STEERING COMMITTEE REPORT TO THE HEALTH & SAFETY COMMITTEE OF SOLID ENERGY NEW ZEALAND LIMITED ON THE RE-ENTRY OPTIONS INTO THE PIKE RIVER MINE DRIFT

EXECUTIVE SUMMARY

1. SENZ has been contracted to determine whether a technically feasible, safe and financially credible means of re-entry to into the Pike River Mine Drift[1] is possible.

2. Initial Work Step Risk Assessment and Control (**WRACs**) were undertaken on a "Staged Re-entry Option" and a "Nitrogen Injection Option" into the Drift. On completion of the WRAC, it was decided that the residual risks were such that the Staged Re-entry Option could not be supported and this option was discarded (a third "Concrete Plug" option having already been discarded). The Nitrogen Injection Option was identified as the preferred option. The Nitrogen Injection Option would involve the use of expanding foam to create a ventilation control structure at the top of the Drift in combination with the use of nitrogen to inertise the atmosphere immediately inbye the plug. If effective, this would permit the re-ventilation of the Drift and recovery in fresh air.

3. The process for approval for the Drift re-entry project using the Nitrogen Injection Option involved the Execution team developing a plan and designing controls once the plan had been risk assessed. The Steering Committee would consider the plan and commission any necessary independent technical reviews of the project and controls. Based on the outcome of the Execution team's process and any technical review, the Steering Committee would make a recommendation to the Health & Safety Committee of the SENZ Board. The Health & Safety Committee would in turn consider the 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.

4. The Project Steering Committee's role in the risk assessment process was to consider and constructively challenge the Execution team plan and commission any necessary technical reviews of the project and controls. Independent technical assistance was obtained by the Steering Committee in the areas of geotechnical engineering, ventilation and process control to assist in the review of the risk assessments from Rob Thomas, Underground Coal Practice Leader of Golder Associates Pty Limited and Dr Dennis Black, Principal Consultant of PacificMGM, Mining and Gas Management Consultants.

5. 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.

6. Having taken these matters into account, the findings of the Steering Committee are that:

6.1 The proposed re-entry methodology for the Nitrogen Injection Option is "technically possible".

[1] For the purposes of this report, references to the **Drift** refer to the 2400m excavation between the Mine portal and the intersection of PRDH45 with the excavation.

6.2 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. In some cases the proposed controls do not achieve a satisfactory level of risk reduction and the residual risk lies at a high or possibly very high status. Many controls are "fragile" and susceptible to failure due to factors outside the immediate control of the operators. The risk assessments demonstrate it is impossible to categorically manage all risks to a level of residual risk that is acceptable.

6.3 Measures required to address these unacceptable risks will be associated with significant cost. The establishment of a second means of egress, or the installation of full ground support, will cost well in excess of the project budget[2] and therefore fails the test of being "financially credible". In addition the implementation of such controls will require significant investment of time which may compromise the integrity of the Rocsil plug (if installed at that stage) and hence the ventilation management control mechanism.

7. The Steering Committee are therefore of the opinion that, 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.

[2] SENZ's 2011 estimate of the cost of developing a second means of egress was around $90 – 105M, with estimated ground support costs based on a fully supported roadway of a further $5k/m.

INTRODUCTION

8. This Steering Committee report on the re-entry options into the Pike River Mine Drift[3] covers the following issues:

8.1 Section 1: The relevant background (including the Mine explosion, the purchase by Solid Energy New Zealand Limited (**SENZ**) of the Pike River Mine, the 2013 Agreement with the Crown, and developments post that Agreement);

8.2 Section 2: The project methodology for re-entry into the Drift (including the options considered for exploring the Drift, and details of the preferred re-entry option (nitrogen injection behind Rocsil plug));

8.3 Section 3: The risk assessment process adopted;

8.4 Section 4: The project evaluation by the Project Steering Committee; and

8.5 Section 5: Management's conclusions and recommendation on whether the preferred re-entry option into the Drift is technically feasible, safe and financially credible to implement.

[3] For the purposes of this report, references to the **Drift** refer to the 2400m excavation between the Mine portal and the intersection of PRDH45 with the excavation.

SECTION 1: RELEVANT BACKGROUND

Mine Explosion

9. On Friday 19 November 2010 at 3.45pm an explosion occurred underground at the Pike River Mine which is located in the rugged Paparoa Range on the West Coast of the South Island of New Zealand. The mine was operated by Pike River Mining Limited at that time.

