Pike River Independent Technical Advisory Group

Conceptual Development Plan for Main Fan Access Roadway Recovery

Executive summary

The current situation

The Drift of the Pike River Mine has been successfully re-entered and made safe. A Ventilation Control Device (VCD2) marks the inbye end of the ventilated section at 2224.5m from the portal datum. VCD2 was established about 20m outbye of a Rocsil plug which was remotely injected through borehole PDRH48 to facilitate control of gases during the re-entry process. A nitrogen rich atmosphere was maintained over the roof fall area inbye of the Rocsil plug, which was seen as presenting a possible spontaneous combustion risk, and also in the mine workings to prevent the occurrence and venting of any flammable gas mixtures. The measures taken were ultra-cautious as WorkSafe demanded an exceptionally robust approach to minimise all perceived potential risks.

Exploration inbye of VCD2 was undertaken by qualified, experienced miners wearing breathing apparatus in a nitrogen-rich atmosphere. The exploration team brought back new information on the roof falls. There are apparently two, the first probably caused by the drilling of a borehole in 2013 and the second which lay a short distance beyond, the result of the explosion and fire on 19 November 2010. Observations were of falls of roof, mainly coal material, rather than extensive failure of the massive roof strata.

Importance of the main fan site

The furthest point reached in the mine lies only a few metres from the junction to the main fan roadway and what could be the most critical items of evidence relating to the cause of the initial explosion on 19 November 2010. This mine was unusual in having the main fan underground rather than on the surface as is common in most coal mines. There were multiple reports of problems in the weeks leading up to the explosion associated with operation of the main fan under full load. Questions over whether these problems were adequately addressed remain. It was evident that leading up to the explosion, Pike River management were keen to '"squeeze" as much ventilation quantity as possible from the main fan to dilute the increasing methane emissions from the hydro panel being mined. Serious technical commissioning problems had been encountered with the fan. There were reports of fan controllers overheating and non-certified, non-approved electrical cabinet doors being left wide open in an attempt to keep components cooler. If correct, this is manifestly unsafe and should have been remedied immediately or stopped, either voluntarily by the company, or challenged by the regulator using formal enforcement powers. The mine was in no fit state to go into production yet that is what happened on a daily basis. An independent technical report commissioned by the families in 2020 (and provided to the police), highlighted some unexpected findings. Specifically, significant areas of concern were associated with electrical power loading at the moment of the explosion. The main finding was that at the time the feeders tripped, there was a fault on only one of the feeders, the one supplying the main ventilation fan.

Advancing exploration to the main fan site

This note describes how the main fan site can be reached safely to obtain essential details that could not be gathered effectively by any remote means. The distances are not great but the effort and care required should not be treated lightly. The distance from VCD2 through the Drift to the main fan roadway junction is about 80m, and turning right towards the main fan itself, (located in a 4-way intersection), a further 50m. The main fan roadway width varies from 4.2m to 5.7m and its height is 3.0m at the Drift junction rising to 6.4m at the main fan intersection.

The proposed approach involves the application of conventional, well-proven mining techniques for excavating, supporting and stabilising the roof falls. Other than where required for holing and isolating various points, the work would be undertaken in fresh air provided by the existing force ventilation system which has more than adequate capacity.

No evidence of spontaneous combustion risk or residual heat

There will no longer be any residual heat as the coal and surrounding strata will have cooled to normal strata temperature over the ensuing years. There is no evidence to suggest an unmanageable spontaneous combustion risk. Carbon monoxide concentrations monitored throughout the drift recovery are consistent with the expected low temperature oxidation of coal (by the air component of the injected nitrogen).

Research and laboratory testing has shown that the Brunner coal in its original state, and also when de-volatilised (where exposed to the underground fire that followed the explosions), shows very low propensity to spontaneous combustion. Neither pre-heating nor coking Brunner coal apparently increases its R70 value (a laboratory measurement of its propensity for self-heating); in fact there is strong evidence to suggest that de-volatilised coal has a reduced propensity to spontaneously combust because it cannot reach the required ‘run-away’ temperature without exposure to a significant external heat source.

Nevertheless, in order to continue the application of the ultra-precautious philosophy required by WorkSafe, it is proposed to inject Rocsil into the fall material to both stabilise it and reduce the surface area available for oxidation. Sealant in two phases will be injected through new boreholes drilled adjacent to PRDH09 & 50 (it would not be feasible to reuse the existing boreholes because drill casings were left in reducing their effective diameter). The multi stage process is illustrated later in this document and in an accompanying power point.

No evidence of increased ground instability around the roof-fall zones

Beyond the geotechnical reports on the technically weak condition (CMRR system of classification) of the ground in its original state (as it was being mined), there appears to be no evidence of increased instability as a result of the explosion or fire. No ground excavations are planned during the re-entry and significant additional steel tunnel support will be systematically erected as part of the roof fall recovery plan. An examination of the surface immediately above the roof-fall conducted in December 2010, noted mine gases venting under pressure through pre-existing geological fissures but found no signs of fresh cracking or ground movement. The report concluded:

“*no evidence of new fractures or instability existed in the area inspected, leading to the conclusion that fractures in the rock were not caused by the current mining activity or a subsequent failure underground.*”

A geotechnical assessment conducted for the PRRA on May 2020 found:

“*based on the review of the existing geological and geotechnical data about the Rocsil plug and rockfall area, there are currently no known geotechnical fatal flaws in advancing to the rockfall consistent with existing geotechnical planning, evaluation and risk assessment prior to the Rocsil plug being installed. Importantly, geotechnical conditions in the drift observed to date have been in general agreement with those predicted since the earlier geotechnical assessment - no signs of significant time dependant tunnel instability have been observed in 2014 and 2019 borehole camera footage captured about borehole PRDH48*”

An inspection beyond the Rocsil plug by a BA team in February 2021 found no deterioration to the roof requiring installation of additional support and no degradation of the roadway coal rib-sides.

Accessing the main fan site

At the junction to the fan roadway (PRDH09), the main drift will remain plugged and the Rocsil plug section entering the northern main fan access roadway breached using BA. Depending on roadway conditions, exploration can progress beyond the stopping in one of two ways:

1. If good roof and floor conditions, continue in BA to the main fan site and erect stoppings to isolate the fan location, or
2. If poor strata conditions, requiring machine access for support installation, progressively extend the forcing ventilation duct with an advancing stopping, (as recommended by mine rescue experts previously for drift re-entry). Erect stoppings to isolate the fan location.

Atmospheric monitoring and control

The current comprehensive gas control and monitoring system has proved exceptionally reliable and would be continued without change. The total methane make of the mine is now very low at around 9 l/s under stable conditions. The methane flow reporting to PRDH53, just outbye of VCD2, is less than 1 l/s and easily diluted by the available ventilation air. Inbye boreholes PRDH52 & PRDH47 are, and would continue to be, used for pressure control, decanting and nitrogen injection to maintain an inert atmosphere in the mine workings. The current Triggered Action Response Plans (TARPS) would be retained.

Cost

The roof fall recovery project is estimated to take 12 weeks and cost a total of $8.0M (including PRRA overheads, staff, hire, consumables, materials including Rocsil and helicopter charter).

1. Background

Labour Government Minister, Andrew Little, joined a families' group Zoom meeting on Wednesday 7 April 2021. Despite supporting the Pike River families on-going campaign for Mine re-entry and body recovery whilst in opposition, the Minister refused to budge on the Government's refusal to conduct a feasibility study to recover the Mine workings or Main Fan site. The Minister maintained he had kept faith with promises made to Pike River families by providing funding to secure Drift re-entry and was not prepared to ask Government for more money to go further.

Throughout the Drift recovery program conducted by PRRA, an independent families' group, including specialised technical experts, continued to investigate the circumstances surrounding the disaster on 19 November 2010 which resulted in the deaths of 29 workers. The families believe that matters of concern, not covered by the Royal Commission, subsequently emerged.

These concerns centre on evidence of electrical power instability identified from power supply graphs released under Official Information Act (OIA). Most explicitly, these findings relate to the specific timing of voltage instability events and the possible consequences of stray earth discharge sparking at multiple non-explosion proof VSD's deployed underground at Pike River, including those which controlled the flume water pumps and the main fan motor.

