, DAO.025.55292/1.
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- <sup>69</sup> Masaoki Nishioka, work record, NISH0002/28.
- <sup>70</sup> Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.20.
- <sup>71</sup> Pike River Coal Ltd, Incident/Accident Form #1086, 5 October 2010, DAO.001.00359/15–16.
- <sup>72</sup> Pike River Coal Ltd, Review of Surface Aux Fan Failure 05/10/10, 7 October 2010, DAO.001.00359/17; Letter, Douglas White to Kevin Poynter, 8 October 2010, DOL3000070182.
- <sup>73</sup> Pike River Coal Ltd, Operations Report Updated to 20 October 2010, DAO.019.00766/8.
- <sup>74</sup> Pike River Coal Ltd, Risk Assessment – Reinstate Surface Ventilation and Underground Power and Ventilation after Fan Failure on 5 October 2010, DAO.002.05202.
- <sup>75</sup> Pike River Coal Ltd, Review of Surface Aux Fan Failure, DAO.001.00359/17–26.
- <sup>76</sup> R & D Consultancy (2007) Ltd, Failure Analysis of Damaged Fan Hub and Dislocated Fan Blade, 4 August 2009, DAO.025.56119.
- <sup>77</sup> Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/14, section 5.2.
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- <sup>79</sup> Attended by Douglas White, Stephen Ellis, Nicholas Gribble, Robb Ridl and other members of the engineering department.
- <sup>80</sup> Pike River Coal Ltd, Review of Surface Aux Fan Failure, DAO.001.00359/17–26.
- <sup>81</sup> Ibid., DAO.001.00359/21. Including the need to establish an incident management team early on in an event. Mr White was allocated this issue and tasked to 'introduce this process to PRCL' by December 2010.
- <sup>82</sup> Emails between Nicholas Gribble, Douglas White, Neville Rockhouse, Stephen Ellis, Danie du Preez, Peter Sinclair, Robb Ridl, Michael Scott and Adrian Couchman, 18–19 October 2010, SOE.024.00305/1–2 and 26 October 2010, SOE.024.00333/1.
- <sup>83</sup> David Reece, witness statement, 2 February 2012, DOL3000150001/16, para. 70.
- <sup>84</sup> Michael Scott, witness statement, 30 May 2012, SCO7770010001/22, para. 84.
- <sup>85</sup> Masaoki Nishioka, work record, NISH0002/27; Douglas White, witness statement, 18 July 2012, WHI005/12, para. 51.
- <sup>86</sup> Anthony Reczek, transcript, pp. 4778–79.
- <sup>87</sup> Andrew Sanders, Police/DOL interview, 14 June 2011, INV.03.24725/93; Department of Labour, Investigation Report, DOL3000130010/96–97.
- <sup>88</sup> Douglas White, transcript, p. 4974.
- <sup>89</sup> Pike River Coal Ltd, Control Room Officer's Event Book, 22 October 2010, DAO.001.02063/1–2; Department of Labour, Investigation Report, DOL3000130010/101, para. 3.8.4; Andrew Sanders, Statement of Andrew John Sanders, 22 May 2011, INV.03.24720/4.
- <sup>90</sup> Michael Scott, witness statement, 30 May 2012, SCO7770010001/26–27, paras 101–05.
- <sup>91</sup> Ibid., SCO7770010001/27–28, paras 107–09; Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/8–9, paras 43–47.
- <sup>92</sup> Letter, Michael Zeitoun to Royal Commission, 1 June 2012, FWF0001/3; Andrew Sanders, Statement of Andrew John Sanders, May 2011, INV.03.24720/4; Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/18.
- <sup>93</sup> Michael Scott, witness statement, 30 May 2012, SCO7770010001/28, para. 110.
- <sup>94</sup> Udo Renk and Jonathan McNee, 'Technical Challenges for the Pike River Coal Project in a Remote Mining Environment', IMM Conference, August 2007, DAO.001.04727/16.
- <sup>95</sup> Udo Renk, second witness statement, 18 May 2012, RENK7770010001/10–11, paras 48–49.
- <sup>96</sup> Email, Udo Renk to Jane Birdsall, 17 October 2011, DOL3000150035/2.
- <sup>97</sup> Petrus (Pieter) van Rooyen, transcript, pp. 5199–201.
- <sup>98</sup> Pike River Coal Ltd, Return Ventilation Design Planning Assistance Notes, undated, DAO.025.53827.
- <sup>99</sup> Memorandum, Pieter van Rooyen to Peter Whittall, Nigel Slonker, Gregor Hamm and Terence Moynihan, 18 June 2009, DOL3000150004.
- <sup>100</sup> Email, Pieter van Rooyen to Jim Rennie and Gregor Hamm, 30 June 2009, INV.03.30237/1.
- <sup>101</sup> Petrus (Pieter) van Rooyen, transcript, pp. 5202–03.
- <sup>102</sup> Memorandum, Douglas White to Peter Whittall, 16 September 2010, INV.03.30273/2; Petrus (Pieter) van Rooyen, transcript, pp. 5202–03.
- <sup>103</sup> Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318/21.
- <sup>104</sup> Zurich Financial Services Australia Ltd, Pike River Coal Ltd – Risk Assessment and Improvement Report: Draft, 18 August 2010, INV.04.00868/16.
- <sup>105</sup> David Cliff et al., Investigation for Nature and Cause, DOL3000130007/47, 19.
- <sup>106</sup> Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 36(a).
- <sup>107</sup> Pike River Coal Ltd, Ventilation Management Plan, 18 November 2008, DAO.003.07114/48, paras 8.8.2–8.8.3.
- <sup>108</sup> Pike River Coal Ltd, Standard Operating Procedure – Collecting Stone Dust Samples, undated but created in February 2010, DAO.001.10700; David Reece, transcript, p. 4585; Department of Labour, Investigation Report, DOL3000130010/220, para. 4.40.
- <sup>109</sup> Kevin Poynter, transcript, pp. 3096–98.
- <sup>110</sup> Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 36(c).
- <sup>111</sup> Pike River Coal Ltd, Ventilation Management Plan, 18 November 2008, DAO.003.07114/48, para 8.8.1.
- <sup>112</sup> Hawcroft Consulting International, Pike River Coal Ltd – Insurance Risk Survey – Underground, CPP and Surface Operations: Draft Report, July 2009, DAO.025.45387/48, para. 8.10; Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710/58, para 8.11.
- <sup>113</sup> Email, Gregor Hamm to Pieter van Rooyen, 12 June 2009, SOE.024.00211/1.
- <sup>114</sup> Dene Murphy, witness statement, 2 December 2011, FAM00057/14, para. 76.
- <sup>115</sup> David Stewart, transcript, p. 3328.
- <sup>116</sup> Department of Labour, Investigation Report, DOL3000130010/229, para. 4.43.6.
- <sup>117</sup> David Reece, transcript, p. 4588.
- <sup>118</sup> Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.21; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/18, para. 119.
- <sup>119</sup> Gregory Borichevsky, Police/DOL interview, 26 April 2011,

- INV.03.18954/125; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/18, 56, paras 119, 394, 398; Department of Labour, Investigation Report, DOL3000130010/227–28, para. 4.42.18.
- <sup>120</sup> Ibid., INV.03.18954/125; Ibid., DOL3000130010/225, para. 4.42.11.
- <sup>121</sup> Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/56, paras. 396–98; Gregory Borichevsky, notes, 22 November 2010, INV.03.29147/20–25.
- <sup>122</sup> Stephen Ellis, witness statement, 31 August 2012, pp. 1–2, paras 4–8.
- <sup>123</sup> Emails, Ian Miller to Andrew Sanders, 30 March–9 June 2010, DAO.003.05299/4–5.
- <sup>124</sup> National Fire Protection Association, NFPA 68: Standard on Explosion Protection by Deflagration Venting, 2007.
- <sup>125</sup> Letter, Michael Zeitoun to Brett Murray, 22 December 2011, FWF0002.
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- <sup>127</sup> Ibid., 30 CFR § 75.310.
- <sup>128</sup> Coal Mining Safety and Health Act 1999 (Qld), s 61; Coal Mining Safety and Health Regulation 2001 (Qld), s 341.
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- <sup>134</sup> Ibid., p. 901.
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- <sup>137</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/36, paras 207–11.
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- <sup>143</sup> Masaoki Nishioka, transcript, p. 3489.
- <sup>144</sup> Petrus (Pieter) van Rooyen, witness statement, PVR001/36, para. 211.
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- <sup>177</sup> John Rowland, witness statement, 25 November 2011, ROW007/2, para. 7.
- <sup>178</sup> David Reece, transcript, p. 4581–82.
- <sup>179</sup> Stephen Ellis, witness statement, 3 May 2012, DAO.042.00042/3, para. 8.
- <sup>180</sup> David Cliff et al., Investigation for Nature and Cause, DOL3000130007/48.
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- <sup>188</sup> Douglas White, transcript, p. 4852.
- <sup>189</sup> David Reece, witness statement, 2 February 2012, DOL3000150001/16, para. 68.
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- <sup>192</sup> Ibid., INV.03.12713/15.
- <sup>193</sup> John Rowland, Brief Report Pertaining to Current Model Update and Point-in-Time Circuit Capacities at Pike River Mine, 2 November 2010, ROW006/4.
- <sup>194</sup> John Rowland, witness statement, 22 October 2011, ROW001/9, para. 35.
- <sup>195</sup> David Cliff et al., Investigation for Nature and Cause, DOL3000130007/52.
- <sup>196</sup> Department of Labour, Investigation Report, DOL3000130010/110, para. 3.11.5.
- <sup>197</sup> Ibid., DOL3000130010/111, para. 3.11.11.
- <sup>198</sup> Plan highlighted by David Reece, MBIE3000010014/1.
- <sup>199</sup> Department of Labour, Investigation Report, DOL3000130010/111, para. 3.11.12.
- <sup>200</sup> The stopping is not shown in Figure 8.17 because it was not included in pre-explosion mine plans at Pike.
- <sup>201</sup> Department of Labour, Plant Location and Ventilation Fan: Rescue 101119\_181 (DOL Investigation Report, Appendix 8), 22 March 2011, DOL3000130008/1. (Extract of plan)
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<sup>203</sup> Ibid., p. 4861.

<sup>204</sup> Pike River Coal Ltd, Pike River Coal Mine: Deputies Production Report, 21 October 2010, DAO.001.02459/1.

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<sup>206</sup> Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Deputies Production Reports for March and October 2010, November 2011, CAC0115/13–22; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Production Reports for November 2010, January 2012, CAC0115A/6–12.

<sup>207</sup> Masaoki Nishioka, work record, NISH0002/21–32.

<sup>208</sup> Ibid., NISH0002/22.

<sup>209</sup> Ibid., NISH0002/27.

<sup>210</sup> Douglas White, transcript, p. 4937.

<sup>211</sup> Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/21, para. 84.

<sup>212</sup> Ibid., DAO.041.00009/21, para. 85.

<sup>213</sup> Department of Labour, Investigation Report, DOL3000130010/124, para. 3.16.4.

<sup>214</sup> Douglas White, transcript, p. 4937.

<sup>215</sup> Gregory Borichevsky, Pike River Coal Mine Disaster 19 November 2010, 2 December 2010, INV.04.00001/7.

<sup>216</sup> Douglas White, transcript, p. 4945.

<sup>217</sup> Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/10–13.

<sup>218</sup> Douglas White, transcript, p. 5137.

<sup>219</sup> Pike River Coal Ltd, Pike River Coal – Deputy Statutory Report, 20 October 2010, DAO.001.02793/1.

<sup>220</sup> Douglas White, transcript, p. 4998.

<sup>221</sup> Ibid., p. 4999.

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<sup>223</sup> Craig Smith, transcript, p. 3474.



## Introduction

1. Knowledge and understanding of the basic principles of methane gas control is fundamental to a mine's ability to design effective controls and safe systems.
2. This chapter describes the hazard of methane in underground coal mines and summarises and assesses Pike's knowledge of its gas reservoir and its approach to managing methane.