10. The explosion caused significant damage to the workings and in particular the fan and upcast shaft. Subsequently, 29 of the 31 miners working underground at the time died.

11. The two miners who survived were working in the Drift, some distance from the mine workings, and they evacuated on foot to the mine entrance.

12. **Figure 1** shows an aerial view of the Pike River Mine complex (which shows the rugged and steep terrain in which it is located), while **Figure 2** provides a more detailed plan of the Mine layout.

Figure 1: Pike Mine Aerial View

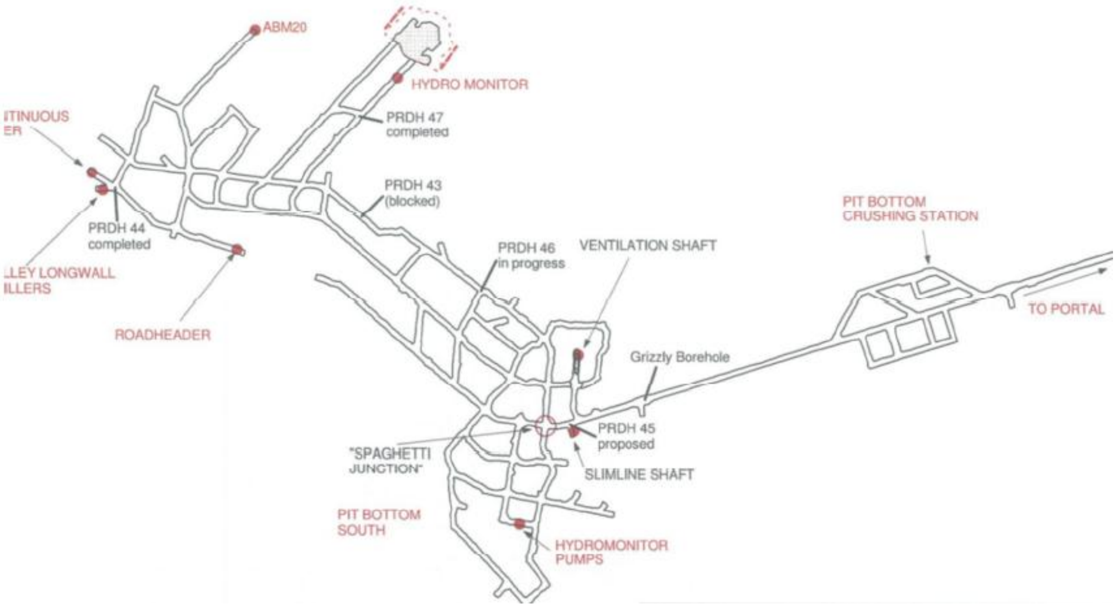


Figure 2: Pike River Mine layout at the time of the explosion

13. **Figure 3** shows the estimated locations of the 29 victims as determined by the Royal Commission of Enquiry. Based on the available evidence, there is nothing to indicate that any of the remains of the victims are located in the Drift itself, although this remains a possibility at the upper extents of the drift to the 2400m mark.