Independent investigations by family experts highlighted commissioning problems reported at the main fan in October 2010, associated with overheating fan control cabinets, sparking at the main fan drive shaft and subsequent removal of a brass sealing ring from the main fan shaft bulkhead wall. The latter created a potential air leakage path which could have allowed methane enriched return air (in the 5% -15% explosive range) to flow over non-explosion proof electrical equipment including the fan motor and associated control switches. Such an occurrence would have required a reversal of airflow, a likely occurrence in over-pressure situations such as those caused by a hydro-panel goaf collapse and the induced wind-blast.

remains of non-explosion proof cabinet LC601 photographed near the top of the ventilation shaft in 2010

Important evidence comprising part of the main fan electrical power supply cabinet, LC601, and associated plastic circuit board pieces were recovered on the surface having been blasted through the ventilation shaft at the time of the disaster, photographed and retrieved from the mountainside to the Pike River manager's office. These items have since disappeared. The police were apparently unaware of this evidence until it was brought to their attention by family experts in 2018.

More recently a section of the main fan cowl (10mm plate construction) estimated to weight 920kgs was recovered close to PBIS by the PRRA recovery team, some 300m from the main fan site.

Aware of the potential significance of the main fan site to a criminal investigation, the families' independent investigation team raised the matter of Mine Re-entry with the Police, PRRA and Government. The Government response was steadfast; there was no more money and once the Drift re-entry program came to an end with the recovery of items of interest from Pit Bottom in Stone, the Drift would be re-sealed and handed back to the Department of Conservation (DoC).

remains of a section of main fan cowl recovered by PRRA near PBIS

The Minister stated that the area of the roof-fall was 'inherently unstable' and that it would be 'phenomenally expensive' to recover the fall in order to access the main fan site. Figures of between $60m and $100m were mentioned in the media although it was later stated that these sums were highly speculative and not based on any feasibility study. In the absence of agreement with the Minister, the families group (which represent 23 of the 29 families) decided to ask the independent technical advisory group to carry out a high-level feasibility study on their behalf.

2. History

In 2012, the national Government established a working group chaired by Solid Energy New Zealand (SENZ), mandated to determine the technical feasibility, financial credibility and safety of mine re-entry and body recovery. This involved engaging a range of technical specialists including representatives from the Pike River Families experts' group along with SENZ and NZ Mines Rescue Service. The High Hazard Unit (HHU) were also involved as active listeners.

Drift re-entry was assumed to be a project upon which the various groups of experts could agree and the Government made it clear they wished progress be made as quickly as possible. It was predicted that Drift re-entry would be accomplished around April 2014. Thereafter, consideration would be given to re-entry of Mine Workings where most of the bodies were thought to be located.

With regard to exploration of the inner mine workings, it was expected it would be more difficult, particularly in the short term, for the various experts to agree. The Government decreed that a panel of experts be assembled to develop a scenario for a Full Re-entry. It was considered important that the families' experts be fully involved with all work-streams including drift re-entry and exploration of the deeper coal mine workings.

2013 Drift re-entry project

The expert panel assembled in February 2013. Without a Drift re-entry, there could be no Mine re-entry, therefore resources were all directed towards the former. A budget of $7.2M was allocated, to be administered by Solid Energy who were by now the new mine owners. Progress was swift and well-structured. The technical debate was robust and effective; risk assessments were professionally facilitated and documents signed off by all participants.

One of the early findings of the risk assessment team, was that in order to stabilise the mine atmosphere, the ventilation shaft would have to be more effectively sealed. Up until this time, a temporary seal was in place comprising a heavy steel plate with concrete placed at the edges. Depending on the prevailing atmospheric conditions (barometric pressure and ambient temperature), fresh air could to be sucked into, or methane gas pushed out of the vent shaft top, with similar fluctuations occurring at the 180m non-rated seal within the Drift entrance portal.

It was apparent that whilst drift and mine re-entry were technical challenges involving processes encountered during 'normal' mining situations, due to the extreme surface terrain, sealing the ventilation shaft would require specialist assistance from the New Zealand Defence Force (NZDF). Work commenced October 2013 on removing damaged infrastructure around the shaft top with the assistance of NZDF using 'heavy-lift' NH90 military helicopters.

The terrain and climatic conditions under which this initial phase of work was performed was formidable. Hundreds of helicopter flights both military and civilian were undertaken. Technical challenges involved in sealing the damaged ventilation shaft had been far from simple, but the engineers, miners and contractors, including the military personnel and civilian helicopter pilots performed with discipline and precision achieving zero equipment damage and zero injuries.

The process went to plan demonstrating both the effectiveness of the risk assessment team's planning and work-step assessment capability. All concerned in the exercise considered it a job well done. The project was on time and on budget with around $4M of the $7.2M budget remaining.

NH90 helicopter in action at Pike River

By Christmas 2013, the ventilation shaft had been sealed by injecting a chemical-cement grout and the mine atmosphere stabilised. The mine atmosphere was declared 'methane inert' comprising 98% methane (CH_4) with small amounts of carbon dioxide (CO_2). During the sequence of fatal explosions between 19th and 28th November 2010, gas samples indicated combustion of coal in the mine. By December 2013, environmental monitoring detected no residual heat source or products of combustion (CO).

Work Step Risk Assessment and Control (WRACs) were initially carried out on only two proposals: a "Staged Re-entry Option" (using BA to incrementally introduce auxiliary ventilation ducting into the drift thus diluting and removing the methane) and a "Concrete Plug Option" (remotely pumping a concrete plug into the drift, just outbye the rockfall at 2240m).

On completion of the WRAC, it was decided that the residual risks associated with both the Staged Re-entry and Concrete Plug Option could not be supported. The 'Staged Re-entry' involved hundreds of hours of BA use, and the 'Concrete Plug' option resulted in difficulties associated with trapping water behind the plug thus creating a potential inrush hazard.

However, during the technical discussion a third alternative - the "Nitrogen Injection" option emerged which, following detailed analysis, was identified as the preferred approach. This was a key moment in the process. The method would involve injecting expanding phenolic foam through a borehole to create a ventilation control structure at the top of the drift. Nitrogen would be injected through other boreholes to inertise the atmosphere inbye of the plug including the fall area and the coal mine workings. The design aim was to prevent the occurrence of flammable gas mixtures and control any spontaneous combustion risk. Furthermore, the drift could be recovered in fresh air, a major safety benefit.

SENZ evaluation processes

Approval for the drift re-entry project involved the various members from the risk assessment team ('Execution team') developing a plan and designing controls. A ‘Steering Committee’ headed by SENZ would then consider the plan by obtaining an independent technical review of the project concepts and risk controls. This invariably resulted in some ‘to and fro’ of questions and responses. The SENZ Steering Committee would then make a recommendation to the SENZ Board Health & Safety Committee. The SENZ Health & Safety Committee would consider the SENZ Steering Committee's recommendation and in turn refer it to the full SENZ Board of Directors to consider the various recommendations and make a final decision as to whether the re-entry project would proceed. In practice this resulted in a ‘phase-by-phase’ approval process.

The Steering Committee's role was to consider and challenge as appropriate, the Execution plan, and commission independent technical reviews of the project and risk controls. Independent technical assistance was obtained in the areas of geotechnical engineering, ventilation and process control.

With the ventilation shaft finally sealed, the mine atmosphere rendered inert, and all the other various safety requirements put in place, the next phase involved remote installation of a phenolic plug into the drift, located at around 2,240m, some 15m inbye the ‘Grizzly Borehole’ - PRDH35, and 38m outbye the misnamed rockfall. No one was underground so the risk of someone being injured during the installation of the plug was minimal.

The purpose of the phenolic plug was to provide a membrane under which water could freely drain, but would prevent a direct gas-exchange-interface between the nitrogen being injected via boreholes into the coal mine workings, and fresh air being introduced into the drift once it was degassed.

De-gassing of the drift would be achieved in the first instance, harnessing the natural buoyancy of methane (SG. 0.55 - half the density of air) decanting via borehole PRBH35 aided by a compressed-air-powered venturi with flame arrestor fitted to the surface discharge orifice.

PRBH48 was drilled at the proposed site of the Rocsil plug injection. A further three surface boreholes were drilled; PRBH 50 and 51 inbye the site of the proposed Rocsil plug, and a de-watering borehole into the south (submerged) coal workings to control water make in the drift and hence obviate any inrush risk at the plug.