## Overview of best practice approach to methane drainage

### Introduction

3. Methane gas occurs naturally in coal mines and is a natural by-product of mining. In the history of coal mining methane explosions have caused more loss of life than any other factor.<sup>1</sup>
4. Increasing coal extraction rates often result in higher rates of methane emissions. However in modern mining, sustainable coal production should not be limited by a mine's inability to prevent gas concentrations from exceeding statutory safe limits, nor compromised by uncontrolled gas-related incidents that endanger life. Investment in effective gas drainage can ensure that mines meet production targets legally and safely.
5. Neither New Zealand's mining legislation nor MinEx Health and Safety Council (MinEx) guidelines specifically address the practice of methane drainage.
6. In February 2010 the United Nations Economic Commission for Europe published a best practice guidance on methane drainage,<sup>2</sup> and the following overview is sourced primarily from this.

### Methane gas

7. Coal seam gases typically consist of 80 to 95% methane, with lower proportions of other gases, including carbon dioxide and nitrogen. Bag samples of gas tested by Pike in 2009 and 2010 showed the seam gas composition at levels between 95% and 99% methane.
8. Methane forms in coal seams as the result of chemical reactions taking place when the coal was buried at depth. Methane occurs in much higher concentrations in coal than other rock types because of the 'adsorption' process, which enables methane molecules to be packed into the coal interstices (gaps or spaces) to a density almost resembling that of a liquid. In a vertical sequence of coal seams like those at Pike River, the methane content of coal often increases systematically with depth and rank (maturity).
9. Methane and other gases stored in the coal seam and the surrounding strata can be released if they are disturbed by mining activity. The amount of gas and the rate of release or emission depend upon several factors, including the initial gas content of the coal, the distribution and thickness of the coal seams, the strength of the surrounding strata, the geometry of the mine workings, the rate of coal production and the permeability of the seam. The total gas flow varies proportionally to how much mining activity disturbs the strata and coal seam.
10. Coal seam gases become flammable and potentially explosive only when mixed with air. Methane is flammable when mixed with oxygen in a wide range of concentrations, but generally between 5 to 15% methane in air by volume. Gas released from mining activity inevitably mixes with the mine's ventilation air, is diluted and passes

through the flammable range. It is therefore critical that methane concentrations in the flammable range are limited in time and location as much as possible, to reduce the potential for exposure to ignition sources and the risk of explosion.

11. Methane is buoyant and rises in air, and layering of methane can occur in poorly ventilated areas underground. Concentrated methane tends:
 

*to collect in roof cavities and to layer along the roofs of airways or working faces. In level and ascensionally ventilated airways with inadequate airflow, the layer will stream along the roof in the direction of airflow, increasing in thickness and decreasing in concentration as it proceeds. Multiple feeders of gas will, of course, tend to maintain the concentration at a high level close to the roof.*<sup>3</sup>
12. Layering extends the area within which an ignition of methane can occur, and acts very effectively as a fuse along which the flame can propagate,<sup>4</sup> with a risk of ignition of much larger accumulations of gas in roof cavities or goaf areas.
13. It is critical to reduce explosion risk by preventing occurrences of explosive mixtures wherever possible, and ensuring separation from potential ignition sources. It is essential to dilute high-purity methane by ventilation air to safe general body concentrations at the points of gas emission. This requires a well-designed ventilation system and knowledge of the seam's gas emission characteristics. Capturing high-purity gas in drainage boreholes at its source, before it can enter mine airways, and removing it from the mine, is another way of minimising the risks.

#### Gas emission characteristics

14. Peak flows of gas occur in a mine's return airways during the coal face cutting cycle and following roof caving. This is particularly the case with hydro mining, which is designed to quickly extract large quantities of coal from thick seams.
15. The volume of gas released from any coal disturbed by mining decreases over time, while continued mining activity adds new gas sources. When mining activity stops, gas continues to desorb from the coal seam and flow from rider seams and surrounding strata, but at a declining rate. Coal seams above and below the working seam may release methane that will migrate through the relaxed strata into the goaf.<sup>5</sup> Unless methane drainage is carried out, this methane will also be emitted into the mine ventilation system.
16. When assessing gas flows and ventilation requirements, mine operators assume steady state coal production and uniform predictable gas emission characteristics. Although this approach suits most planning needs, other factors such as outburst and sudden emissions of gas from the floor create safety hazards and are not easily predicted, although the geological and mining factors indicating the risk of such events can often be identified.
17. Outburst is the sudden ejection of gas, coal and sometimes rock from a solid coal face into mine workings. Outburst hazards include asphyxiation, burial and impact injuries, and damage to mine equipment and systems. Outburst is a risk in certain mining situations where coal seams have a high gas content and low permeability. Structures in the coal seam, such as faulting, may increase the potential for outburst where they change gas migration or the gas drainage characteristics of the coal. Assessing the outburst risk for a coal seam requires collection, testing and analysis of gas data from core samples, and relating the results to other coal seams where outbursts have occurred. The use of such data for safety planning cannot be overstated. Management of the hazard typically involves pre-draining the coal, before mining begins, to reduce its methane content to below an identified critical gas content amount (m<sup>3</sup>/tonne).<sup>6</sup>

#### Pre-drainage

18. Pre-drainage of gas ahead of mining is done by drilling boreholes into the coal seam. Drilling can occur from the surface or within the seam from underground drill rigs.
19. Horizontal in-seam drilling for pre-drainage involves the drilling of boreholes from underground roadways into future mining areas. Moderate to high natural coal seam permeability is required to ensure significant decay of gas content over a reasonable period of time. A standpipe is installed at the collar of the borehole and connected to a

pipeline that removes the captured gas from the area. Problems with this method can include high water emissions pressurising the pipeline, borehole instability and directional control of drilling. Additional hazards are created if actively draining boreholes are later intersected by mining operations.

20. Coal permeability directly affects the time needed to drain gas to the required average gas content value. The lower the coal's permeability, the more time is necessary. The ultimate feasibility of pre-drainage depends on the available time for degassing the coal before mining and the cost of the drilling operation.
21. Modern directional in-seam drilling techniques and patterns can maximise the amount of gas removed from the seam. Patterns designed for pre-drainage purposes typically involve multiple boreholes about 20–30m apart drilled from one location in a fan, or parallel, orientation, and in a formation to ensure minimal intersection by future mine workings. Boreholes are designed to target the gas and drain the coal, with a sufficient lead time, typically more than six months, before there is intersection by mining.<sup>7</sup>
22. The flow rate of gas from a gas drainage borehole will vary with time. High initial flow occurs from the expansion and desorption of gas in the immediate vicinity of the hole. This may diminish fairly rapidly but then increase again as the surrounding strata are dewatered, which increases the relative permeability of the coal and also the flow of gas. This in turn is followed by further decay as the area of influence is depleted of gas.<sup>8</sup> Structures in the surrounding strata, including faulting, can also affect gas emission and flow rates.
23. From a strictly regulatory perspective, only enough gas needs to be captured to ensure that a mine's ventilation system can adequately dilute the methane to a level below the permitted maximum. However, methane drainage also affects productivity, since the capacity of the ventilation system and the efficiency of a mine's methane drainage system will determine the maximum rate of coal extraction that can be safely achieved from a gassy coal face.
24. Introducing a gas drainage system, or increasing its effectiveness, is often cheaper than increasing ventilation air volumes. Investment in 'good practice' gas drainage systems therefore results in less downtime from gas emission problems, safer mining environments and the opportunity to reduce emissions and use more gas, which may have financial benefits under emissions trading schemes.

#### The need for gas data

25. Pre-planning of methane drainage is critical, and the design of gas drainage and ventilation systems to ensure safe mining requires knowledge of the amount of gas adsorbed in the coal (the gas content). Coal seam methane contents typically range from trace levels up to around 30m<sup>3</sup>/t.
26. To assess gas content (which should not be confused with specific emissions),<sup>9</sup> core samples are taken from the coal seam, sealed in canisters in as fresh a state as possible, and maintained at near reservoir temperature while gas is allowed to desorb. The measured release rate allows estimation of the quantity of gas lost before sampling, and the gas remaining in the coal is also measured, by crushing the coal and measuring the amount released. An overall gas content assessment can then be made. The composition of the gas can also be established by chemical analysis.

#### Design of a gas drainage system

27. The design of a methane drainage system should reflect the maximum expected gas flows from all sources in the mine. The system must ensure that gas in the drainage pipeline is not diluted to less than 30% methane in air, safely above the explosive range. That requires quality borehole sealing, including proper installation of standpipes, the systematic regulation of individual boreholes and suction pressure from the surface to assist with the flow of gas from the holes and through the pipeline, if assistance is required. Water also needs to be controlled in the system to prevent pressure build-ups.
28. Underground drainage pipe systems are vulnerable to damage from mining equipment, blasting activities, strata movement and roof collapse. The drainage system should be designed to minimise these risks.

### Monitoring of drainage systems

29. Gas drainage systems require continuous monitoring and management to determine effectiveness and performance. Mixture, gas flow and concentration, gauge pressure and temperature should all be monitored, with measurements made of individual boreholes, the gas drainage pipework and at the surface. Changes in barometric pressure affect gas flows and should also be recorded to assist in standardisation of flow data. The data obtained from monitoring these parameters is essential for safety planning.
30. Modelling of gas emissions can provide predictive information on the effects of increased coal production rates on gas flows. Modelling can also forecast the maximum controllable gas flow and the associated maximum coal production rate, depending upon methane limits and ventilation quantities.<sup>10</sup>

## The need for pre-drainage at Pike River

### Methane content of the seam

31. When Japanese company Mitsui Mining Engineering Co. Ltd carried out drilling at Pike River in 1993, methane was 'bubbling out' of drillholes close to the fault,<sup>11</sup> and reports from a series of consultants between 2000 and 2010 described Pike River's gas content levels as moderate to high.<sup>12</sup> Pike technical services co-ordinator Gregory Borichevsky described the mine as 'very gassy' because areas being mined were bounded by faults that had isolated blocks of coal. In these areas the coal had not been exposed to atmospheric pressure and gas remained adsorbed within the seam until intersected by mining activity.<sup>13</sup> In Masaoki Nishioka's experience, high methane emission was generally to be expected near faulting in coal seams.<sup>14</sup>
32. The company's knowledge of the gas content levels within the coal seams was limited because of the relatively small number and wide spacing of vertical drillholes from the surface. Core sampling of vertical drillholes for gas content analysis began in 1999, and gas content results were available from 18 of the 33 surface holes drilled before the explosion (PRDH8 to PRDH40). These showed methane gas content levels varying from 1 m<sup>3</sup>/t to 10 m<sup>3</sup>/t, with the higher levels recorded close to the Hawera Fault.<sup>15</sup>
33. The company's knowledge did not improve to any significant degree once in-seam drilling began, as discussed further below. Few of the horizontal in-seam boreholes had core samples taken for gas content testing.<sup>16</sup> The day before the explosion Pike received gas content results from sampling of its most recent borehole, GBH019,<sup>17</sup> ranging between 2.80m<sup>3</sup>/t to 5.32m<sup>3</sup>/t.<sup>18</sup> After the explosion Pike advised Queensland's Safety in Mines Testing and Research Station (SIMTARS) that the mine's coal seam gas content before drainage was approximately 8m<sup>3</sup>/t.<sup>19</sup>

### Advice on the need for pre-drainage

34. In 2006 Pike was informed that the high (but variable) permeability and porosity of the Brunner seam meant gas control 'will not be able to be accomplished by ventilation means alone.'<sup>20</sup> Minarco Asia Pacific Pty Ltd recommended pre-drainage in areas of the mine, particularly to the north and for the initial development inbye from the stone drive.<sup>21</sup> Minarco also recommended flanking boreholes in advance of development, and suggested the extent of pre-drainage required should be confirmed by further modelling of the gas reservoir. Investigation into likely emission rates was 'essential', and regular gas surveys were necessary particularly during the first period of development.<sup>22</sup>

### Pike's intended approach

35. Pike intended to use pre-drainage to reduce methane gas content in the Brunner seam before mining. General manager Peter Whittall described Pike's intended approach in a paper presented to a coal operators' conference in 2006:

*Recent sampling has determined a seam gas content of 7.0-7.5 m<sup>3</sup>/t at the proposed seam entry location. This is at a depth of 85 m. This gas content is considered to be difficult to control by ventilation means alone and in seam gas capture (pre-drainage) will be used as part of the roadway development process. PRCL*

will aim to reduce seam gas to  $<3\text{m}^3/\text{t}$  prior to mining, however where insufficient lead-time is possible, a maximum content of  $6.5\text{m}^3/\text{t}$  will be sought so as not to pollute the intake airways with rib emissions. In thick seam mining a more significant impact is content per square metre as the whole seam is removed during hydraulic extraction and the gas is liberated to the return airways.<sup>23</sup>

## In-seam drilling at Pike River

### Purpose

36. Pike intended to supplement its limited geological knowledge from surface drillholes by the use of in-seam directional drilling for geological exploration.<sup>24</sup>
37. The delays that plagued the initial development of the mine infrastructure, and the resulting pressures to produce coal, meant that all the in-seam boreholes drilled up to the time of the explosion were designed for exploration of the seam, rather than for the systematic reduction of methane gas content.<sup>25</sup>
38. Some long boreholes, over 2000m with multiple branches, were drilled to delineate the seam. Although these holes would have provided some reduction in seam gas content in the areas drilled,<sup>26</sup> coverage was neither wide nor systematic and methane drainage was incidental. The boreholes did not serve to reduce methane gas content in the hydro panel down to Pike's planned  $< 3\text{m}^3/\text{t}$  levels.