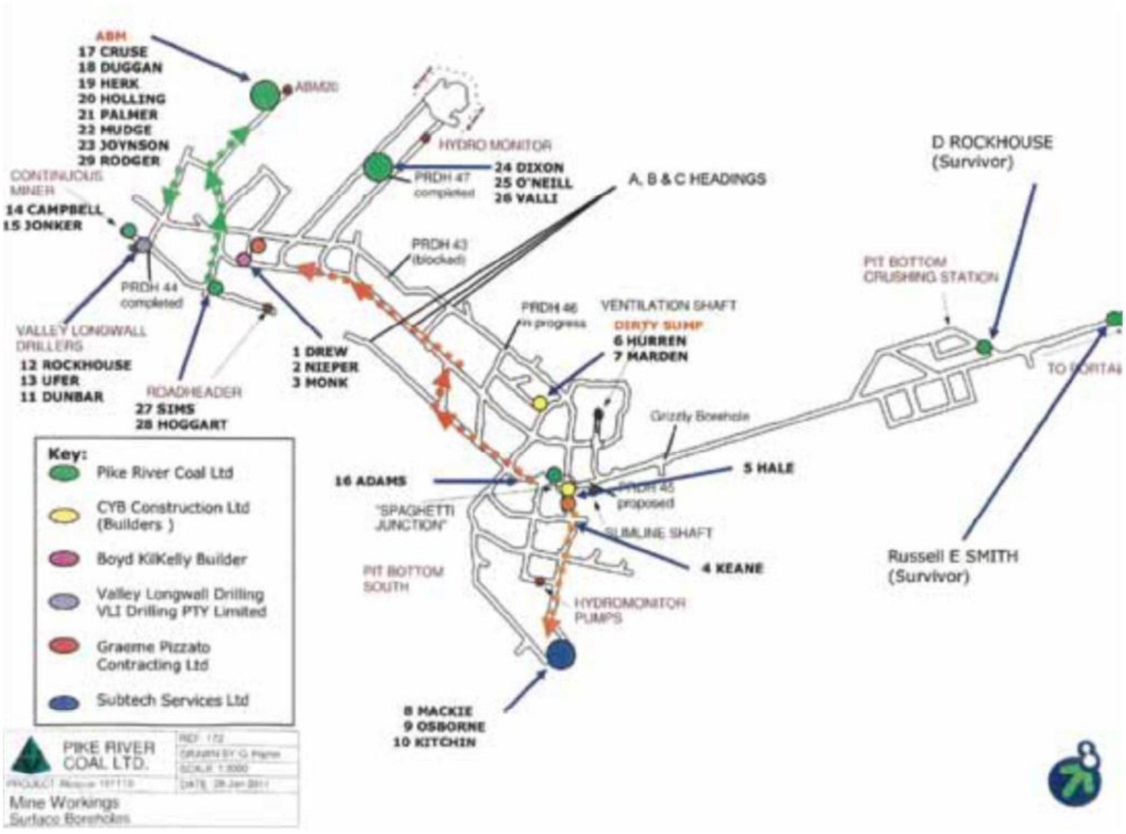


Figure 3: Assumed locations of men at time of explosion (Pike River Royal Commission of Enquiry)

SENZ's Purchase of the Pike River Mine

14. On 17 July 2012 SENZ purchased the Pike River Mine through its wholly owned subsidiary Pike River (2012) Limited. SENZ made it clear at the time of the purchase that it regarded the re-entry to the Mine Workings as being highly unlikely due to economic and safety considerations. SENZ did however undertake to determine whether a safe, technically feasible and financially credible method existed for the re-entry and exploration of the Drift.

15. On 8 November 2012, a report was prepared by Messrs Stevenson, Creedy and Feickert titled "A scheme for the recovery of the Pike River mine drift and re-entry of the workings". This report was commissioned by representatives of the families of the victims of the explosion at the Pike River Mine (the **Families**) and included:

15.1 Phase 1 – Mine Redevelopment programme including completion of risk assessments, funding of boreholes into mine workings and completion of Drift re-entry.

15.2 Phase 2 – Workings re-entry programme including Mines Rescue examination of the roof fall at the top of the Drift, the drivage of a by-pass road to access the workings, the establishment of a safe method for connecting the drivage to the existing gas filled workings and preparation of search and recovery methods.

15.3 A Preliminary Risk Appraisal considering 17 identified risks and approximately 42 suggested controls.

15.4 The conclusion that "The Families advisors consider the proposed methodology to represent a safe, legal and workable system. The Mines Rescue is comfortable with this approach. Further work on the detail is in progress. No detailed costing has been undertaken but an indicative cost for the project additional to the drift re-entry could be of the order $7 million".

16. On 28 November 2012, SENZ wrote to Messrs Stevenson, Creedy and Feickert and advised that:

16.1 The view held by Solid Energy that there was no safe, technically credible and financially credible plan that could be adopted for the re-entry to the mine workings had not changed as a result of the plan presented by the advisors.

16.2 If the Families were able to present a plan that met the test of the regulators, any other necessary authorities and which was fully funded, SENZ would not stand in the way of its implementation (although it would need to be made clear that any such plan was not endorsed by SENZ).

16.3 SENZ management would prepare a report on the re-entry plans for the Drift which would be subject to external review, and this plan would be implemented if it was safe, technically feasible and financially credible.