Drift re-entry project halted

By February 2014, it was apparent that the project had lost some momentum and by April 2014 the drift re-entry effort stalled. One batch of Rocsil expired due to delays in taking a decision to proceed. Then a second batch also spoiled despite being stored in the pit baths in a vain attempt to stop the chemicals going off. Further delays were encountered during early 2014 which consumed the remaining budget with no discernible progress.

Nitrogen Plant removed from site

Before any formal announcement was made by SENZ, the nitrogen injection plant was removed from site despite being a key component in the preferred ‘Nitrogen Injection’ re-entry plan. In November 2014, SENZ announced they were not going to proceed with drift re-entry.

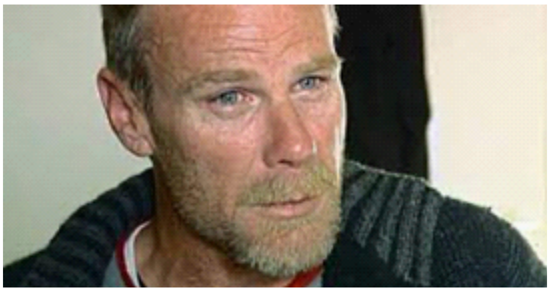
Drift re-entry formally rejected

An extract from SENZ Steering Committee Report to Government dated 4 November 2014 read:

"*Based on the review of the risk assessment process and on the technical reports prepared to review specific elements of the proposed project, four key areas have been identified by the Steering Committee as having high residual risks associated with them. These four areas are strata failure, gas / ventilation management, complexity of risk controls, and subsequent entrapment…..… Having taken these matters into account, the findings of the Steering Committee are that …. the proposed re-entry methodology for the Nitrogen Injection Option is "technically possible". However, the safety of the proposed method for re-entry relies on the accurate and consistent implementation of multiple controls many of which are subject to human error……and although the identified events and scenarios are low probability, there are remaining high risks in many proposed elements that pose significant risk of single or multiple fatality. Therefore the proposed re-entry of the Drift at Pike River should not proceed on this basis*".

SENZ disposes of Pike River mining equipment and assets

By 2014 year-end, SENZ and the National Government had rejected all further appeals by the Pike River families to re-enter the Drift. The families, supported by independent technical advisors, continued some dialogue with Government officials. Alternative ownership models were proposed by the families, and Government suggested the potential for a borehole robot re-entry into the drift. Although prototype assessments were undertaken at considerable cost, nothing of significance materialised.



SENZ commenced work on preparing the portal for installation of a reversible engineered seal. This subsequently changed to being a solid concrete permanent seal which further upset the families. Between 2014 and February 2018 SENZ had removed, sold off or scrapped specialised coal mining rated equipment and demolished most of the mine infrastructure. Families' technical representatives warned, '*what had been sold off for cents would take millions to replace'*.

(clockwise from top) - Dean Dunbar, Anna Osborne and Sonya Rockhouse, Anna, Bernie and Sonya

Placement of a permanent concrete plug in the drift portal entrance was halted in December 2016. This was assisted by the land owner transferring ownership of the access road to the Pike River families who had blockaded all access to the concrete trucks. The families resolve held firm even when threatened with prosecution.

Technical Select Committee Hearing

In February 2017, Tony Forster, Dame Fiona Kidman and Bernie Monk provided written and verbal evidence in support of Pike River Drift re-entry at a Government Technical Select Committee.

(left to right) - Tony Forster, Dame Fiona Kidman and Bernie Monk. Anna, Sonya, Dean, Steve and Carol Rose, and other family members in the background.

Later that same day, during a separate hearing, the Chair of SENZ stated that they "*would rather resign than permit the drift re-entry to go ahead.*" Nevertheless, in parallel with an ongoing families-backed independent criminal investigation into the cause of the disaster (the police having suspended their criminal investigation in 2014), the families independent technical advisors continued to develop a conceptual Drift re-entry plan.

A change in Government

Following the announcement of a Labour lead coalition government in October 2017, a more detailed conceptual drift re-entry plan was released by families independent technical advisors to Minister Andrew Little in February 2018 at the same time as the formation of the Pike River Recovery Agency (PRRA). This conceptual recovery plan provided a basis for the successful PRRA Drift re-entry operation in 2020/21.

3. A plan to access the Main Fan Site

Relevance of the Main Fan Site to the Police investigation

Throughout the period of the drift recovery by PRRA, the independent families group continued to investigate circumstances associated with the fatal blast on 19th November 2010. In particular, specific issues of concern emerged associated with the first blast. These concerns centred on new evidence of instability in the electrical power supply graphs, damaging effects of voltage instability on variable speed drives (VSDs) potentially causing stray earth discharge sparking. Evidence of main fan commissioning problems were also reported in October 2010 associated with overheating fan control electrical cabinets, sparking at the main fan shaft, and subsequent removal of a brass sealing ring from the main fan shaft bulkhead wall. The latter action introduced a potential air-reversal flow path (in over-pressure situations such as a goaf collapse induced wind-blast) between return air and non-protected electrical equipment including the main fan motor and associated switches.

The following extract was taken from a Pike River Mine document dated 2 November 2010:

" *I recall xxxxxx saying there were problems running the drive up to full speed when you attempted to run the new drive up last Wednesday (drive was current limiting at 410 Amps?). The motor is rated FLC 423 Amps (at 375 kW) and the drive to greater than 500 Amps - can you please review the drive settings and discuss with xxxxxx and see if there is any way we can squeeze the full rated output from the motor (without causing problems). Having said this, it does look like we may struggle to reach 50 Hz running speed - the SCADA trends indicate we were drawing around 390 Amps at 48 Hz, and roughly speaking I would expect around 13% increase in power demand to lift the speed from 48 Hz to 50 Hz - but I'm not sure what that equates to in terms of current* " ?

This is an extract from relevant maintenance documentation:

429	Ventilation	700H drive currently running at ~ 67 degC, cabinet temp ~ 30 deg. Doors being left open for cooling? What is an acceptable operating temperature for these drives, and what are long term plans for cooling?	Who is responsible for this work?

An independent technical report commissioned by the families in 2020 highlighted significant areas of concern associated with the electrical power loading at the moment of the explosion. The main finding was that at the time the power supply feeders tripped, there was a fault on only one of the three feeders, <u>the one supplying the main ventilation fan</u>.

Aware of the potential significance of the main fan site to the police criminal investigation, the families' independent investigation team raised the matter of mine re-entry with the police, PRRA and Government. The Government response was steadfast, there was no more money and the drift re-entry program would be terminated in May or June 2021 once the items of interest had been recovered from Pit Bottom in Stone. The Drift would then be re-sealed and handed over to Department of Conservation (DoC). The Minister stated that the area of the roof-fall was 'inherently unstable' and that it would be 'phenomenally expensive' to recover the fall. Figures of between $60m and $100m were mentioned to the media although it was later admitted that these sums were highly speculative and not based on any feasibility study.

New Information

On Wednesday 17th February 2021, Dinghy Pattinson had led a team of miners wearing BA beyond the Rocsil Plug. This was to fulfil a commitment made to the families that the 'massive rockfall' which blocked entry into the deeper mine workings would be examined to determine whether any human remains were present. Whilst no remains were found, Dinghy was able to provide concise and accurate information in his observations including the condition of the coal ribs, and the extent and constituent material of the 'rockfall', which transpired was neither 'massive' nor comprised of 'rock'. Photographs of the site and samples of burnt coal were taken, subsequently handed over to the police forensic team.

The fall zone comprised two distinct roof-falls, in which all the visible material was coal. Dinghy reported as being able to see around the first roof-fall associated with PRBH50 and identified the outer edge of the main fan roadway junction roof-fall as being in line with the left hand side inner edge of the widened section (9m wide) of roadway made to accommodate wet coal recovery. From this position it was possible to accurately fix the distance from the edge of the junction roof-fall to the centre line of the main fan access roadway at 15m.


photos taken by Dinghy Pattinson at the roof fall zone shows only coal

Zoom Meeting with Minister Andrew Little

A families group Zoom meeting was held with Andrew Little, the Minister for Pike River on Wednesday 7 April 2021, in which the Minister refused to budge on the Government conducting a feasibility study to examine the recovery of the mine workings or the main fan site. After further discussion, the families' group (which represented 23 of the 29 families) decided to ask their independent technical advisors to conduct a high-level feasibility study on their behalf.