### Valley Longwall International

39. In 2008 Pike contracted VLI Drilling Pty Ltd (VLI) to provide in-seam drilling services. The contract required VLI to drill directional in-seam boreholes with branches to the roof and floor of the coal seam to Pike's specifications, take core samples from the boreholes when requested, provide and maintain the specialist equipment and provide trained drillers and fitters/offsiders.<sup>27</sup> The contract was managed by geologist Jimmy Cory from Pike's technical services department.
40. VLI's crews generally comprised an experienced driller and at least one offsider. VLI had its own health and safety management documentation system relating to the contracted tasks, which it provided to Pike.<sup>28</sup> Site-specific documents were also created and VLI staff participated with Pike staff in a risk assessment on 14 November 2008 into the hazards arising from the drilling operations.<sup>29</sup>

### The drilling method used at Pike River

41. The directional drilling equipment used by VLI comprised an electro-hydraulic drill rig and a drill string, consisting of a down-hole motor and rotating drill bit, drill rods and an electronic drill guidance system.<sup>30</sup> The drill rig, shown below, was fitted with a gas monitor that alarmed at 1% methane and cut power to the rig when the sensor detected 1.25% methane.



Figure 9.1: Track-mounted Boart Longyear LMC75 drill rig<sup>31</sup>



42. The drilling method involved orientation of the down-hole motor (a 3m rod) to aim the slight bend in the tool towards the desired drilling direction. The down-hole motor (driven by a supply of water intensified by a pump on the rig) was fed in and out of the hole and rotated (to change orientation) using the rig's hydraulics. The electronic guidance survey tool (also approximately 3m long) relayed information back to a receiver unit with the driller, and was separated from steel rods by a copper rod to ensure no magnetic interference. The driller operated the drill rig, spinning rods onto the drill string and using a rotation unit to push the rods, the survey tool, the down-hole motor and the resulting hole to the required distance.<sup>32</sup>
43. The photographs below show the drill bit, down-hole motor and assembly, and a close up of the rotating drill bit with high-pressure water forced through the assembly to provide rotation and torque to the bit.



**Figure 9.2: Bit, down-hole motor and assembly<sup>33</sup>**



**Figure 9.3: Rotating drill bit with high-pressure water<sup>34</sup>**

44. At Pike River, roof touches or coal seam roof intersections (branches) were drilled as a hole proceeded forward, normally at 40m intervals depending upon structural complexity in the area. When the borehole reached the planned limit, the drill string was progressively withdrawn and branches drilled down to the floor of the coal seam.<sup>35</sup>
45. The directional guidance system controlled the borehole trajectory, which was pre-planned using 3D modelling software, guided by the geological model of the seam. Real-time survey information was obtained at 6m intervals and combined with logs kept by the drillers, enabling accurate mapping of the coal seam.<sup>36</sup>



### Installation of gas riser and pipeline

46. A risk assessment into in-seam drilling involving VLI and Pike staff and held in November 2008, before drilling began, identified the need for a 'gas discharge solution'. Three options were assessed,<sup>37</sup> and Pike adopted the second, installing a gas drainage system during December 2008 and January 2009.<sup>38</sup>
47. Pike installed a 6" gas riser into an existing cased vertical drillhole, PRDH36, which was located close to the first VLI drill stub. A 4" fire-resistant anti-static (FRAS) pipeline (range) was connected to the three standpipes in place in the drill stub. Pike installed a flame arrestor on the surface for safety reasons,<sup>39</sup> but no pump or suction arrangement to assist with gas flow through the range.
48. Mr Cory prepared a memorandum to staff on the procedures required for underground connection of the gas drainage line and the necessity for water traps to be drained regularly. He also suggested that the engineering department start a maintenance schedule for the surface flame arrestor.<sup>40</sup> Many of these procedures were not followed consistently.<sup>41</sup>

### Management of gas at the drill face

49. VLI established a gas management system at its drill sites in accordance with its own standard procedures, which included:
  - drilling through a standpipe – a gland driven into the wall face and grouted into position as a permanent access point to the borehole;
  - using valves connected to the standpipe to divert the flow of water and/or gas while drilling, and contain or divert the water and/or gas after drilling;
  - using a stuffing box, which prevents gas or water from the borehole from entering the mine's atmosphere, enabling it to be diverted to a gas/water separator; and
  - using a gas/water separator to assist with managing the flow of gas from the borehole and directing it through a T-piece into the mine's gas drainage line, or free venting the gas into the return ventilation system, in accordance with Pike's instructions.<sup>42</sup>

### Initial in-seam boreholes

50. Boreholes were assigned individual identifiers, from GBH (geological borehole) 001 up to GBH019 by the time of the explosion.
51. In-seam drilling began at Pike River in December 2008 from a drill stub in pit bottom, aimed at development around that area. The second in-seam borehole intersected the large stone graben (a down-thrust block of strata bordered by parallel faults), estimated at up to 220m wide in places, the significance of which Pike was unaware from its earlier geological exploration. By the time Pike got through the graben the focus was on roadway development and the ability to pre-drain the coal seam was limited.<sup>43</sup>
52. No core samples for coal seam gas desorption testing could be taken from the first few in-seam boreholes, as the drilling method and the size of the graben meant samples would have a 'coal to canister' time exceeding one hour, giving unreliable results.<sup>44</sup>

### The slimline shaft

53. The collapse of the ventilation shaft on 2 February 2009 severely limited mine ventilation. To recover air capacity, Pike drilled the slimline shaft from the same surface drill pad location it had recently used to install the gas drainage system. Figure 9.4 below shows the gas riser (yellow) with flame arrestors, and the brown pipe is connected to the top of the slimline fresh air shaft.



**Figure 9.4: Gas riser and slimline shaft<sup>45</sup>**

54. The bottom of the 6" riser is shown below connected to the 4" gas drainage line labelled in yellow, at the entrance to what became the fresh air base (FAB) in mid-2010.<sup>46</sup>



**Figure 9.5: Bottom of gas riser at entrance to the FAB**

55. To drill the slimline shaft the flame arrestors at the surface had to be disassembled and removed and the gas drainage line temporarily decommissioned, which resulted in suspension of the drilling programme. VLI's crews left Pike and returned to Australia.
56. The three active boreholes were temporarily closed at the collar, and boreholes GBH001 and GBH002 were soon intersected by development and became inactive for gas flow monitoring.<sup>47</sup>

#### **Commencement of drilling and extension of the drainage pipeline**

57. VLI returned to Pike River in May 2009 and continued the drilling programme, completing GBH003 and drilling six more holes by the end of 2009.<sup>48</sup>
58. Very limited gas flow data was obtained from these boreholes. Three were quickly intersected by roadway development and only initial flow measurements were taken,<sup>49</sup> and no gas flow measurements could be taken from the other three.<sup>50</sup> Nor were core samples obtained during the drilling of any of these holes to permit gas content analysis.
59. In October 2009 the gas drainage range was modified and extended by the installation of a 4" Victaulic pipeline dedicated to the in-seam drilling programme, and installation of a water trap at the riser.<sup>51</sup> The pipeline continued to extend as new borehole drilling locations were established.<sup>52</sup>

60. Four more boreholes were drilled between December 2009 and March 2010 and connected to the gas drainage line.<sup>53</sup> All had initial high gas and water makes, but subsequent gas flow measurement was hampered by those factors and by poor management of the drainage line.

## Problems with Pike River's gas drainage system

### System at full capacity

61. By April 2010 the gas drainage line was at full capacity. High water capture in recent boreholes, and ineffective dewatering of the drainage line and at the drill rig,<sup>54</sup> resulted in resistance and regular flooding of the line, impeding the drainage of gas from the holes and making the system ineffective and highly pressurised. Accurate measurement of gas flows was impossible.

### Warnings from workers

62. On eight occasions in March 2010 Pike deputies completed statutory reports noting their concerns with the overpressurised gas drainage system.<sup>55</sup> VLI's drilling co-ordinator Gary Campbell also voiced his concern that the gas drainage system was inadequate for the gas make, which was affecting their ability to continue drilling some holes.<sup>56</sup>
63. On 11 April 2010 Brian Wishart, an experienced underviewer, sent this email to Mr Cory:

Attention Jimmy Cory

General Concerns Methane drainage system PRCL 11/4/2010

I would like to bring to your attention again the inadequacy of our Methane Drainage system.

1 – The running of a gas drainage system in intake airways is of concern to me as any trouble that we have with water traps, which is very regularly causes methane to vent into our intake roadways this scenario would not happen in NSW or QLD as this kind of arrangement would not get past a risk assessment process and would not be allowed, we should also not allow this practice.

2 – The positioning of this system in 3ct also leaves it venerable to damage from jugos ect.

3 – We now also have a fresh air base with a methane riser in the middle of it.

4 – Over the weekend we had to reposition a water trap at the FAB as it was installed in such a way that the FAB door could not be dropped down in an emergency?

5 – On numerous occasions I have found methane free venting in the old drill stub, while we are drilling there is so much pressure in the line that this stub does not actually discharge any methane into the system.

6 – Water traps are continuously filling with water at a rate faster that they can be drained.

7 – The first trap in the line is that inundated with water while drilling that the trap tube is by bull hose draining straight into the flumes which also surges gas into the return.

8 – "There is a definite problem when we are pushing water up the riser".

9 – This is all due to the line being too small for the sheer volume of methane we are trying to force downhill then up the riser.

10 – My list goes on... but by now I'm sure you get the picture.

It is my opinion that the VLW drill program should be suspended until the line is renewed with larger pipes installed out of the intake. I am well aware of the pressures we are under as a company but this should not be the pressure that possibly one day causes us a serious incident.

Last night the surges in the system were so violent that I was concerned it could blow of the rubber pipe which connects to the trap in the 3/B intake position. This would be very dangerous, if this happened with nobody in the vicinity to close the valve at macdow cribo which is not easily accessible we would have full flow methane directly into the intake and in turn across macdow headings I'm sure with that flow the methane would be in the 5 – 15% range with plenty of Oxy not a nice scenario.

Just to bring to your attention the suspected findings of the American pit that recently exploded was centered around an inadequate methane drainage system.

History has shown us in the mining industry that methane when given the write environment will show us no mercy. It is my opinion that it is time we took our methane drainage here at PRCL more seriously and redesigned our entire system.