16.4 No other undertakings in respect of the Pike River Mine were given by SENZ

17. Subsequently, on 20 December 2012, Prime Minister John Key wrote to SENZ. The Prime Minister noted that the advice he had received to that time pointed to a re-entry into the main mine workings being extremely hazardous, and reiterated his earlier statement to the Families that it was unlikely the Government would be prepared to fund a stand-alone body recovery operation involving entering the main mine workings. However, the Prime Minister committed to the Families that the Government "*would fund such exploration [of the Drift] if a safe, technically feasible and financially credible plan were developed that Solid Energy and the High Hazards Unit were comfortable with*". The Prime Minister requested that, in conjunction with experts for the Company, Pike River Families and the High Hazards Unit of the Department of Labour (**HHU**) a meeting take place in early 2013 to work together in developing a plan for Drift exploration. A meeting of the relevant parties was convened in Christchurch on 25 and 26 February 2013.

2013 Agreement with the Crown

18. On 23 September 2013, SENZ entered into an "*Agreement relating to the provision of a grant to fund exploration of the Pike River Mine Drift*" with the Ministry of Business, Innovation and Employment (**MBIE**) and Pike River (2012) Limited (the **2013 Agreement**). Under the 2013 Agreement SENZ agreed amongst other matters to provide Risk Assessment Services in respect of three identified options for exploring the Drift to determine whether one of the options (or some other option) was safe and technically feasible to implement. The three options (the **Re-entry Options**) for consideration were:

18.1 Staged re-entry where the Drift was recovered and re-ventilated section by section by Teams from the New Zealand Mines Rescue Trust (**Mines Rescue**) using breathing apparatus in an inert nitrogen atmosphere;

18.2 Constructing a remote seal where a substantial plug was placed towards the intersection of PRDH45 and the Drift via boreholes from above the Drift, and the entire Drift was re-ventilated following plugging; and

18.3 Installation of a Rocsil plug at the upper end of the Drift and replacing the methane atmosphere in the Drift and part of the Mine with nitrogen and re-ventilating the Drift using an auxiliary fan.

19. The key aspects of the Agreement include the following (together referred to as the **Services**):

19.1 Risk Assessment Services in respect of three identified options for exploring the Drift to determine whether one of the options (or some other option) was safe and technically feasible to implement (as set out in Schedule 1) – these three options are covered in the next section of this report. SENZ was required to contract with Mines Rescue for its participation in the Risk Assessment Services (clause 5.2);

19.2 Ventilation Shaft Sealing Services. These included site preparatory work, procurement, materials transport, ventilation shaft seal, and demobilisation (as set out in Schedule 2);

19.3 Drift Re-entry Preparation Services. These included site preparatory work, procurement, materials transport, Drift re-entry preparation work (including injecting a Rocsil plug) and demobilisation (as set out in Schedule 3); and

19.4 The necessary investigations, enquiries and analysis to determine whether the performance of Drift Recovery Services (as set out in Schedule 4) was safe and technically feasible.

20. If it was determined that the performance of Drift Recovery Services was safe and technically feasible, then SENZ agreed to undertake the Drift Recovery Services (clause 2.3). However, if SENZ formed the view on an objective and reasonable basis that Drift recovery was not safe and technically feasible, then (subject to consultation) SENZ was not required to arrange for the performance of the Drift Recovery Services (clause 8.4).

21. MBIE agreed to provide a grant of not more than $7.2 million (the **Grant**) to SENZ to enable it to procure the performance of the Services (clause 2.1). Of the total Grant amount, $550,000 related to Risk Assessment Services (Schedule 1), $2.72 million related to Ventilation Shaft Sealing Services (Schedule 2), $1.45m related to Drift Re-Entry Preparation Services (Schedule 3), and $2.4m related to Drift Recovery Services (Schedule 4). MBIE was not required to pay any monies in excess of the Grant, and SENZ was not required to undertake or arrange any further work in relation to the Services in the event that MBIE had paid the full amount of the Grant but the Services had not been completed (clause 9.1).

22. SENZ was required to establish a project steering group (the **Steering Group**) in relation to the Services. This was comprised of four persons. The Steering Group's role was to monitor performance of the Services and consider possible changes to the Services and their cost implications, provided always that the Services were safe (clause 12.2).

23. The Agreement commenced on 23 September 2013 and ran until 30 June 2014 (clause 3.1(b)). Since that time the parties to the 2013 Agreement appear to be continuing on the basis that the Agreement still applies.

24. In practice, at the time of the signing of the Agreement and as a result of the Prime Minister's request to commence work as soon as possible, SENZ had already commenced the work on determining which of the suggested Re-entry Options was the most credible.

25. All three options were considered by SENZ with input from external experts, (some of whom represented the Pike River Families), the HHU, Mines Rescue and the NZ Police. Two options were subjected to initial risk assessment before the preferred option was identified and a full risk assessment undertaken. This provided the background for a recommendation to the SENZ Board of Directors in August 2013.