It was understood by families' representatives that the Pike River drift abandonment would commence once recovery of evidence from Pit Bottom in Stone was completed, which at the current rate of progress, could be as early as the end of May 2021. Therefore, it was imperative that the study was conducted and a conceptual plan submitted to government as soon as possible.

Geotechnical Stability of fall zone

The methodology proposed for recovering the roof falls at PRDH50 and PRDH9 to facilitate safe access to the inner mine working, in particular the main fan access roadway, addresses the primary concern of the risk of injury due to working under unsupported or inadequately supported ground, and entrapment by a fall of ground due to the single egress nature of the operation.

Whilst steps could be taken to control ground movement, provision of a second means of egress does nothing to mitigate these risks, since by definition, recovering a tunnel roof fall, until the point of break-through is achieved (when all the additional ground control measures have already been implemented) is a strictly 'one way in, one way out' operation.

This implies that all ground failure risk control measures that are reasonably practicable should be taken. The term 'reasonably practicable' also implies that the latest and best technology should be chosen since mining engineering does not stand still in terms of its evolution.

The term "*inherently unstable*" was used by the Minister to describe the roof collapse zone. This concern was treated seriously and with an open mind. In addition to the new information provided under OIA by PRRA, the independent technical advisory group examined geotechnical borehole cores, Uniaxial Compressive Strength (UCS) data, geological studies and reports conducted at the mine surface after the explosion, and at the top of the drift tunnel during planning and construction stages. More recently, in 2020, geotechnical studies were conducted to support the planned re-entry by PRRA beyond the exiting Rocsil plug to inspect the roof fall.

Strata in the region of the roof fall is described in geotechnical terms as weak to moderately strong with a UCS index of between 10 to 20MPa, containing very weak to weak carbonaceous and coal bands, with areas of clay infill and shear zones. The Brunner Seam, where it is intersected by the drift, has a thickness up to about 11m, intermittently bedded with sedimentary partings including mudstones, fine sandstone and coal. The coal seam was described in drillers' logs as dark brown to black with minor partings and bright cleat faces. Cleats were steeply inclined and closely spaced with a smooth stepped nature. Overall the coal was described as very weak and brittle. Reports noted that by coal slabs could fall from the roof prior to support being erected. It was also noted that the roadway is aligned at an unfavourable angle to the regional major horizontal stress.

At a depth of cover of less than 100m, observations of roof behaviour after reinforcement was installed, noted reasonably favourable conditions in conjunction with the anticipated low CMRR values and the number of structures predicted. Notwithstanding the roof collapses at PHDH9 and PRDH50 (one as result of the explosion and one as a result of drilling operations) this may account for the apparent lack of significant ground movement and relative roadway stability in the 10 years since the disaster. Reports by Dinghy during his inspection towards the edge of the roof fall zone (supported by the photographs taken there) indicate no signs of 'edge guttering' which if present, would indicate a degree of void migration developing above the bolted height.

In international mining a 'Coal Mine Roof Rating' (CMRR) system is used to classify the strength of strata in coal mines in order to inform the ground reinforcement decisions. This classification is mentioned in a study conducted at Pike River in 2009. Although a CMRR assessment was not conducted at Pike River, the author of the report estimated that it would fall into the range between 20 to 25 in coal and 30 to 35 in stone. Any value below 45 is considered 'weak'. Developed by the US Bureau of Mines in 1994, CMRR it is widely used to assist in the design of coal mine reinforcement. Studies conducted in 2007 by NIOSH, found that 75% of the data collected at coal mines in Australia fell in the 'moderate to weak' CMRR ground classification.

The ground reinforcement system selected for the immediate roof of the coal-pit-bottom area, which comprised of up to 5m coal overlaid by sandstone and mudstone beds, was a pattern of 6 x 2.1m resin encapsulated roof bolts per metre of advance, supplemented by 2 x 8m long 60 tonne capacity mega-strand cables every metre.

Borehole PRDH9 is significant because it is situated in the middle of the roof collapse at the main fan roadway junction. Core samples indicate the roof of the Brunner seam was intersected at 81m depth and floor of the seam at 88m resulting in a total coal seam thickness of 7m. Information provided by PRRA suggest the height of the roadway at the junction intersection was only 3m meaning that up to 4m coal was left in the roof. The coal seam is overlaid by a 1.5m thick bed of fine grained green-grey sandstone above which is 1m of carbonaceous mudstone. The sandstone/ mudstone sequence continues for another 3m to the base of the Rider coal seam which is 1.5m in thickness. The zone above the main Brunner seam is collectively referred to as 'inter-burden'. The Island Sandstone monolith commences at 73.29m depth below the surface extending to within 3m of the surface.

Studies conducted in 2010 to establish the wind blast potential for Panel 1 (the hydro panel) at Pike River referred to lithological logs indicating that the immediate roof of the Brunner seam is readily caveable, including the Brunner Rider seam up to the Island Sandstone. The typical inter burden is quoted as between 5m to 7m. Borehole logs taken at PRDH9 in the centre of the junction roof fall confirm the inter burden thickness at this site is indeed 7m. The Island Sandstone is described in the report as "massive and strong" with a UCS index between 50 and 140MPa.

The report concluded that the Island Sandstone was competent enough to bridge “indefinitely” across the planned 31m span of Panel 1 (hydro-panel). On this basis, there seems to be a low risk of the Island Sandstone failing across the much smaller span of a 5m roadway junction.

In terms of a general description of ‘inherently unstable’ ground, there is no doubt that geotechnical studies concluded that the unsupported strata below the Island Sandstone is classified as ‘weak to very weak’ but apparently responds well to ground reinforcement. This confirms that not only is additional access tunnel support required, but that all reasonably practicable measures should be taken to stabilise the existing roof-fall voids before commencing excavation of the fallen material.

Notwithstanding the inherent weakness of the strata, the presence of nearby faulting and the effects of heat on the strata material that collapsed, there is no information to suggest that stability either above or below ground, at or around the roof fall zone at boreholes PRDH9 and PRDH50, has measurably altered since 2010 as a result of the explosion or fire. Indeed the geotechnical report conducted for PRRA prior to breaching the Rocsil plug in February 2021 came to the conclusion that for the limited time required, it was safe for the inspection team to conduct an inspection of the roof fall in the absence of any additional support.

Spontaneous Combustion Risk

An OIA submission made to PRRA on 12 April asked;

“*as far as you are aware, have any R70 tests ever been conducted by the Police, Agency, SENZ or WorkSafe, on burnt coal samples recovered from the Pike River roof fall”*?

Response:

“*I am not aware of any being conducted by NZ Police, Solid Energy New Zealand Limited or WorkSafe. The Pike River Recovery Agency (‘The Agency’) has conducted several tests but not from the roof fall - the closest is from PRDH52 which is 97m in-bye of the slimline shaft. The Agency commissioned a number of reports which are attached to this response. Please note, while there are grounds for withholding these reports, the Agency has decided to release them:*

B3 technical report 2019/TR017 testing of Millerton Mine Brunner seam

CB3 Technical report 2019/TR009 Pike River Drill Hole 52

CB3 Technical report 2019/TR016 Pike River Drill Hole 52

CB3 Technical report 2019/TR017 Pike River Drill Hole 52

CB3 technical report 2019/TR026 testing of Millerton Mine Brunner seam.

The independent technical advisory group examined R70 tests conducted by Dr Basil Beamish on Australian and New Zealand coal samples as far back as 2006, in order to establish the spontaneous combustion risk rating of baked or coked coal. Samples of Brunner coal taken from boreholes PRDH19, #20 and #21 were analysed in 2006. A report prepared by Dr Beamish on 3 October 2006 referred to previous spontaneous combustion studies using an adiabatic oven to define the self-heating rate index (R70) of Australian and New Zealand coals, including the Pike River coalfield.