Regards

Brian Wishart

Figure 9.6: Email from Brian Wishart to Jimmy Cory<sup>57</sup>

64. Some issues with the system were already known,<sup>58</sup> but this email provoked an immediate response.<sup>59</sup> Mr Cory showed it to Pieter van Rooyen, who took it to the next production meeting where 'various actions' were discussed.<sup>60</sup> Short-term remedies were implemented, and Pike engaged an Australian gas drainage consultant, Miles Brown of Drive Mining Pty Ltd.<sup>61</sup>

### Insufficient planning and design

65. At the time it was installed Mr Whittall 'fully expected' that the 4" pipeline would eventually become inadequate, but the small diameter pipeline was chosen because 'it was easiest to start with'.<sup>62</sup>
66. In these circumstances, close management of the pipeline and monitoring of gas concentrations, pressure and flow was essential. Yet no manual measurement or monitoring processes were established when the system was installed, and commonly used sensors (measuring real-time flow and pressure and reporting to the control room) were not installed on the system.<sup>63</sup>
67. Pike's gas drainage system was designed with insufficient information on gas flows or the mine's future drainage requirements. David Reece considered that the gas drainage system was clearly inadequate for the methane levels predicted and experienced.<sup>64</sup>

### Location of pipework and gas riser

68. Gas drainage pipelines carrying high-purity methane under pressure should be located in a mine's return airway to minimise the risk of damage from blasting and mining equipment.
69. At the time of the explosion, the whole pipeline ran downhill to the riser, working against the natural inclination of methane to rise.<sup>65</sup> Significant pressure was required to force the gas along the 4" pipeline and to the top of the riser, and the pressure peaked at the highest point on the pipeline, at the drill stub. This led to difficulties for the drilling crews in managing water and gas from boreholes.<sup>66</sup>
70. The pipeline was installed primarily in the return airways leading from connected boreholes outbye to the riser (as shown below in green), but it also ran for about 100m in the intake airway (shown in pink) from the overcast near the underground fan through Spaghetti Junction before turning left and then right to the gas riser located at the entrance to the slimline shaft/FAB. This created a significant hazard.

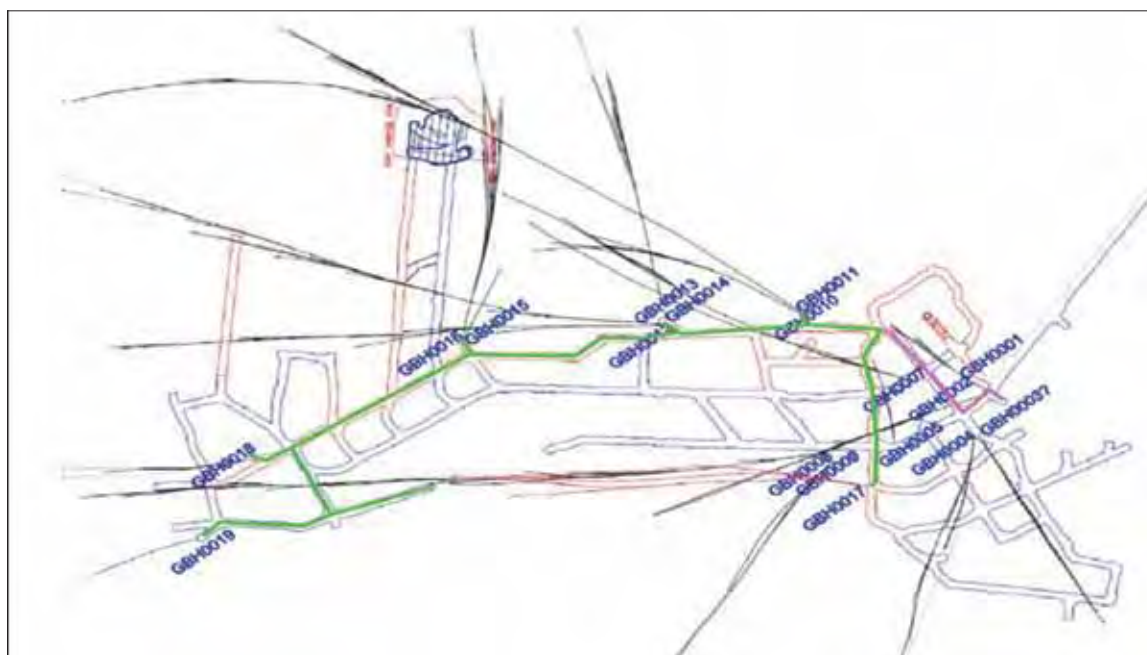


Figure 9.7: Gas drainage line and in-seam boreholes<sup>67</sup>



71. During a risk assessment into the operation of the ventilation fans held on 14 October 2010, an action plan recorded the need to move the methane drainage lines into a better area, away from the methane sensor at the main fan motor.<sup>68</sup> This had not occurred by 19 November 2010.
72. Staff from the technical services department disagreed with the decision to establish an FAB near the gas drainage line and riser, but the design decision was not theirs.<sup>69</sup> Mr Reece also criticised the decision:

*you wouldn't have something of a hazardous nature like that in that sort of a location, you'd want to keep them significantly separated. ... A different roadway, you wouldn't have them anywhere near each other.*<sup>70</sup>

### The intersection of boreholes

73. Also not ideal was the frequent intersection of boreholes by the mining process. Intersections create a risk of frictional ignitions and the potential for release of large volumes of gas at the face. Intersections also reduce the effectiveness of gas drainage since boreholes must have a pipe connection to the drainage line to remain useful for that purpose.<sup>71</sup>
74. A safe operating procedure for borehole intersection was in place,<sup>72</sup> but it appears the procedures were not necessarily followed.<sup>73</sup> Pike commissioned a review and received expert advice in July 2010 on changes required to its safe operating procedure.<sup>74</sup>
75. A more structured approach to advising operational crews about upcoming intersections, via borehole warning zones marked on permits to mine,<sup>75</sup> was implemented but crews sometimes remained unaware of imminent intersections with gas boreholes. An example occurred in August 2010 when the ABM crew mined 3m past the indicated 'stop' point in the permit to mine for the intake in panel 1, intersecting in-seam boreholes and with the roof strata unsupported.<sup>76</sup>
76. Intersections with boreholes sometimes occurred shortly after the holes were drilled.<sup>77</sup> This meant little time for reduction of methane levels in the area drilled, and did not allow the technical services department to obtain gas flow and content data from the holes for planning purposes.
77. Pike's accident and incident reports show gas drainage issues were reported by workers. For example in August 2010 a butterfly valve was found partially open, which allowed flammable gas to enter the fresh air intake. In July 2010 a worker found a borehole hose that was incorrectly connected. In February 2010 there was back pressure in the gas drainage range. In August 2009 there was a report that:

*The gas drainage holes in C/2-1 stub are all in floor & branching into multiple holes. This is making it very dangerous & hard to try & plug these holes which are producing large amounts of methane. To try & plug these holes requires people to be working in an explosive/very high CH<sub>4</sub> atmosph [sic]. Tech Services need to plan these holes & intersecting points better to avoid repeats of this situation.*<sup>78</sup>

78. Vehicle collisions were sometimes reported. For example in July 2009 a buried gas pipe was hit by mistake, puncturing it and releasing methane into the workings. Also in July 2009 a worker was:
- using the roadheader to trim corner for vale fan the head caught some rib mesh pulling it down along with the gas drainage hose cutting it, releasing gas and water from the drainage line, 3-4% CH<sub>4</sub>.*<sup>79</sup>
79. Causes identified in the reports include not following procedure, lack of knowledge and training, lack of skill or experience, congestion and substandard work practices.<sup>80</sup>

## Expert advice on gas drainage

### Drive Mining Pty Ltd

80. New South Wales mining engineer Miles Brown,<sup>81</sup> engaged to advise Pike on its gas drainage system,<sup>82</sup> conducted three site visits in 2010, each involving underground inspections and consultation with staff from the technical

services department. He gave Mr Cory training, including on gas flow measurement, and provided lengthy technical reports supplemented by email advice when required.

81. Mr Brown requested information on Pike's gas reservoir before he arrived. No gas content data was available as up until then Pike had not taken any core samples during its in-seam drilling programme.<sup>83</sup>

#### Miles Brown's first site visit

82. When Mr Brown visited Pike River on 28–29 April 2010 he found Pike's drainage system under significant pressure and inadequate for the gas flows experienced from the thick Brunner seam. There was inadequate maintenance of the pipeline and no method for measuring gas flows. Mr Brown recommended the VLI drillers not to force any further gas into the pressurised pipeline, to reduce the risk of gas emissions around their drill site.
83. Mr Brown suggested the design of flanking drainage holes as a minimum for all development headings, including the proposed hydro bridging panels, and gas content core sampling at 200m spacing. A lack of data meant he was unable to properly design a gas drainage system and had to make assumptions about the gas reservoir. He provided a gas drainage schedule for Pike, noting:

*This schedule highlights the fact that draining such a thick seam without a large lead time or enough data to quantify an accurate decay curve leads to the conclusion that if there is 8 m<sup>3</sup>/t of gas then development rates will be affected. The solution will be to gain more knowledge quickly and if high levels of gas are found introduce a smaller spacing of drainage holes. This will increase costs, however will assist with increasing development rates.<sup>84</sup>*

84. Mr Brown advised Pike to improve its gas drainage system by:
- installing a new gas riser inbye of current development within three months, with a minimum 10" internal diameter to service the current and future drainage needs; and
  - upgrading all current and future underground drainage pipes to 10" pipes to lower frictional resistance and pipeline pressure, increase drainage capacity and water control, and improve the ability to maintain the system.
85. Mr Brown also urged an assessment of the outburst risk of the Brunner seam, and cautioned that if the gas content was 'confirmed above 8m<sup>3</sup>/t or a GeoGas DRI of 900, then development should be stopped until a risk assessment for continuation has occurred'.<sup>85</sup> The DRI900 method has been universally accepted by the mining industry for determining outburst threshold limit values.<sup>86</sup>

86. Mr Brown described the need for data collection over the next three months as a 'key' recommendation:

*Gas Content Cores must be taken to not only allow the assessment of an area but to determine the drainage parameters. These core results also determine if the coal seam is liable to Outbursts. . . . Hole flow data assists in the determination of pipeline and riser design. This flow data along with virgin core results help create the decay curve for drainage which is the backbone of a drainage model. This allows for the development of hole spacing requirements.<sup>87</sup>*

87. Pike accepted that recommendation, noting 'no historical gas-flow data has ever been collected from in-seam drill-holes and the gas reservoir content is therefore unknown'.<sup>88</sup> Collection of gas flow data and information on the gas reservoir began in mid-June 2010 when Mr Cory began recording some weekly gas data measurements.<sup>89</sup> Pike took one core sample on completion of in-seam borehole GBH014,<sup>90</sup> but the sample was compromised and no gas desorption testing or analysis was possible.<sup>91</sup> From August 2010 Mr Cory began to measure and monitor essential flow data from all individual holes, after measuring sets were installed at the borehole standpipes and at the bottom of the 6" riser.<sup>92</sup>

#### Outburst management plan

88. Pike created a draft outburst management plan in July 2009, although no signed or final version was available to the commission.<sup>93</sup> It aimed to reduce and minimise the risks associated with outbursts in development panels by



draining in-seam gas content to below agreed threshold limits, and by implementing a system of measurement and risk assessment before authorisation of mining, via the permit to work process.<sup>94</sup>

89. Parts of the plan reflected Australian documents,<sup>95</sup> and had no relevance to Pike River.<sup>96</sup> Other parts were simply not followed or ignored in practice, for example:

*Prediction, in the form of comprehensive data acquisition and extensive in-seam drilling, and prevention by way of effective gas drainage coupled with gas flow monitoring, and regular core sampling so that the Mine Manager is always aware of the seam gas and structure environment into which the Mine is about to develop or extract, are the two prime components of The Plan. These form the input into the Authority to Mine process which, upon completion, will determine the mining methodology to be used to develop each roadway or sequence of roadways and extraction panels.<sup>97</sup>*

90. The plan also stated, as a basic operating principle, 'that no mining will take place when the gas content of the coal is above the established Outburst Threshold Level'.<sup>98</sup> A risk assessment into ventilation and gas monitoring on 7 September 2010 also recorded 'propensity testing' as an existing control of the outburst risk.<sup>99</sup>
91. The outburst threshold level for the Brunner seam was still unknown at the time of the explosion.