26. At the August 2013 meeting of the Board of Directors conditional approval was given for the project to proceed on a step by step basis with initial approval given for the sealing of the ventilation shaft. Subsequent steps would require further consideration by the Board before approval would be granted. This decision was conveyed to the Crown via the State Owned Enterprises Minister (Tony Ryall) in a letter from the Chairman of SENZ.

Developments Post the 2013 Agreement

27. In October and November 2013 work commenced on the Ventilation Shaft Sealing Services, a pre-requisite to enable management and control of the Mine environment. This work involved the removal of the ventilation fan and associated infrastructure located at the shaft collar which had been damaged in the series of explosions and fires that occurred at the time of the initial incident. In early 2011, a temporary seal had been constructed by Mines Rescue. However this proved to be ineffective, and the permanent sealing of the shaft with appropriate materials and engineering design was necessary.

28. The re-entry methodology proposed in the approved Work Step Risk Assessment and Control process (**WRAC**) included the use of a remotely placed plug of expanding foam at an appropriate point in the Drift. The Drift floor is constructed of river gravels compacted by traffic. In low places on the floor, water can be seen to be running on the surface which slopes outward towards the portal at approximately 9°. It was deemed necessary to evaluate the use of the expanding foam product in a similar environment prior to committing to its use. A trial of the product was conducted in November 2013 at an underground mine in Australia, selected for the similarity of physical conditions, to establish the likelihood of water accumulating behind the plug once placed. The trial was successful and demonstrated the effectiveness of the placement method and the ability of the foam to create a seal that permitted water to pass under it and not accumulate on the uphill side.

29. Initial work involving the use of NZ Defence Force aircraft and personnel was completed in October 2013 leaving the shaft collar ready for the sealing work to commence. This involved the placement of a plug at the intersection of the shaft and the Alimak rise, approximately 90m below the surface. Once this step was completed, a concrete "foundation" was poured at the base of the shaft section and an expanding foam product used to fill the shaft to near the surface. A further concrete plug was then placed at the collar. This work had the immediate effect of increasing the volume of methane reporting to the portal of the drift, indicating the Mine upcast shaft was effectively sealed.

Figure 4: Pike River Ventilation Shaft after 4 explosions and subsequent fire.

Figure 5: Shaft collar after sealing work completed.

30. In February 2014 a review of the WRAC already completed was undertaken using internal and external input. The WRAC review focused on the preparatory work required to be completed prior to any re-entry being undertaken and also identified those events that remained of concern despite the application of appropriate controls. These “top events”, which related to the re-entry of the Drift itself, were then subjected to further analysis using advanced risk assessment tools (as expanded upon below).

31. Following approval from the SENZ Board, preparatory work then commenced on the Drift Re-entry Preparation Services. This involved the construction of boreholes to enable water management, placement of instrumentation and nitrogen injection. Three boreholes were constructed for this purpose, all work being undertaken by helicopter-supported drill rigs. Once completed, the opportunity was taken to use borehole cameras to examine that section of the mine intersected by the hole. While some items of interest were seen in these boreholes (for instance damaged mine infrastructure), nothing of forensic interest was discovered. Test work on pumping of the water in the flooded “pit bottom in coal” section of the mine was completed.

32. In parallel with the preparatory work being undertaken, further risk assessment (using bowties together with Fault Tree analysis) reviews were completed using teams comprised of internal resources and different (to prior work) external experts. This work was completed to a point where a draft iteration of the risk assessment process was available for review by August 2014. The Event Tree analysis did not undergo the same level of review.

SECTION 2: PROJECT METHODOLOGY

Options Considered

33. Schedule 1 of the 2013 Agreement identified three possible options for exploring the Drift. These were:

33.1 Staged re-entry where the Drift was recovered and re-ventilated section by section by Mines Rescue Teams using breathing apparatus in an inert nitrogen atmosphere (**Staged Re-entry**);

33.2 Constructing a remote seal where a substantial plug was placed towards the intersection of PRDH45 (see **Appendix 1** for drill hole locations) and the Drift via boreholes from above the Drift, and the entire Drift was re-ventilated following plugging (**Concrete Plug**); and

33.3 Installation of a Rocsil plug at the upper end of the drift and replacing the methane atmosphere in the Drift and part of the Mine with nitrogen and re-ventilating the Drift using an auxiliary fan (**Nitrogen Injection**).