These comparison studies were used to obtain a relative indication of the propensity of the coal to spontaneously combust. This report establishes an R70 value for the Brunner coal of 0.13^{o}C/h for an ash content of 5.6% on a dry basis. This value is considered anomalously low for a high volatile bituminous rank of coal, presumably a function of its coking properties. Dr Beamish concluded that the coal has a low reactivity to oxygen and the intrinsic spontaneous combustion propensity is classified as low (Class 1).

More recent studies conducted at the request of PRRA (promptly released in full under OIA) were examined as part of this review. There is nothing in any of these studies, conducted between 2016 at Mandalong NSW and 2019 at Pike River, on the basis of R70 testing, to indicate there is any increased risk of spontaneous combustion due to pre-burnt, baked, or coked coal. Dr Beamish noted in respect of the sample tested below:

"*It is clear from these results and the results of the R70 self-heating rate testing that the heat-affected coal is not capable of reaching thermal runaway, unless it is exposed to a significant external heat source. Even then, it would take a considerably long time for the coal to reach thermal runaway*".

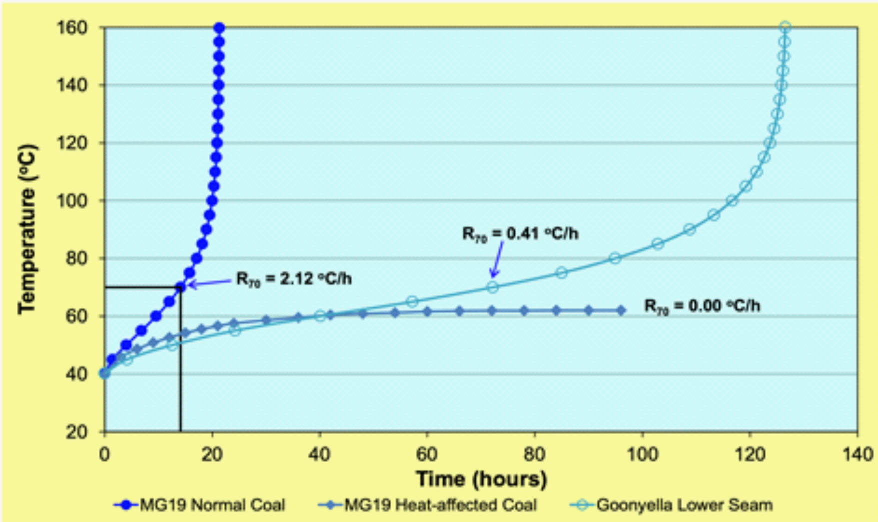


Figure 1: Adiabatic R_{70} self-heating curves for normal and heat-affected coal from MG19, Mandalong Mine compared against high rank bituminous coal from the Goonyella Lower Seam

Whilst reassured by these initial findings, the independent technical advisory group concluded that a cautionary approach should be adopted in terms of ground control and ventilation, consistent with the mining protocols already sanctioned by WorkSafe and adopted by PRRA. Irrespective of the R70 rating of a coal seam, the likelihood of a spontaneous combustion in any underground mining environment should be reduced as a result of the influence of site factors and incubation behaviour with appropriate controls being used to manage risks such as an adequate gas monitoring system combined with relevant Trigger Action Response Plans (TARPS). These are currently in place at Pike River and would remain so.

The proposed, robust plan would allow the recovery of the roof falls to be conducted in fresh air, while the inner mine workings remain atmospherically isolated from the drift and the new activities by means of Rocsil plugs maintained under positive nitrogen pressure. The current comprehensive gas control and monitoring system has proved exceptionally reliable and would be continued without change. The total methane make of the mine is now very low at around 9 l/s under stable conditions.

The methane flow reporting to PRDH53, just outbye of VCD2 is less than 1 l/s and easily diluted by the available ventilation air. Inbye boreholes PRDH52 & PRDH47 are, and would continue to be, used for pressure control, decanting and nitrogen injection to maintain an inert atmosphere in the mine workings. The current Triggered Action Response Plans (TARPS) would be retained. On this basis it would be possible that the Main Fan Site re-entry should be safely conducted in fresh air, thus minimising manual handling risks and irrespirable atmosphere risks.

Use of Rocsil cavity filler

The proposed use of Rocsil as a cavity filler as well as a ventilation plug has been assessed. Rocsil has been reported as used in over 400 applications in Australia and New Zealand, most frequently as a roof void filler on longwall mining operations and also to stabilise roof falls in gate roads and mine access tunnels. It is compressible without structural degradation, will not fail due self-weight and is highly resistant to internal vertical shear. The manufacturer states that Rocsil has a load bearing capability of between 10 to 20 tonnes/m^2 which provides confinement and excellent adhesive qualities which sticks it to the surfaces onto which it is pumped allowing the material underneath to be cut out. It has a low exothermic reaction, will not overheat and is credited as among the safest and most productive means of cavity filling in underground mines in the world.

Independent tests conducted by PRRA found that the Rocsil product they had placed inside a shipping container (as a trial) had a lower compressive strength than that quoted and had to deform significantly before building up confinement stress. The independent technical advisory group have no means of investigating this matter further but noted that PRRA went ahead with its use. However, unlike the brief PRRA examination of the roof fall, the roof fall recovery program would not be reliant on Rocsil as a primary support. On this basis, and the fact that it has already been tried and tested at Pike River Mine, it was selected by the independent technical advisory group as the most suitable medium to fill and stabilise the roof void. In conjunction with the systematic erection of steel RSJ tunnels supports, it will facilitate safe re-entry of the main fan site.

Time and Cost

The primary support material will be mining grade 125mm x 112mm Rigid Steel Joist (RSJ) section @ minimum 27 kgs/m straight roof beams 4.3m (total length); 4m minimum internal span, with 2 x 3m legs set on hardwood sole pads. Each beam will be connected by 3 bolted tie bars and each leg by 2 bolted tied bars. The completed support will be fully timber strutted and lagged. Including all brackets and ancillary components, each setting will cost approximately $1200. If each support frame is erected at 1m intervals, taking a maximum number of settings required at 120; total cost in steel and components = **$144,000**.

Taking a conservative advance rate of 2m per shift and 2 shifts per day, (4m/day) for 120 settings = 30 days / 6 weeks excavation and systematic ground support installation. Allowing 1 week for each new hole to be drilled including Rocsil injection, 2 weeks plus 1 week contingency = 3 weeks. Allow further 3 weeks for Fan Re-entry and removal of items of interest. Estimated additional mining personnel costs for 12 weeks = **$264,000.** The Agency has quoted a standing charge of $1.5M/ month regardless of what task it is performing. An estimated cost of the project lasting 3 months = **$4.5M.** The additional cost of a CM4500 to aid material clearance, if available, would be approximately $6000/week = **$72,000.** The cost of a diesel loading shovel is included in the PRRA standing charges.

Helicopter costs associated with Rocsil injection

Helicopter	Costs associated with Rocsil plug 29/10/2019 - 5/11/2019		$58,300.00
Subtotal			$58,300.00
Total Cost		**GST Excluded NZD**	**$58,300.00**

Helicopter costs must also be factored in. Total cost $60,000 x 4 rounds of injection = **$240,000**

In terms of injecting the Rocsil into the voids, it was initially thought that it might be possible to re-use PRDH50 and PRDH9. This idea was subsequently rejected as impracticable because the casings were left in reducing the effective diameter; Rocsil injection requires a hole diameter of not less that 151mm. The costings below were provided by PRRA. This process would rely upon two new holes drilled close to and parallel to existing PRDH50 and PRDH9. These are referred to as #50a and #9a. These will cost $340,000 each; approximate total = **$700,000.**

DRILLING BUDGET

Assumption is holes drilled out and cased to 151mm. This is the minimum size required for Rocsil injection

Site Establishment Drill Rig & Gear	$7,500.00
Drillhole design & Pad Construction (Incl. Heli, Survey)	$33,150.00
Drilling Costs (Incl Geo Op Support)	$129,400.00
Casing Costs (SW)	$15,666.67
Hole Completeion & Sealing	$28,600.00
Helicopter Costs	$61,087.50
Demob	$ 7,500.00
Subtotal	$282,904.17
Contingency (20%)	$56,580.83
Total Cost	**$339,485.00**

It is estimated that the program would require up to 4 rounds of injections. Each round of Rocsil (based on previous experience at Pike River) consumed just under 14,000 kgs of materials, filling a void of 300m^3 (10m long, 5m high, 6m wide) and costing approximately $300,000. That works out at roughly $1000/m^3. It is estimated that not more than 1200m^3 in 4 rounds of injection would be required equivalent to $1.2M. The total cost quoted for the existing Rocsil plug was $741,000 of which $438,000 was associated with shipping and charges. Assuming that shipping 28 tonnes of chemicals (as one load) would cost approximately the same as the single 14 tonnes load previously used, the total Rocsil cost is estimated to be $1.2M + $450,000 = **$1.7M** (subject to any refunds on chemicals not used).