#### **Miles Brown's second site visit and Pike's decision to free vent methane**

92. Mr Brown returned to Pike River from 28 June to 1 July 2010. During his underground inspection he became concerned about the imminent uncontrolled intersection of GBH012, a highly pressurised borehole, by a development mining machine. After discussion, Douglas White made an operational decision to 'free vent' the borehole into the main return, by releasing gas directly into the mine atmosphere via a valve on the borehole standpipe. Free venting occurred over several days in a controlled manner and methane levels were kept within a target maximum of 1% in the main return. GBH012 was then intersected on 7 July 2010 with reduced gas make and limited impact on mining.<sup>100</sup>
93. Free venting released large quantities of methane and allowed Pike to 'make full use of the existing dilution capacity in the main returns to relieve this pressure on the gas drainage line and to actively manage gas from the Panel 1 area in advance of mining'.<sup>101</sup> This was a more attractive alternative than relying on an inadequate drainage system. In early July 2010 Pike decided to free vent all three boreholes in the hydro panel to the return before they were intersected by development of the panel headings, to avoid 'possibly days of lost development' while the holes were depressurised at the face.<sup>102</sup> Large quantities of methane were free vented from these holes,<sup>103</sup> and methane levels were closely monitored.<sup>104</sup>
94. Free venting became part of a new gas management strategy, although no formal procedure existed. In July 2010 the technical services department prepared a draft gas drainage management plan,<sup>105</sup> and issued operational advisory notices setting out the strategy.<sup>106</sup> Deputies, underviewers and surface controllers were to manage the process so the level of methane at the main fan remained below a maximum of 1.25%, with a target level of 1% in the return. Intersected boreholes required installation of standpipes and hosing into the return.
95. Mr Brown's second report, finalised on 22 July 2010 after discussions with Pike, recorded the continuing struggle to maintain the gas drainage system. Gas make was greater than the system's capacity, and the pressure at the bottom of the riser was considerably greater than the flow of gas up the riser.<sup>107</sup> Overall the system was highly restrictive.<sup>108</sup> Mr Brown made a number of short-term suggestions and advised Pike to plan for a suction unit on the upgraded system.
96. Mr Brown stated that beginning hydro extraction before the underground fan was commissioned would increase methane levels in the return and have a negative effect on the available ventilation. He doubted the desired extraction rates were achievable without an upgraded gas drainage line.<sup>109</sup>
97. Mr Brown calculated production scenarios, but noted a number of assumptions,<sup>110</sup> including the unknown effects of the surrounding strata on gas emission calculations for panel 1, and increased methane levels from the ABM20 development miner. Although his calculations indicated a more manageable situation once the main underground

fan was commissioned, he had 'major' concerns about predicted methane levels in the hydro panel return and advised that additional air would be required for panel 1.<sup>111</sup>

98. Mr Brown suggested replacing the 4" pipeline with a 12" diameter line, and that Pike use the slimline fresh air shaft as the gas riser until a new 12" riser could be drilled and installed inbye.<sup>112</sup> He urged Pike to start 'vital' weekly gas flow and emission measurements, and create a database to inform future gas flow estimations and for emissions trading legislative requirements.<sup>113</sup>
99. By this time three core samples had been taken from GBH16,<sup>114</sup> a borehole flanking the hydro panel. One worrying gas content result of 8.29m<sup>3</sup>/t fell just below the outburst threshold limit of 9m<sup>3</sup>/t identified for the Bulli coal seam in Australia. Mr Brown repeated his advice that additional gas cores must be taken from new boreholes drilled ahead of development, and cautioned:

*If ever the DRI900 limit is exceeded then development must not mine this area until drainage has occurred and a new core sample has been taken and found to be below this value. As Pike River is approaching outburst threshold limits additional drilling should be conducted to both drain the coal of gas but to [sic] understand the gas reservoir.*<sup>115</sup>

100. There was no additional in-seam drilling to reduce the gas content levels in panel 1, although one of Mr Brown's assumptions was pre-drainage down to 3m<sup>3</sup>/t in that area.

### **Mechanical Technology Ltd**

101. Pike also engaged mechanical engineer Chris Mann, of Mechanical Technology Ltd in Auckland, to report on gas utilisation options and to address Mr Brown's recommendations for upgrading the drainage line.<sup>116</sup> In his multi-purpose report to Pike in August 2010,<sup>117</sup> Mr Mann agreed that Pike's gas drainage system was inadequate for the gas levels experienced and required upgrading. He described Pike's gas flow measurements as 'rudimentary' and dismissed the mine's historic predictions of gas drainage flows of 300l/s, estimating peak flows of up to 1400l/s for the next 10 years as multiple panels were drained.<sup>118</sup>
102. The system's borehole pressure was high and Mr Mann suggested that, before the pipeline upgrade, Pike should install a temporary blower at the top of the gas riser to provide suction on the system. He estimated this would approximately double the flow of gas from the boreholes and through the pipes.<sup>119</sup> Mr Mann agreed that Pike should upgrade the current pipeline to a 12" diameter range, pre-drain the seam to a methane content of 2–3m<sup>3</sup>/t and install a temporary flare to flare gas out of the drainage system if that could be achieved safely.<sup>120</sup> He, too, suggested Pike consider using the slimline fresh air shaft as a temporary gas riser.

### **Miles Brown's third site visit**

103. Mr Brown made a third visit to Pike River from 13 to 17 September 2010. Panel 1 roadways were completed, equipment was being installed for the monitor panel and Pike was about to begin hydro extraction. There had been no upgrade of the gas drainage infrastructure, the underground fan had not been commissioned and free venting was still occurring. Lack of certainty in mine planning and the fact that inadequate gas data had not been obtained for a sufficient period of time meant Mr Brown could not provide a drilling design for pre-drainage. His third report dealt primarily with short-term tasks.<sup>121</sup>
104. Mr Brown found improved control of the gas drainage holes and no water in the pipeline as a result of Pike's better management of the system, although only three non-critical holes were connected and only approximately 40l/s of gas was flowing up the riser.<sup>122</sup>
105. Mr Cory was continuing with weekly gas drainage measurements and spreadsheets had been set up for recording data from each borehole.<sup>123</sup> Pike also planned, but had not yet begun, weekly gas emission measurements to identify where gas was being emitted and its effects on production.<sup>124</sup>
106. Mr Brown also suggested the VLI drilling crews required greater direction to manage the gas at their stubs in a more regimented way, as their next drill site was at the highest elevation yet and at the end of the pipeline range, so

would be the most pressurised. He suggested continued free venting to the ventilation system with connection to the pipe range once a hole was completed.

107. An outburst threshold value had still not been estimated. Mr Brown described core sampling as 'the single most important task' that needed to be regimented, as results were vital for estimating an outburst threshold rating, estimating gas hole flows and for the creation of a decay curve for the Brunner seam. This in turn would assist Pike in estimating pipeline and riser requirements for the future. He suggested 'all efforts' should be made to obtain a DRI900 level for safe mining.<sup>125</sup>
108. The evidence of further borehole core sampling provided to the commission is of samples taken from boreholes GBH018 in September 2010 and GBH019 in November 2010,<sup>126</sup> both located in the south-west corner of the workings as shown in Figure 9.7. Pike received results of gas desorption testing from those samples just before the explosion on 19 November, but no outburst threshold limit had been established.

## Pike's approach to methane management

### Insufficient pre-drainage of panel 1

109. The following diagrams show the proposed production area of the hydro panel, and the expected gas emission area for gas flows from the surrounding strata.<sup>127</sup> Long in-seam boreholes intersect the panel,<sup>128</sup> and faulting to the east of the panel is shown.

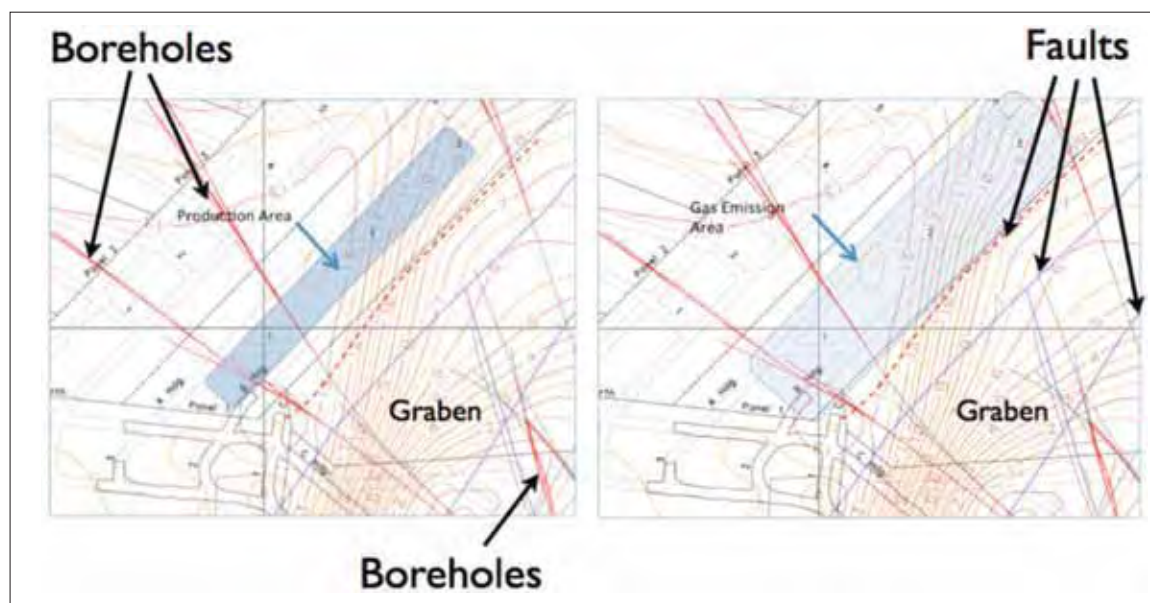


Figure 9.8: Panel 1 production area and panel 1 area of interest for gas emissions<sup>129</sup>

110. Borehole GBH016 was subsequently drilled 'flanking' the eastern boundary of panel 1, but no drainage holes were drilled within or to the west of the panel. GBH016 and the intersected boreholes were designed primarily for exploration of the seam, not for systematic pre-drainage of methane from the panel before mining.<sup>130</sup>
111. The gas content core sample result of 8.29m<sup>3</sup>/t from GBH016 underlined the need for further drainage of the area, particularly given the use of an untried hydro-extraction method in a thick seam with the likelihood of high methane release. However, coal extraction from panel 1 began without pre-draining the seam down to safer gas levels.

### The hazard of free venting

112. Free venting created an additional hazard by increasing the level of methane within the mine's return, removing (up to) a 1% buffer and putting pressure on the ventilation system. It required close monitoring and effective management.

113. In practice, free venting involved staff opening a borehole until gas levels in the return got to around 1%, which allowed sufficient capacity for 'little peaks' to go up to a maximum of 1.25%, 'with the idea being that they could go, always go and turn it back down again if they needed to'.<sup>131</sup>
114. Mr Borichevsky monitored gas levels and trends and reported these to the daily production meetings until the new production manager, Stephen Ellis, took over running the meetings about mid-September 2010. Messrs Borichevsky and Ellis gave conflicting evidence about the change of focus in the production meetings, but the daily review and reconciliation of gas levels and trends did not occur regularly from that point on.<sup>132</sup>
115. Although more air was available to the mine from October 2010, when the main underground fan came online, the ventilation system was almost immediately at capacity and at times struggled to cope with the high methane levels experienced from hydro and development mining.
116. Expert evidence before the commission was that the practice of free venting is only a 'stop-gap' measure and no longer a common or preferred practice for dealing with problem amounts of methane. Mr Reece described reliance on free venting as 'not done these days'.<sup>133</sup>
117. Pike had initially described free venting as an interim measure when dilution capacity in the return permitted,<sup>134</sup> until the (then imminent) drainage system upgrade. Given anticipated high methane levels, it was not expected to continue once hydro panel extraction began.<sup>135</sup> But the practice did continue up to the time of the explosion.