Staged Re-entry

34. Under this option, following the purging of methane in the Drift and replacement with nitrogen, a team wearing breathing apparatus would advance up to 100m beyond the last point of fresh air supply and erect a temporary stopping. This “recovered” section would then be scour-ventilated to enable the re-establishment of services and fresh air to this now advanced point. The process would be repeated until the Drift was recovered.

35. This Staged Re-entry option was rejected as:

35.1 It required men to repeatedly work in an irrespirable atmosphere throughout the recovery process;

35.2 There was no way to ascertain ground conditions and roof support integrity; and

35.3 There was no physical barrier between the furthest point of re-entry and the workings themselves.

Concrete Plug behind Rocsil Plug

36. Using Rocsil or alternative products a “dam” would be created at the upper end of the Drift and a concrete plug poured through a drill hole to fill the Drift in by the “dam”. The “seal” that was then created would permit the Drift out past the “dam” to be re-ventilated to fresh air so the Drift could be recovered.

37. This option was rejected as there were a number of significant risks that existed with the proposal, including:

37.1 The creation of a concrete plug behind the “dam” would require at least 500m3 (+/- 1200 tonnes) of concrete to be placed through a 100m + borehole from hoppers delivered by helicopter in 900kgs loads.

37.2 In addition the plug could effectively seal the Drift which would avoid methane leakage but would result in an accumulation of water behind the plug (the mine makes +/- 4 lt/sec). Unless the plug could be given an "engineered" status, and/or a water management solution was provided, this would create a risk of uncontrolled inundation.

Preferred Option - Nitrogen Injection behind Rocsil Plug

38. The Solid Energy Health and Safety Management System (HSMS) sets out the requirement for appropriate forms of assessment relative to the inherent risk in the project. Consequently, initial Work Step Risk Assessment and Control (**WRACs**) were undertaken on the Staged Re-entry Option and the Nitrogen Injection Option. On completion of the WRAC, it was decided that the residual risks were such that the Staged Re-entry Option could not be supported and the option was discarded. The Nitrogen Injection Option was identified as the preferred option. The placement of a remote plug using expanding foam was then subjected to a detailed WRAC. The risk management information available indicated that the Nitrogen Injection Option merited consideration by the Board of SENZ in August 2013.

39. The Nitrogen Injection Option would involve the use of expanding foam to create a ventilation control structure at the top of the Drift in combination with the use of nitrogen to inertise the atmosphere immediately inbye the plug. If effective, this would permit the re-ventilation of the Drift and recovery in fresh air.

40. For all options considered it was apparent that control of the mine ventilation situation was a pre-requisite. Despite the leaking shaft seal being the only control for the management of the methane environment (the mine makes between 60 and 100 lts / sec CH_4), effective management of the mine and its drift atmospheres was difficult and sealing of the ventilation shaft was required.

41. Key steps under the Nitrogen Injection Option would involve:

41.1 Purging the Drift and the majority of the Mine workings of methane using nitrogen;

41.2 The remote placement of a Rocsil plug; and

41.3 The maintenance of a nitrogen rich atmosphere inbye the plug while the Drift is re-ventilated with fresh air, using an appropriately placed 300mm diameter exhausting drill hole (PRDH52) to provide an exhaust airway and pressurising the Drift utilising the surface fan.

42. This approach was tested and augmented by Dr Roy Moreby of Morvent Mining Ltd in June 2014 and endorsed as being a sound approach in his report titled "Pike River Drift Re-entry Gas and Ventilation Management"

43. Once a fresh air atmosphere had been established from the portal to PRDH52, the Drift would be re-entered by Mines Rescue personnel supported by technical services from the SENZ workforce. When the Drift had been recovered to the fullest extent possible, a permanent seal would be constructed at a suitable site (outbye the Rocsil plug).