ROCSIL COSTS

These costs are the actuals taken from the installation of the Rocsil Plug in 2019

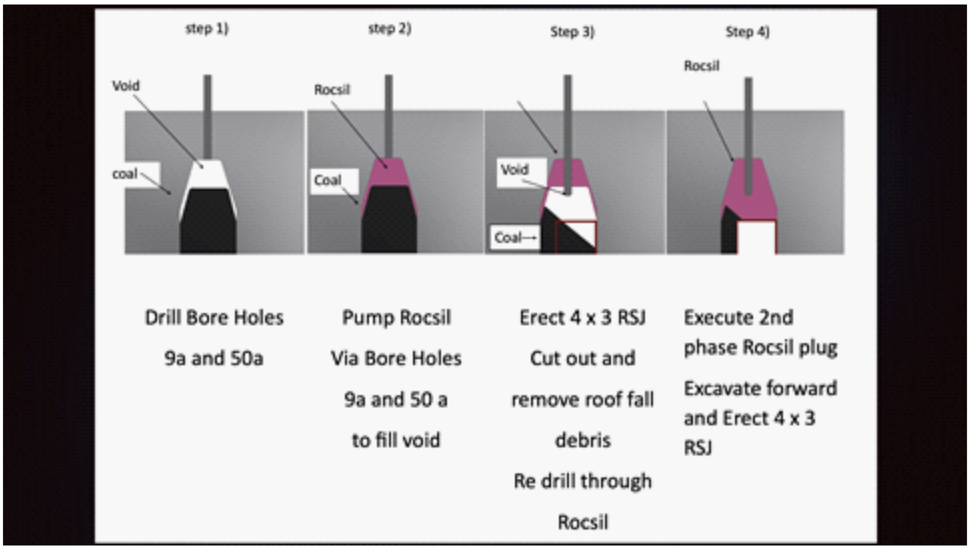
Rocsil costs

Labour		$73,878.00
Risk Assessment		$30,000.00
Rocsil Foam 25,000kg		$575,000.00
Transport		$30,000.00
Transport return containers		$17,500.00
Equipment hire		$15,203.52
Transport and container hire		$21,500.00
Mob, Demob and Travel		$30,000.00
Transport Sydney to Pike		$35,193.63
Return Transort to Sydney Port		$41,631.46
Transport Sydney to Pike		$136,180.56
Consumables		$8,090.62
Subtotal		$1,014,177.79
Unused Rocsil product returned credit		$272,599.53
Total Cost	**AUD**	**$741,578.26**

The estimated total cost of the proposed main fan re-entry program lasting 12 weeks is **$7,620,000.** Any additional time taken by WorkSafe to assess existing exemption compliance requirements and an amended PHMP/PCP for ground control and ventilation, and for PRRA to undertake full risk assessments would have to be added on. If these planning and assessment measures were taken in parallel with existing work streams there would be minimal additional cost.

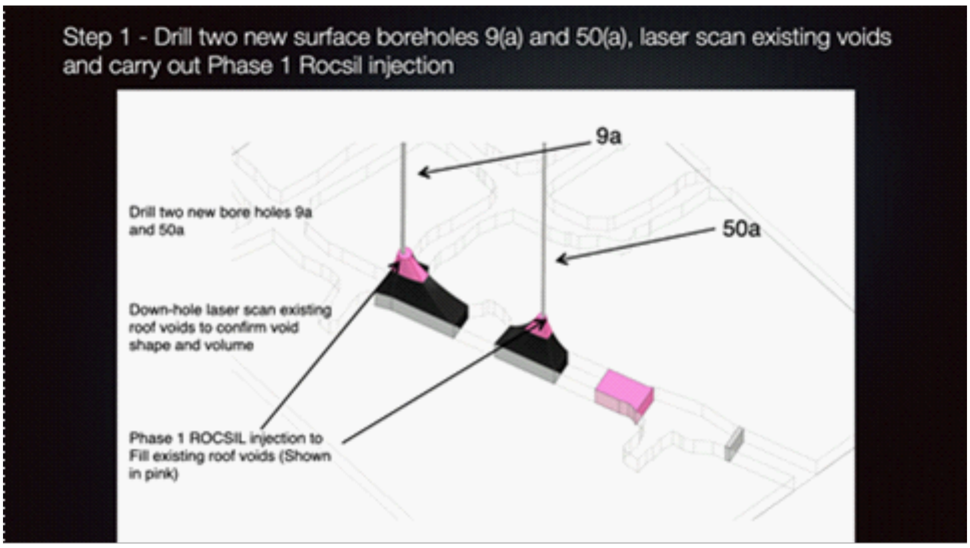
Roof fall stabilisation sequence proposal

It is proposed to first stabilise, then excavate, the roof fall zones in 4 stages, as shown below.

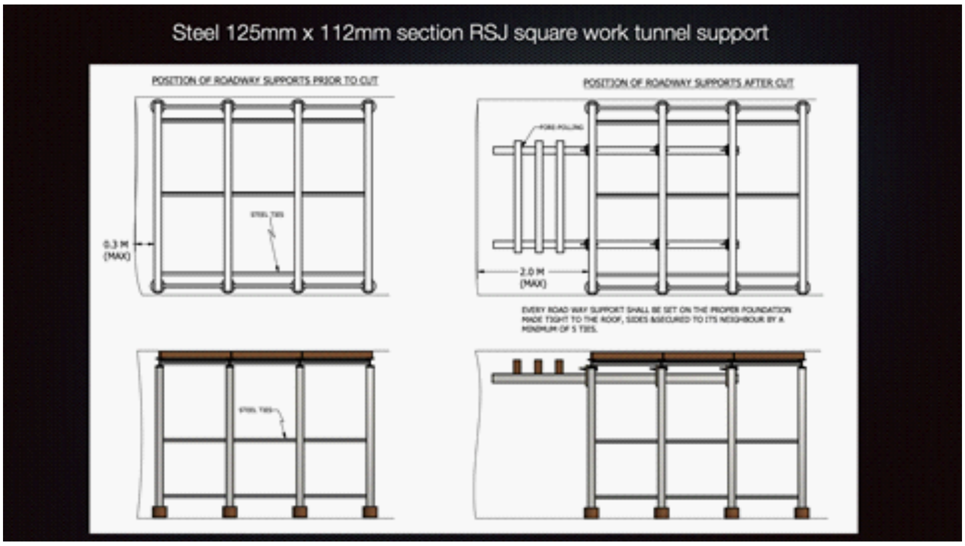


Step 1: Mobilise drill rigs on the mine surface and drill 2 new boreholes from existing drill platforms sites directly into the roof above both roof falls, drilled closely adjacent to existing boreholes PRDH50 and PRDH9.

These are identified in the diagrams as 50a and 9a respectively. Once both holes are completed, using a down-hole laser, scan the voids to establish their precise shape and volume and then place a Rocsil plug on top of both existing roof falls. This performs the dual function of installing primary confinement support to the exposed faces of the void (before any loose material is loaded out) and maintaining a gas membrane - plug between the Drift and inner Mine working.