#### Deferral of the system upgrade

118. Mr Mann had investigated the scope and cost of upgrading the drainage system, and budgetary approval had been given to install a bigger pipeline and riser.
119. The technical services department considered it was impractical to upgrade the current 4" pipeline or the 6" riser in the existing locations. It also rejected the suggestion that the larger slimline fresh air shaft be used as a temporary gas riser, given the stub was, by then, designated as the FAB. Instead a location inbye to the north-west was identified as suitable for installation of a new larger gas riser, which would then be connected to a new 12" pipeline installed from that location to the active drill stubs. Roadway development to this location was estimated to be three months away.<sup>136</sup>
120. Mr van Rooyen explained that his department was concentrating on finding a longer term solution to Pike's problems, and installing a new larger capacity gas drainage system was part of that plan. Otherwise, 'trying just to solve a short term problem creates other problems that's not always foreseen when you try and solve the problem'.<sup>137</sup> Mr van Rooyen estimated installation of the new gas drainage infrastructure would have taken a further six months from the time he left Pike in early November 2010.<sup>138</sup> A temporary blower/pump arrangement on the surface to increase the flow of gas from the boreholes and through the pipes was not installed. Pike continued to extend the 4" pipeline to newly drilled in-seam boreholes.<sup>139</sup>

#### Failure to assess the risks

121. The free venting programme successfully reduced the hazard created by the overpressurised drainage line. Yet the effect was the release of large quantities of methane into the mine's returns, extending the duration and location of potentially explosive mixtures underground. High methane levels continued, particularly after panel 1 extraction began, but there is no evidence of a risk assessment of the free venting practice.
122. In August 2010 both Hawcroft Consulting International and Zurich Financial Services Australia Ltd,<sup>140</sup> during annual insurance assessments, noted the need for Pike to conduct a risk assessment of the methane hazard in the mine. Hawcroft recommended Pike should 'expedite' a risk assessment into gas and ventilation, and 'implement suitable measures to ensure the methane in the underground workings remains at management, risk free levels'.<sup>141</sup>
123. The 7 September 2010 risk assessment report into ventilation and gas monitoring assessed the hazard of 'gas drainage',<sup>142</sup> but made no mention of free venting. Some controls did not exist, or were ineffective in addressing the actual hazard. For example, the existence of a safe operating procedure for gas drainage was listed as an existing

control, although it was not finalised until 5 November 2010.<sup>143</sup> The risk of high methane levels from exploration holes in development headings referred to the 'specification of new drainage system' as an existing control,<sup>144</sup> but it did not exist. The assessment did not recognise the use of pre-drainage as a control measure to reduce in situ gas content to safer levels. Nor did it identify Pike's limited knowledge of the characteristics of its gas reservoir as a hazard in itself.

### Lack of oversight by the Department of Labour

124. Kevin Poynter, the DOL mines inspector dealing with the company in 2010, was unaware that Pike's gas drainage system was inadequate for the gas levels encountered. He did not know of the reliance on free venting or the lack of gas data, and he did not audit the systems Pike used to measure and monitor gas flow and emission rates. He acknowledged that the department did not know whether Pike's methane drainage system met health and safety standards.<sup>145</sup> The location of the gas riser at the FAB should also have been an issue of concern to the regulator.<sup>146</sup>

### The gas drainage system at November 2010

125. A few weeks before the explosion, VLI had begun drilling GBH019, and several in-seam boreholes were free venting to the mine's atmosphere. Problems with management of the gas drainage system continued with gas flow from borehole GBH018 backing up and restricted by the 4" pipe.<sup>147</sup> Les Tredinnick, McConnell Dowell's underground superintendent, advised Pike staff in October of a 'whistling' standpipe and methane being emitted through the stone floor in A heading in pit bottom north. This had not been addressed by 19 November 2010.<sup>148</sup>

126. The following graph prepared by the joint investigation expert panel<sup>149</sup> summarises the total daily methane volumes ( $\text{m}^3/\text{day}$ ) for the drainage system gas from July 2010 until the explosion. The red line depicts the volume of methane measured at the bottom of the gas riser, which decreases from the beginning of July when the practice of free venting began with GBH012 disconnected from the range. The blue line shows the volume of methane free vented to the mine's atmosphere for dilution by ventilation; and the grey line shows the total methane flow from all boreholes. These measurements began on 20 August 2010, the start of gas flow measurement from individual boreholes. The green line shows the total methane volume flowing into the range from September 2010 when weekly gas drainage measurements commenced.

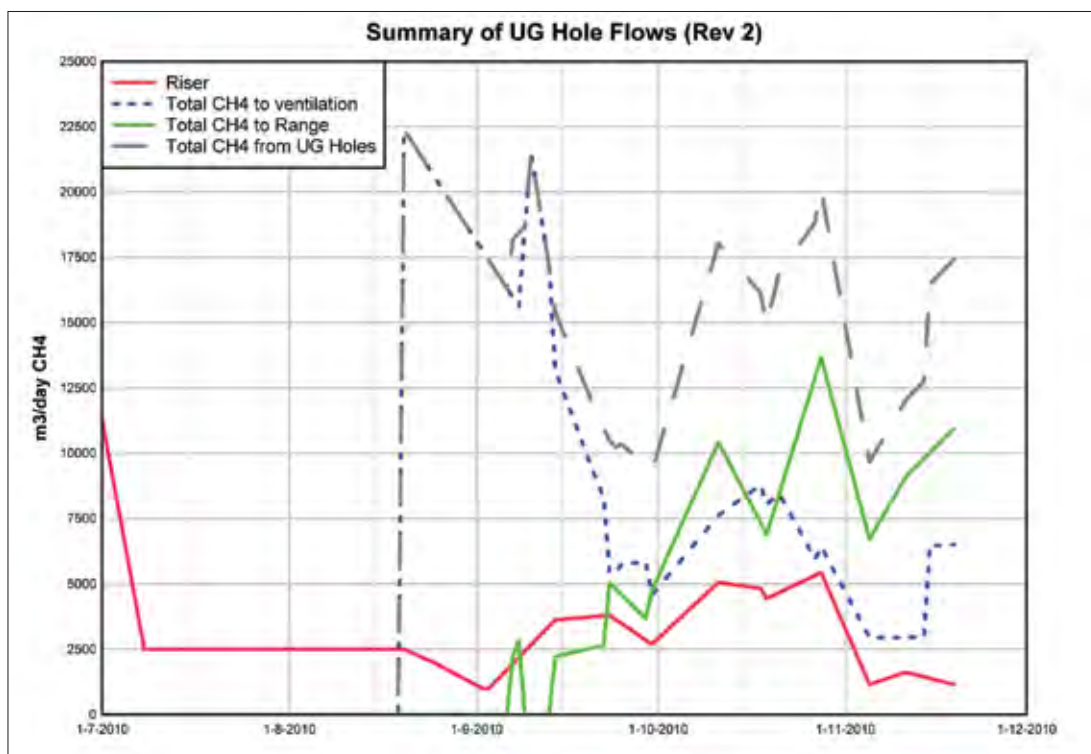


Figure 9.9: Graph summarising total daily drainage system gas flow measurements<sup>150</sup>



127. The noteworthy features are the high volume of methane free vented when compared to the volume of gas entering the range, and the difference between the volumes entering the range and reaching the bottom of the riser. For example, on the day of the explosion the measured gas flow into the range was 126.4l/s but only 13.3 l/s was measured at the gas riser. Such discrepancies dated back to the beginning of October. Various explanations for the difference have been suggested including leakage, methane back-feeding into other areas, a blockage in the range or incorrect measurements at the gas riser.<sup>151</sup>
128. As late as 27 October 2010, there was no accurate recording of methane emissions and no comprehensive system in place to capture, record and store all data permanently.<sup>152</sup>
129. The expert panel criticised Pike's gas management approach:

*Significantly, there was a lack of specific gas drilling design and implementation for adequate in situ gas reduction; a particularly inadequate gas drainage system with substandard pipeline dimensions and lack of evacuation (pumping); and little determination of in situ gas content (cores) linked with an authority to mine.*<sup>153</sup>

## Conclusions

130. The following key features marked the management of methane drainage at Pike River:
- In-seam drilling undertaken from December 2008 was designed to explore and delineate the coal seam. Pre-drainage of the coal seam was a secondary purpose of the drilling and was often prevented by intersection of boreholes before gas levels could decay.
  - A limited gas drainage system was installed in 2009 which, by early 2010, was inadequate to service the gas flows experienced from in-seam boreholes and was poorly managed. Management of the system improved, but the system capacity was not upgraded.
  - Free venting of methane into the mine return began in July 2010 to relieve pressure on the range in the interim, and continued to the time of the explosion.
  - Adequate gas data was not gathered until August 2010. Knowledge of the gas reservoir remained limited.
  - Gas management continued to be a problem into November 2010 even after the main fan improved the ventilation capacity.

## ENDNOTES

<sup>1</sup> Malcolm J. McPherson, *Subsurface Ventilation Engineering*, CAC0158/389, ch. 12.1.

<sup>2</sup> United Nations, Economic Commission for Europe, *Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines* (ECE Energy Series No. 31), 2010, [http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide\\_MethDrain\\_es31.pdf](http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf)

<sup>3</sup> Malcolm J. McPherson, *Subsurface Ventilation Engineering*, CAC0158/412, ch. 12.4.2.

<sup>4</sup> Ibid.

<sup>5</sup> Ibid., CAC0158/410, ch.12.4.1. The author suggests a range of methane migration from some 200m above to 100m below the working horizon.

<sup>6</sup> Volume of gas contained per mass of coal substance in situ.

<sup>7</sup> David Reece, transcript, pp. 4502–03.

<sup>8</sup> Malcolm J. McPherson, *Subsurface Ventilation Engineering*, CAC0158/421, ch. 12.5.1.

<sup>9</sup> Specific emissions represent the total volume of gas emitted per tonne of coal mined over any given period. Gas from all sources is measured, i.e. not just from the coal that is being extracted, but all the strata that is disturbed

and becomes relaxed as the void left by the mining process collapses.

<sup>10</sup> Modelling requires adequate data collection that includes seam gas contents, mechanical properties of the rock and coal strata, mining geometry and coal production rates.

<sup>11</sup> Masaoki Nishioka, transcript, p. 3481.

<sup>12</sup> AMC Resource Consultants Pty Ltd, *Pike River Coal Company Final Feasibility Study – Project Summary*, 23 June 2000, NZOG0007/10, 18; Minarco Asia Pacific Pty Ltd, *Pike River Coal Company – Ventilation Report*, June 2006, DAO.001.04505/5; Hawcroft Consulting International, *Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report*, July 2010, DAO.003.08710/60; Zurich Financial Services Australia Ltd, *Pike River Coal Ltd – Risk Assessment and Improvement Report*, 18 August 2010, INV.04.00868/15.

<sup>13</sup> Gregory Borichevsky, Police/DOL interview, 26 April 2011, INV.03.18954/7–8; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/9, para. 57.

<sup>14</sup> Masaoki Nishioka, transcript, p. 3481.

<sup>15</sup> Pike River Coal Ltd, *Summary Tables of Drillhole Gas Measurements*, June



2008, DAO.025.42433; CRL Energy Ltd, CSG Canister Desorption Results (PRDH037), 2009, DAO.025.36396.