44. This process is set out schematically in **Figure 6** below:

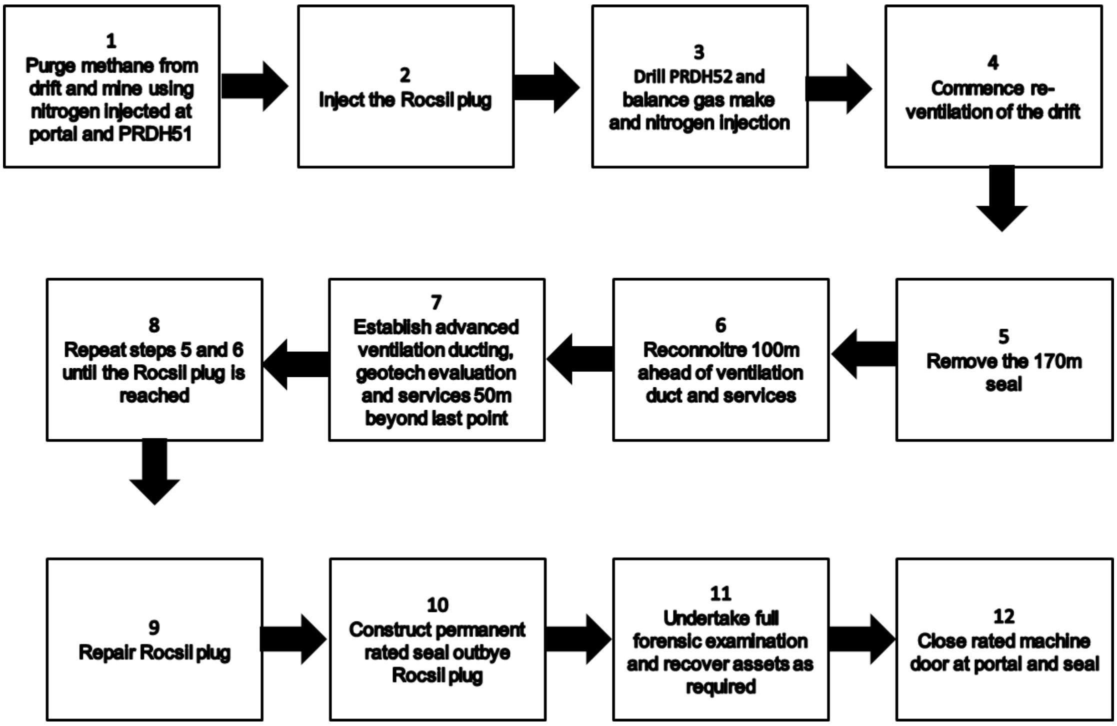


Figure 6: Sequence of steps in drift re-entry

45. A more detailed description of the proposed Nitrogen Injection Option methodology is included in **Appendix 3**.

SECTION 3: RISK ASSESSMENT PROCESS

46. A flowchart setting out the risk assessment process adopted for the re-entry project is shown in **Figure 7** below. Further detail is provided below on the management structure and approval process, the WRAC process, the more detailed analysis of Top Events carried out, and the timetable and participants involved in the risk assessment process. The risk assessment methodology and tools are an integral part of the **Solid Energy Health and Safety Management System.**