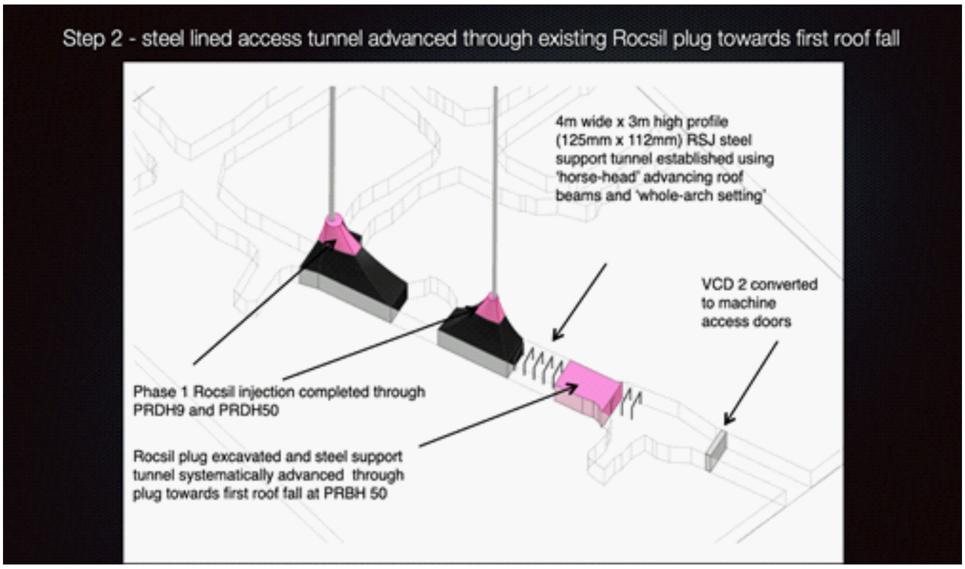


Simultaneously underground, and after PRDH50a is placed, convert the VCD2 to machine doors, and advance towards the edge of the existing Rocsil plug, installing any additional roof bolts as required, establish the 4m x 3m flat-top RSJ tunnel support system in secure ground utilising crown mounted fore-pole advancing bars and machine mounted whole-arch-lifter.



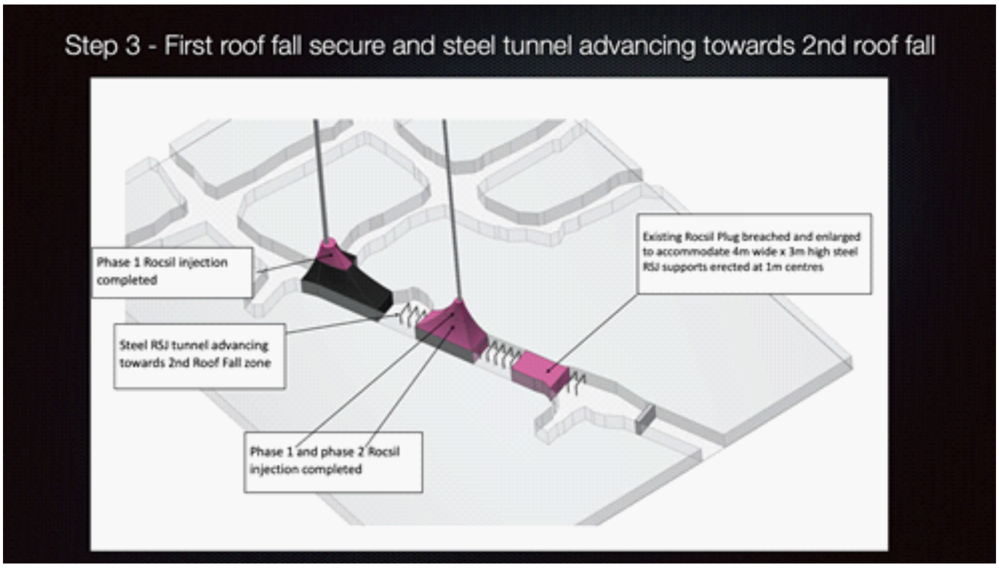
Ventilate the new ‘working face' zone, systematically advancing and erecting steel-arch lined access tunnel supports on top of 300mm x 300mm hardwood sole pads (to prevent the support legs penetrating the ground) at 1.0m intervals, bolted-tie-barred and in-flange timber strutted.

Step 2: Systematically erect steel tunnel support lining and install force auxiliary ventilation ducting through the existing Rocsil plug, advancing towards the edge of the first fall zone PRDH50.



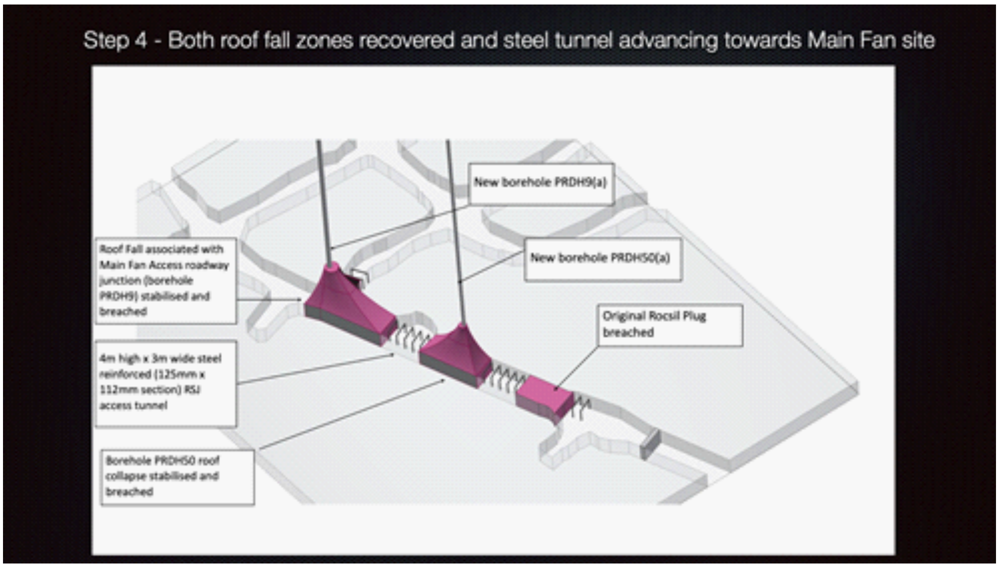
Excavate loose material taking as much coal and other debris away as will freely run. Excavation of loose material imbedded in Rocsil foam could be achieved using either the diesel loader and/or a refurbished, locally available CM4500, (ideally, if time permitted, a new hydraulic Celtic Miner could be imported). Using a remote module, the CM has the potential to operate under the fall area if assessed as safe to do so. As in normal mining ‘mucking out’ operations using routinely in coal and metalliferous mining, the diesel loader could also safely advance its bucket several metres under the fall area whilst the drivers cab remains under fully supported ground. The quick-detachable-system (QDS) means that an ‘arch lifting’ device can be readily fixed to the machine jib to enable rapid support erection, the beams then secured by advancing steel fore-poles before packing tight to the roof. This is standard mining practice.

Step 3: Withdraw the miner / excavator. Re-drill PRDH50a through the phase 1 Rocsil plug. Inject phase 2 Rocsil plug to infill the debris void excavated between the drift roadway floor and underside of phase 1 Rocsil plug.



Systematically advance forward excavating loose floor coal and Rocsil. Systematically erect steel 4m x 3m steel frames at 1.0m intervals. Work forward towards the main junction fall zone packing and infilling the new support structure tight to the roof and sides.

Step 4: Repeat as above, excavating as much loose material from the main roof fall zone as safe to do so. Re-drill PRDH9 and install phase 2 Rocsil plug. Advance steel lined tunnel by excavating the loose floor coal and Rocsil embedded material. Erect new steel lining at 1.0m intervals. The statutory support rules will stipulate that supervisors must erect support at the prescribed minimum spacing but are free to increase the density of support if deemed necessary. In practice, this will be closely monitored and spacings can be halved to 0.5m intervals to instantly double the support capacity. This is standard mining practice.



Breakthrough

There are a number of options that must be considered at the point of breakthrough, depending on the circumstances and 'as found' ground support conditions. All are controllable using normal mining practices. If human remains are discovered, everything would be done to ensure their proper examination and repatriation by implementing the existing police DVA protocol.