<sup>16</sup> Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the In-seam Holes, 14 October 2010, DAO.025.44571/3.

<sup>17</sup> Shown in Figure 9.7.

<sup>18</sup> For example: CRL Energy Ltd, CSG Canister Desorption Results, 18 November 2010, DAO.025.34092, DAO.025.34090 and DAO.025.34094.

<sup>19</sup> Safety in Mines Testing and Research Station, Review of Gas Data Following Pike River Explosion on 19 November 2010 for New Zealand Police, 7 April 2011, SOE.001.00004/8.

<sup>20</sup> Minarco Asia Pacific Pty Ltd, Ventilation Report, June 2006, DAO.001.04505/27.

<sup>21</sup> Ibid., DAO.001.04505/27, 6.18. However as discussed below no pre-drainage of the area between the stone drive and the connection to the shaft occurred – Peter Whittall, transcript, pp. 878–79.

<sup>22</sup> Minarco Asia Pacific Pty Ltd, Ventilation Report, June 2006, DAO.001.04505/6, 15.

<sup>23</sup> P. Whittall, 'Pike River Coal – Hydraulic Mine Design on New Zealand's West Coast', in N. Aziz (Ed.), *Coal 2006: Coal Operators' Conference*, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2006, pp. 161.

<sup>24</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/39, para. 230.

<sup>25</sup> Ibid., PVR001/43, para. 253; P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine – An Essential Planning Tool', in AusIMM New Zealand Branch Annual Conference 2009, CAV0001/705.

<sup>26</sup> David Reece, witness statement, 2 February 2012, DOL3000150001/21, para. 92.

<sup>27</sup> David Carter, witness statement, 9 August 2011, VLI0001/4, paras 8–10.

<sup>28</sup> The documentation included risk assessments, critical work procedures, JSEAs and work method statements on its directional drilling procedures and for coring and gas testing from underground exploratory drillholes: Valley Longwall International Pty Ltd, Standard Work Method Statement, 15 August 2008, DAO.032.03294.

<sup>29</sup> Pike River Coal Ltd, Risk Assessment Report – In-seam Directional Drilling Provided by Valley Longwall Drilling, 14 November 2008, DAO.032.00244.

<sup>30</sup> P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine', CAV0001/710.

<sup>31</sup> Peter Whittall and Jimmy Cory, In-seam Directional Drilling at Pike River Coal Mine: An Essential Planning Tool – AusIMM conference – Queenstown, August 2009, DAO.007.25198/6.

<sup>32</sup> David Carter, witness statement, 9 August 2011, VLI0001/5, paras 16–22.

<sup>33</sup> Peter Whittall and Jimmy Cory, In-seam Directional Drilling at Pike River Coal Mine, DAO.007.25198/4.

<sup>34</sup> P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine', CAV0001/709.

<sup>35</sup> Ibid., CAV0001/710.

<sup>36</sup> Ibid.

<sup>37</sup> Pike River Coal Ltd, Risk Assessment Report, DAO.032.00244/11–12.

The first option was to 'utilise existing gas drainage pipeline', which was (described as a 4" polypipe non-FRAS pipe) installed as a control measure when Pike mined through the Hawera Fault. Further details of this pipeline are unknown from documentation filed with the commission.

<sup>38</sup> Memorandum, Jimmy Cory to Peter Whittall, 29 January 2009, DAO.003.16304; Memorandum, Jimmy Cory to Kobus Louw, 12 February 2009, DAO.003.16311.

<sup>39</sup> Petrus (Pieter) van Rooyen, transcript, p. 5229.

<sup>40</sup> Memorandum, Jimmy Cory to Kobus Louw, 12 February 2009, DAO.025.53172.

<sup>41</sup> John (Jimmy) Cory, witness statement, 18 June 2012, COR0001/12–13, paras 53–60.

<sup>42</sup> David Carter, witness statement, 9 August 2011, VLI0001/7, para. 33.

<sup>43</sup> Peter Whittall, transcript, p. 879.

<sup>44</sup> Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the Inseam Holes, 14 October 2010, DAO.025.44571/3.

<sup>45</sup> Photograph sourced from Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/5.

<sup>46</sup> Mechanical Technology Ltd, Pike River Coal – Methane Gas Drainage and Utilisation Concept Design Report, August 2010, MED0010070099/22.

<sup>47</sup> Pike River Coal Ltd, Monitor and Report, 14 October 2010, DAO.025.44571/5.

<sup>48</sup> Ibid., DAO.025.44571/6. Boreholes GBH04-05 and 07-10. There was no borehole labelled GBH006.

<sup>49</sup> Ibid. GBH003 (greater than 50l/s), GBH004 (greater than 50l/s), and GBH008 (135l/s)

<sup>50</sup> Ibid. No measurements could be taken from GBH005 (as the borehole was abandoned as the area was required for development), GBH007 (due to a recovery operation for drilling rods lost down the borehole), or GBH009 (which was grouted on completion to allow a drill and blast crew to develop a heading through stone).

<sup>51</sup> Memorandum, Jimmy Cory to Pieter van Rooyen, 21 October 2009, DAO.003.16400/2; Pike River Coal Ltd, Operations Report, 16 November 2009, DAO.019.00568/6; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/43, para. 257.

<sup>52</sup> Ibid., PVR001/40, para. 236.

<sup>53</sup> GBH010 to GBH013: Pike River Coal Ltd, Monitor and Report, 14 October 2010, DAO.025.44571/6–7.

<sup>54</sup> Ibid., DAO.025.44571/4.

<sup>55</sup> Simon Donaldson on 5 March (DAO.003.15146) and 6 March (DAO.003.15150), Stephen Wylie on 13 March (DAO.003.15197), Simon Donaldson on 14 March (DAO.003.15199), Boyd Molloy on 18 March (DAO.003.15215), Simon Donaldson on 22 March (DAO.003.15252), Russell Smith on 24 March (DAO.003.15261) and Simon Donaldson on 30 March (DAO.003.15304).

<sup>56</sup> Gary Campbell, Police/DOL interview, 13 January 2011, INV.03.08182/12–18.

<sup>57</sup> Email, Brian Wishart to Jimmy Cory, 11 April 2010, DAO.025.32975/1.

<sup>58</sup> Emails between Jimmy Cory and Lunagas Pty Ltd, 26 March 2010, INV.03.29639/3; John (Jimmy) Cory, witness statement, 18 June 2012, COR0001/20, para. 102.

<sup>59</sup> Ibid., COR0001/20, paras 97–100.

<sup>60</sup> Petrus (Pieter) van Rooyen, transcript, p. 5230.

<sup>61</sup> Pike River Coal Ltd, Operations Report, 19 April 2010, DAO.019.00616/7; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/44, paras 260–62.

<sup>62</sup> Peter Whittall, transcript, pp. 913, 910.

<sup>63</sup> David Reece, transcript, p. 4537.

<sup>64</sup> Ibid., p. 4536.

<sup>65</sup> Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/93, para. 3.5.1.

<sup>66</sup> Drive Mining Pty Ltd, Pike River Coal Ltd – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/9.

<sup>67</sup> Department of Labour, diagrams, DOL3000150025/1. (Diagram modified by the commission)

<sup>68</sup> Pike River Coal Ltd, Main and Standby Fans Operation and Control: Risk Assessment V2 (Draft Document), 14 October 2010, SOE.024.00333/11.

<sup>69</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/40–41, paras 239–42.

<sup>70</sup> David Reece, transcript, pp. 4542–43.

<sup>71</sup> David Reece, witness statement, 2 February 2012, DOL3000150001/21, para. 93.

<sup>72</sup> Pike River Coal Ltd, Mining Towards Boreholes not Fully Cemented: Safe Operating Procedure (Final Document), 6 January 2010, DAO.001.04188.

<sup>73</sup> Department of Labour, Investigation Report, DOL3000130010/90, para. 3.4.17.

<sup>74</sup> Memorandum, Jimmy Cory and Gregory Borichevsky to Peter Whittall, Pieter van Rooyen, Douglas White and Michael Lerch, 2 June 2010, DAO.003.16495/5; Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/21–22.

<sup>75</sup> Memorandum, James Wimbridge to Bernard Lambley, Brian Wishart, Lance McKenzie, Martin Palmer, Dean Jamieson, Jan Joubert and Peter O'Neil, 19 July 2010, DAO.003.16345; Pike River Coal Ltd, Risk Assessment – Intersection of In-seam Borehole GBH0008 along 1West CT AB6, 29 October 2010, DAO.025.34614.