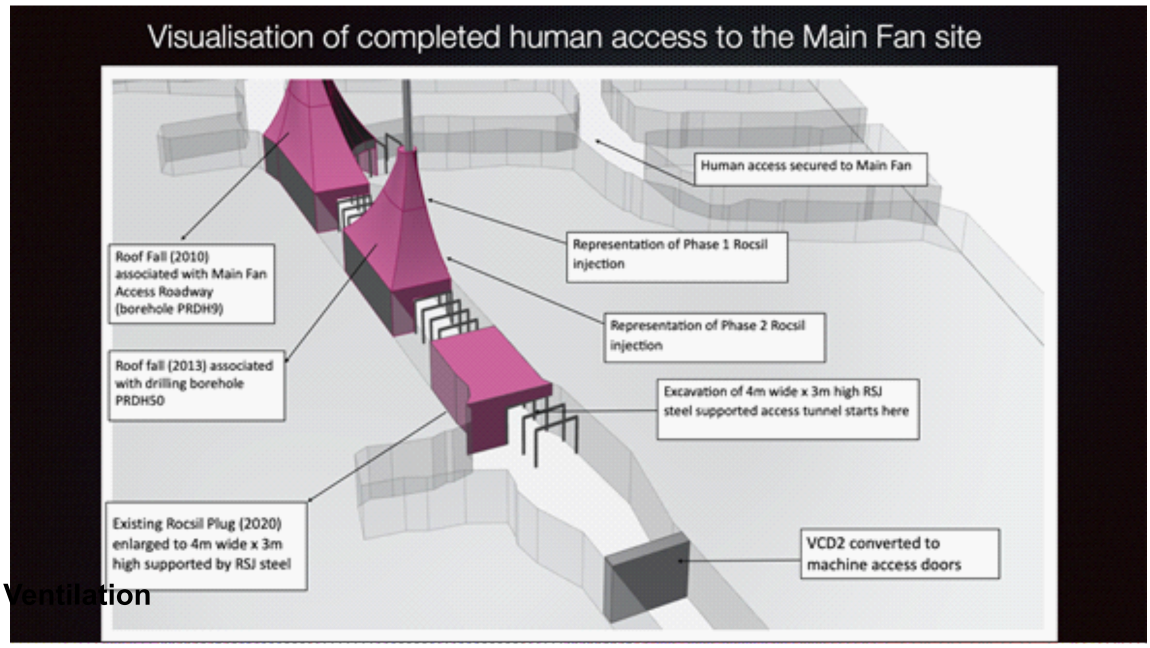
From a position of safety within the steel lined access tunnel, mining and ventilation engineers would assess conditions at the void edge transition zone into the main fan access roadway. They would examine the adequacy of the remaining Rocsil roof plug (injected as part of 'Phase 2') in terms of residual ground confinement, as well as effectiveness as a gas plug. Using probes, they would test how far Rocsil had flowed into the roadway as well as sample the environment ahead.

A decision could be made on whether or not a third Rocsil plug should be installed on the inbye edge of the roof fall zone in the main fan access road. If deemed necessary, additional Rocsil foam could be placed using the existing borehole PRDH9, manually placing the injection nozzle as required. Using the same logic, the main (straight ahead) Drift would either remain plugged by the Rocsil (injected in 'Phase 2'), more Rocsil foam could be injected, or depending on what was visible upon re-entry (such as human remains or the Drift-Runner), a stopping could be erected allowing further police lead investigations.

This is an ultra-cautions approach given the forcing auxiliary ventilation pressure available and low spontaneous combustion risk. Following the approach already used by PRRA breaching the initial Rocsil plug, examination could be conducted in BA and a temporary stopping installed. Ventilation would then be introduced to this point. If conditions in the fan roadway are assessed as satisfactory on inspection, exploration would continue in BA to the fan site and stoppings erected to isolate the fan location.

Should strata conditions prove to be poor, requiring machine access in fresh air (as recommended by a US mine rescue expert previously for drift re-entry) for support installation, the re-entry would involve systematically advancing the steel support tunnel beyond the junction and progressively extending the forcing ventilation duct with an advancing stopping. Stoppings would then be erected to isolate the fan location.

Use of fresh air ventilation at all stages of the main fan recovery is considered acceptable and the risks manageable as spontaneous combustion and fire ignition risks have been shown to be low and would be further mitigated by the use of Rocsil to minimise airflow through broken coal. Research has proved that neither risk is increased in the presence of heat-affected Brunner coal.



Ventilation

The ventilation plan will not be described in detail within this discussion document but has been fully designed and modelled, and supports this 4 - stage recovery approach.

The Celtic Miner - CM4500 pictured below, is a robust, compact mining cutter / excavator used in coal mining and civil engineering tunnelling. It has no electrical components, is fully hydraulic powered by umbilical hose (which can be several hundreds of metres long), CE approved for use in coal mine methane environments and approved for use in New Zealand. A unit imported into New Zealand in 2009 by SENZ is still available, following refurbishment.

4. Conclusions

For over 10 years, Pike River families have fought for answers about what happened and why their loved ones were engulfed in a methane explosion in a supposedly 'modern coal-mine' managed by qualified mining engineers and equipped with technology that was supposed to make such workplaces safe. The Royal Commission made many valid recommendations based on what they knew at the time but failed to identify the actual cause of the blast, so the international mining community is still none the wiser.

The families demand to know the truth, and for those found responsible for any reckless acts to be held accountable. The recovery of their loved one's bodies to be laid to rest in a place of their own choosing is a fundamental human instinct. Over the last 10 years, promises to help the families achieve some peace and reconciliation were readily made and just as readily broken.

Following a change in government in 2017, progress was at last achieved by recovering the Drift, recovering items of interest for the police from PBIS, and accessing the roof fall zone. There should be no doubt that this has been a significant achievement and those responsible for its support and execution deserve proper recognition. In doing so, PRRA increased the prospect of a successful criminal investigation and also provided new and important information on the nature of the 'massive rockfall' blocking off the inner mine workings. It transpires the blockage was neither 'massive', nor comprised of 'rock'.

Gaining access to the underground fan site could facilitate more detailed forensic examination of critical electrical and mechanical components and associated enclosures potentially providing answers as to why the mine exploded. Those answers are potentially less that 50m away.

This discussion document does not purport to minimise the technical challenge nor should it be regarded a definitive risk-assessed plan. What it represents is a conceptual feasibility study and roof-fall recovery methodology, developed by experienced mining engineers who have done this kind of work before. It highlights a credible method using standard mining practices by which recovery of the main fall and access to the underground ventilation fan could be safely achieved.

The proposed programme of work to recover the roof fall could be completed in around 12 weeks at an estimated cost of under $8M, a significant sum, but it would represent good value in relation to the considerable effort and cost already devoted to Drift re-entry.

There is no argument that the Drift re-entry has incurred unforeseen delays and escalated costs, apparently approaching $50M, but this is no fault of the Pike River families and should not be used against them. None of this was their fault.

This report has been provided in good faith by independent international mining experts supporting the Pike River victims and families, at no cost to the Families or the New Zealand taxpayer. Roof void stabilisation is a legitimate fall recovery technique known to practicing mining engineers and can be robustly defended. This is something that should have been done years ago and now is the time to finally keep that promise.

The Independent Technical Advisory Group

6 May 2021

Victims of the Pike River Mine disaster, 19th November 2010

Conrad Adams, 43 (Greymouth),
Malcolm Campbell, 25 (Greymouth - Scotland),
Glen Cruse, 35 (Cobden),
Allan Dixon, 59 (Runanga),
Zen Drew, 21 (Greymouth),
Christopher Duggan, 31 (Greymouth),
Joseph Dunbar, 17 (Greymouth),
John Hale, 45 (Ruatapu),
Daniel Herk, 36 (Runanga),
David Hoggart, 33 (Foxton),
Richard Holling, 41 (Blackball),
Andrew Hurren, 32 (Greymouth),
Jacobus 'Koos' Jonker, 47 (Coben - South Africa),
William Joynson, 49 (Dunollie - Australia),
Riki Keane, 28 (Greymouth),
Terry Kitchin, 41 (Runanga),
Samuel Mackie, 26 (Greymouth),
Francis Marden, 42 (Runanga),
Michael Monk, 23 (Greymouth),
Stuart Mudge, 31 (Runanga),
Kane Nieper, 33 (Greymouth),
Peter O'Neill, 55 (Runanga),
Milton Osborne, 54 (Ngahere),
Brendon Palmer, 27 (Cobden),
Benjamin Rockhouse, 21 (Greymouth),
Peter Rodger, 40 (Greymouth - Scotland),
Blair Sims, 28 (Greymouth),
Joshua Ufer 25 (Australia),
Keith Valli, 62 (Winton).