- <sup>76</sup> Memorandum, James Wimbridge to Douglas White, Bernard Lambley and Grant MacLean, 17 August 2010, DAO.025.41497.
- <sup>77</sup> Gary Campbell, Police/DOL interview, 13 January 2011, INV.03.08182/18–19.
- <sup>78</sup> Simon Donaldson, Incident/Accident Form, 30 August 2009, DAO.002.09069/2.
- <sup>79</sup> D. Murphy, Incident/Accident Form, 31 July 2009, DAO.002.08933/2.
- <sup>80</sup> Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC 0115/10–20.
- <sup>81</sup> Mr Brown was interviewed during the joint investigation by DOL and the police, and also by counsel assisting the commission in 2011, but subsequently declined to sign a witness statement for the commission.
- <sup>82</sup> Email, Jimmy Cory to Miles Brown, 13 April 2010, DAO.001.05060/1.
- <sup>83</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/16.
- <sup>84</sup> Ibid., DAO.001.04811/8.
- <sup>85</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/17. GeoGAS DRI 900 is a method developed by GeoGAS Pty Ltd to define outburst threshold limits for coal seams other than the New South Wales Bulli seam. The method requires measuring the volume of gas emitted from a coal core sample after crushing for 30 seconds. The result is related to the total gas content of the full core sample in order to calculate a figure which, if above 900, indicates there is a risk of an outburst of coal and gas if a geological structure (such as faulting) is present.
- <sup>86</sup> D. Black, N. Aziz, M. Jurak and R. Florentin, 'Outburst Threshold Limits – Are They Appropriate?', in N. Aziz (ed.), Coal 2009: Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2009, pp. 185–92.
- <sup>87</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/17.
- <sup>88</sup> Memorandum, Jimmy Cory to Gregory Borichevsky, 24 May 2010, DAO.003.16501/2.
- <sup>89</sup> Email, Jimmy Cory to Miles Brown, 20 June 2010, DAO.001.05096/1.
- <sup>90</sup> Pike River Coal Ltd, Operations Meeting Minutes, 16 June 2010, DAO.002.14622/4.
- <sup>91</sup> Pike River Coal Ltd, Operations Meeting Minutes, 30 June 2010, DAO.002.14672/3.
- <sup>92</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/13; Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the In-seam Holes, 14 October 2010, DAO.025.44571.
- <sup>93</sup> Pike River Coal Ltd, Outburst Management Plan: Management Plan (Draft Document), 7 July 2009, DAO.003.06920.
- <sup>94</sup> Ibid., DAO.003.06920/4, 8.
- <sup>95</sup> For example see University of Wollongong's website on outburst hazards: <http://www.uow.edu.au/pdfs/OMP.pdf>
- <sup>96</sup> For example, the plan states that 'PRCL has a long history of mining the Bulli Seam' – a coal seam in New South Wales: DAO.003.06920/9,11, 37.
- <sup>97</sup> Ibid., DAO.003.06920/13.
- <sup>98</sup> Ibid., DAO.003.06920/12.
- <sup>99</sup> Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/4.
- <sup>100</sup> Memorandum, Gregory Borichevsky and Jimmy Cory to Pieter van Rooyen, 5 July 2010, DAO.001.04572/1–2.
- <sup>101</sup> Ibid., DAO.001.04572/1.
- <sup>102</sup> Ibid.
- <sup>103</sup> When the target level of 1% methane was achieved in the main return, daily methane volumes peaked at 67,514m<sup>3</sup> with typical daily volumes of 62,000 to 63,000m<sup>3</sup> from GBH012 and GBH013: Pike River Coal Ltd, Operational Advisory – Gas Drainage Management Plan – Panel 1 Degassing and Borehole Intersections, 27 July 2010, DAO.001.04566.
- <sup>104</sup> Gregory Borichevsky, notes, July 2010, INV.03.29202/9–18.
- <sup>105</sup> Pike River Coal Ltd, Gas Drainage Management Plan (Draft Document), undated, DAO.002.03631.
- <sup>106</sup> Memorandum – Operational Advisory, Gregory Borichevsky to Pike River operational staff, 8 July 2010, DAO.001.04569; Memorandum – Operational Advisory, Gregory Borichevsky to Pike River operational staff, 27 July 2010, DAO.001.04566.
- <sup>107</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/4.
- <sup>108</sup> Ibid., DAO.001.04909/8: The drainage system showed a flow of approximately 135l/s of methane, and the flame arrestors at the surface of the gas riser were highly resistant due to coal fines and water emitted through the drainage pipelines.
- <sup>109</sup> Ibid., DAO.001.04909/10–11.
- <sup>110</sup> Ibid., DAO.001.04909/10. Including a 20m-wide extraction panel and pre-drainage of the area down to a level of 3m<sup>3</sup>/t of methane, shown in a table.
- <sup>111</sup> Ibid., DAO.001.04909/10–11.
- <sup>112</sup> Ibid., DAO.001.04909/12.
- <sup>113</sup> Ibid., DAO.001.04909/23.
- <sup>114</sup> Pike River Coal Ltd, Q1 Sheet – GBH0016, 19 July 2010, DAO.025.34058; VLI Drilling Pty Ltd, Inseam Drillhole Report – GBH0016, 30 July 2010, DAO.025.45024/23.
- <sup>115</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/28.
- <sup>116</sup> Emails between Chris Mann, Gregory Borichevsky, Miles Brown and James Cory, 1–15 July 2010, DAO.001.05008.
- <sup>117</sup> Pike was interested in reducing its liability under New Zealand's Emissions Trading Scheme by capturing methane and converting it to carbon dioxide using a flare, and in future options for the generation of electricity. Mr Mann's report also addressed these options.
- <sup>118</sup> Based upon known flows from boreholes and an assumed decay curve prepared by Miles Brown: Mechanical Technology Ltd, Pike River Coal – Methane Gas Drainage and Utilisation: Concept Design Report, August 2010, MED0010070099/17–18.
- <sup>119</sup> Ibid., MED0010070099/23: He suggested the blower could be installed on the concrete pad at the current gas riser site subject to addressing safety issues with the flame arrestor.
- <sup>120</sup> Ibid., MED0010070099/16–25.
- <sup>121</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/3.
- <sup>122</sup> Ibid., DAO.012.02524/4: Mr Brown was concerned that connected borehole GBH008 appeared to be blocked at the intersection point, meaning the gas flow make may only have been from a newly drilled hole.
- <sup>123</sup> Ibid., DAO.012.02524/6.
- <sup>124</sup> Mr Brown suggested these should be taken from the same locations at which a ventilation survey had been recently conducted with Pike's ventilation consultant John Rowland.
- <sup>125</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/7, 11.
- <sup>126</sup> Pike River Coal Ltd, Q1 Sheet – GBH0018, 27 September 2010, DAO.025.34088; Q1 Lost Gas Desorption Sheets – GBH0019, 8–10 November 2010, DAO.025.34782/2–4.
- <sup>127</sup> The Rider and Papparao seams above and below the hydro panel may also contribute to the gas emissions.
- <sup>128</sup> Some of the in-seam boreholes are marked in red and black, used to represent drilling through coal and stone respectively.
- <sup>129</sup> Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/10. (Labels added by the commission)
- <sup>130</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/42, para. 253.
- <sup>131</sup> Gregory Borichevsky, Police/DOL interview, 7 June 2011, INV.03.20410/73.
- <sup>132</sup> Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/37, para. 257; Douglas White, transcript, pp. 4917–21; Petrus (Pieter) van Rooyen, transcript, p. 5215; Stephen Ellis, witness statement, 14 March 2012, DAO.041.00042/3–4.
- <sup>133</sup> David Reece, transcript, p. 4541.
- <sup>134</sup> Memorandum, Gregory Borichevsky and Jimmy Cory to Pieter van Rooyen, 5 July 2010, DAO.001.04572/1.
- <sup>135</sup> Pike River Coal Ltd, Gas Drainage Management Plan (draft document), DAO.002.03631/4. Although undated or signed off, it must have been created in early July 2010. See also: Hawcroft Consulting International, Pike River Mine

– Risk Survey, DAO.003.08710/57.

<sup>136</sup> Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/46, 50, paras 271, 294. Subsequently a design review based upon further geological information resulted in a change of direction and development to the west (towards the proposed location of the second intake, return and egress), and another location for the new riser was identified.

<sup>137</sup> Petrus (Pieter) van Rooyen, transcript, p. 5235.

<sup>138</sup> *Ibid.*, pp. 5233–35.

<sup>139</sup> Gregory Borichevsky, notes, 3 August 2010, INV.03.29202/19; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/35, para. 240.

<sup>140</sup> Zurich Financial Services Australia Ltd, Pike River Coal Ltd – Risk Assessment and Improvement Report, 18 August 2010, INV.04.00868/9.

<sup>141</sup> Hawcroft Consulting International, Pike River Mine – Risk Survey, DAO.003.08710/58.

<sup>142</sup> Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/11.

<sup>143</sup> Pike River Coal Ltd, Management of the Gas Drainage Line: Safe Operating Procedure (Draft), 5 November 2010, DAO.025.34471/3.

<sup>144</sup> Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/5.

<sup>145</sup> Kevin Poynter, transcript, pp. 3095–96.

<sup>146</sup> David Reece, transcript, p. 4543.

<sup>147</sup> Emails, Jimmy Cory to Miles Brown, 9 November 2010, DAO.001.05057/1.

<sup>148</sup> Leslie Tredinnick, Police/DOL interview, 15 December 2010, INV.03.03263/19–29, and map INV.03.03382.

<sup>149</sup> Keith Stewart, witness statement, 16 August 2012, MBIE3000010012; Email, Tim Harvey to Jane Birdsall, David Reece and Keith Stewart, 16 August 2012, MBIE3000010016.

<sup>150</sup> Graph, 16 August 2012, MBIE3000010017/1.

<sup>151</sup> David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/43, para. 9.3.

<sup>152</sup> Email, Gregory Borichevsky to Danie du Preez, Pieter van Rooyen and Jimmy Cory, 27 October 2010, INV.04.01375/1.

<sup>153</sup> David Cliff et al., Investigation for Nature and Cause, DOL3000130007/12, para. 6.1.

## Introduction

1. All underground coal mines require gas monitoring to detect and help prevent explosive accumulations of gas. There are three main forms of gas monitoring: remote gas monitoring systems, machine-mounted sensors and hand-held sensors.<sup>1</sup> The first two systems may be used to isolate or 'trip' electric power if the concentration of flammable gas exceeds safe levels.<sup>2</sup>

## Remote gas monitoring

2. Remote gas monitoring usually consists of tube bundle and/or real-time systems.<sup>3</sup> Industry practice in Australia is to have both in place, and in Queensland it is also standard to have a gas chromatograph at each mine.<sup>4</sup> A gas chromatograph provides the most comprehensive analysis of mine gases, and is particularly suited to manage spontaneous combustion events.<sup>5</sup>
3. Real-time or telemetric monitoring systems rely on underground electronic sensors that send a signal to the surface in real time. They provide rapid feedback to the control room about the underground conditions and are the best method for identifying a sudden event such as a methane plug or a fire. However, they require underground power, and the sensors must be located in underground conditions, which may be damp or dusty. The sensors tend to have limited measuring ranges; for example, methane can usually be detected only up to 5%. They are also prone to being 'poisoned', or shutting down when exposed to gas beyond their maximum level. They are not as useful as tube bundle systems for long-term trending or in oxygen depleted locations, and they require frequent recalibration. In addition, despite providing 'real-time' feedback, the signals are not instant. Energy New Zealand calculated the two systems at Pike River had lag times of up to 29 and 44 seconds each before results were reported to the control room.<sup>6</sup> There was also a lag time of eight to 13 seconds before power was tripped underground following a high gas reading.<sup>7</sup>
4. A tube bundle system uses plastic tubes that run from within the mine to the surface. A vacuum pump draws gas samples to the surface, where they are analysed for a range of gases – usually carbon monoxide, carbon dioxide, methane and oxygen. The advantages of a tube bundle system include the ability to measure several different gases from a single sample, the fact the system does not rely on underground power, and the ability to use more sensitive analysis equipment on the surface. A tube bundle system is also more likely to remain functional after an underground explosion. The surface analysis and pumping equipment should always survive, and if underground tubing is damaged, new tubes may be lowered into the mine and connected to the system. Because of its greater accuracy and flexibility, the system is ideally suited to long-term trending, as well as monitoring oxygen depleted goafs and sealed-off areas that are not suitable for real-time equipment. The main downside of a tube bundle system is the time taken to retrieve a sample from underground, which may be 20 minutes or more, depending on the distance the gas sample must travel. This delay is not relevant when monitoring trends.

### The Pike monitoring system as planned

5. Consistent with Australian practice, both the Minarco Asia Pacific Pty Ltd ventilation report in 2006 and the ventilation management plan in 2008 proposed real-time and tube bundle systems for Pike River.<sup>8</sup> Under the ventilation management plan, the real-time and tube bundle systems were to run continuously.<sup>9</sup> The ventilation engineer was to identify the location of all sampling points, and ensure these were marked on a plan,<sup>10</sup> establish

alarm levels for each sample point, and review them monthly after a ventilation survey.<sup>11</sup> Alarm levels were to be posted on a ventilation plan in the surface controller's room,<sup>12</sup> and surface controllers were to acknowledge and record all alarms and the actions taken to investigate them.<sup>13</sup> There was to be a trigger action response plan (TARP) setting out the mandatory responses to various alarm levels.<sup>14</sup> Finally, any interruption in the electronic monitoring system was to be remedied as soon as practicable, and any delay was to be drawn to the attention of the mine manager and ventilation engineer.<sup>15</sup> These procedures were appropriate, but they were not followed at Pike River.

### The Pike River remote gas monitoring system as built

6. Pike River had a real-time gas monitoring system, but not a tube bundle system. In the absence of a ventilation engineer, general manager Douglas White determined the location of the underground sensors for the real-time system.<sup>16</sup>
7. In June 2010 consultant electrical engineer Michael Donaldson recommended the locations for the sensors. It was a matter for the ventilation officer to determine the final locations.<sup>17</sup> Mr Donaldson's June 2010 plan had eight methane detectors, including two at the furthest inbye points in the mine as it existed at that time.<sup>18</sup>
8. Mr White said he sat down with Mr Donaldson approximately four or five weeks before the explosion to determine where the sensors would go.<sup>19</sup> However, as at 19 November 2010 there were no sensors beyond the ventilation shaft reporting to the surface from the return.
9. The ventilation management plan required the mine manager and ventilation engineer to sign and date accurate ventilation plans at least every three months. These were required to show all key features of the ventilation system, including the gas monitoring sample points, the restricted zone, the location of emergency escapeways, refuge bays and rescue facilities, boreholes and many other features. No accurate plan was ever produced at Pike showing all these features.
10. On 10 March 2010 the then mine manager, Michael Lerch, signed a ventilation plan and asked, 'Is this the ventilation plan as defined in vent management plan 5.3.1 (attached)?', 'Restricted zones?', 'Other information listed in 3.1 attached?'.<sup>20</sup> Over the following months no ventilation plan at Pike contained accurate records of the required matters. All pre-explosion plans were incomplete or inaccurate to varying degrees, and none provided an accurate record of the gas monitoring system.
11. As at 19 November 2010 there were eight fixed methane sensors connected to the surface control room,<sup>21</sup> shown in Figure 10.1.



Figure 10.1: Location of fixed methane sensors<sup>22</sup>