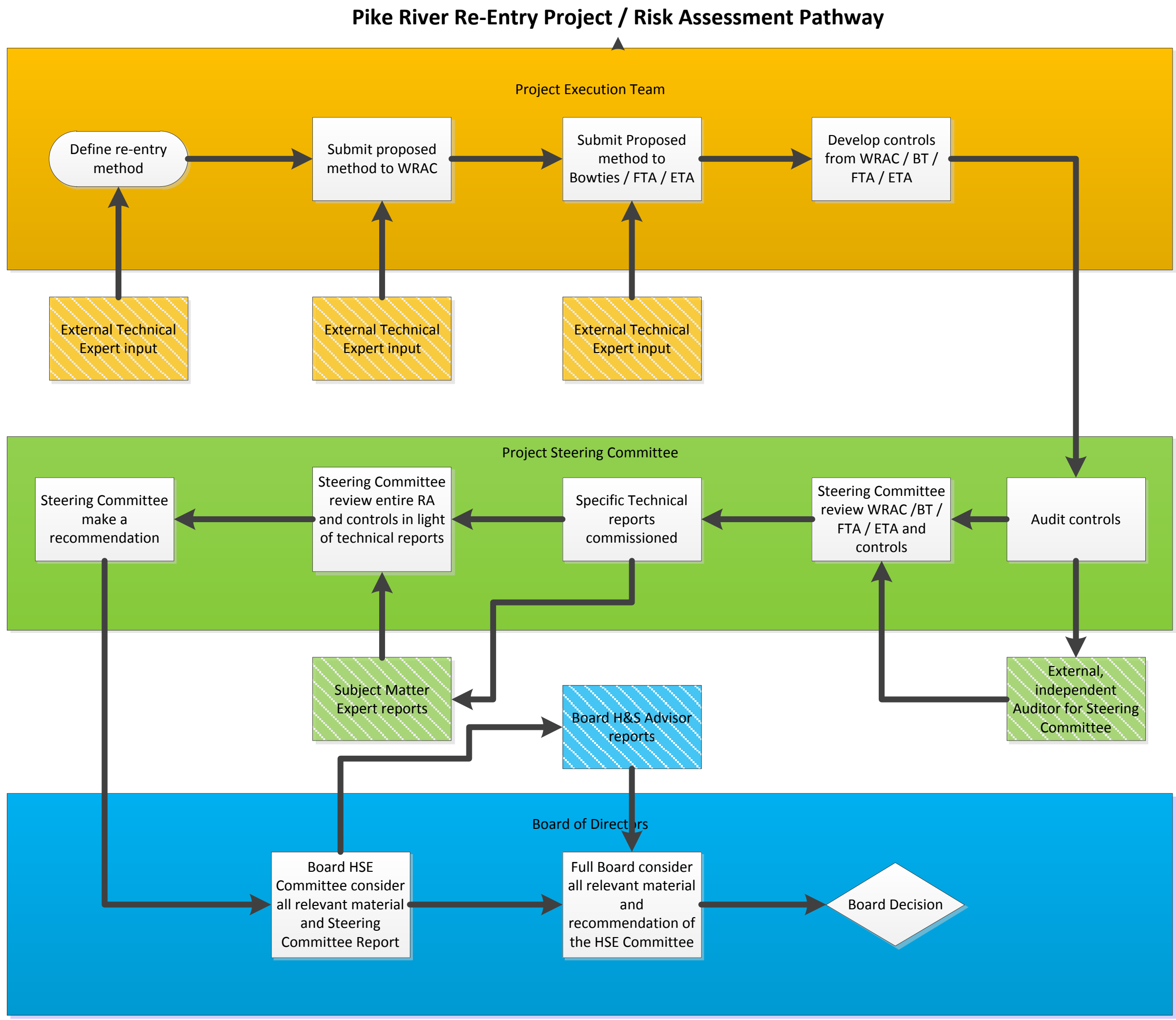


Figure 7: Risk Assessment Pathway

Management Structure & Approval Process

47. A management structure was established to oversee the risk assessment process. The management was broken into three broad areas:

47.1 A Project Steering Committee (distinct from the Steering Committee required under the 2013 Agreement with the Crown) comprising representatives of the project team, the SENZ executive and external expertise;

47.2 Independent, external expert reviewers who were appointed in the areas of geotechnical engineering and technical assessment. The input from these expert reviewers supported the final evaluation of the risk assessments and proposed controls;

47.3 The project Execution team which was retained as a separate entity.

48. The process for approval for the project involved five levels of design and review:

48.1 the Execution team developed the plan and designed controls once the plan had been risk assessed;

48.2 the Steering Committee would consider the plan and commission any necessary independent technical reviews of the project and controls;

48.3 based on the outcome of the Execution team's process and any technical review, the Steering Committee would make a recommendation;

48.4 the SENZ Board HSE Committee would consider the Steering Committee's recommendation and in turn refer it to the full Board;

48.5 the full SENZ Board of Directors would consider the various recommendations.

49. At that stage a final decision would be made as to whether the re-entry project would proceed.

Work Step Risk Assessment and Control Process

50. The tool elected for the assessment of the risks associated with the proposed methods for re-entry was a Work Step Risk Assessment and Control process (**WRAC**). The completion of a risk assessment using this tool requires the project to be broken into tasks and within the task a series of job steps. Each job step is then considered by the risk assessment team to identify the hazards associated with that step, who then consider the risk posed by determining the consequence of that hazard being realised and the likelihood of the realisation. The resultant risk, referred to as the initial or raw risk, is then re-ranked on the basis that the existing controls and any proposed controls are implemented to reduce the likelihood of the event occurring. In undertaking this re-ranking to arrive at the residual risk, one does not alter the consequence but only the likelihood.

51. Despite the use of controls of various types, some risks remain at a level that is considered unacceptable and these are subsequently subjected to a more detailed assessment using tools such as the Bowties analysis, Fault Tree Analysis (**FTA**) and Event Tree Analysis (**ETA**) consistent with the requirements of the HSMS. These events are referred to as Top Events. The risk assessment process is set out in **Figure 8** below:

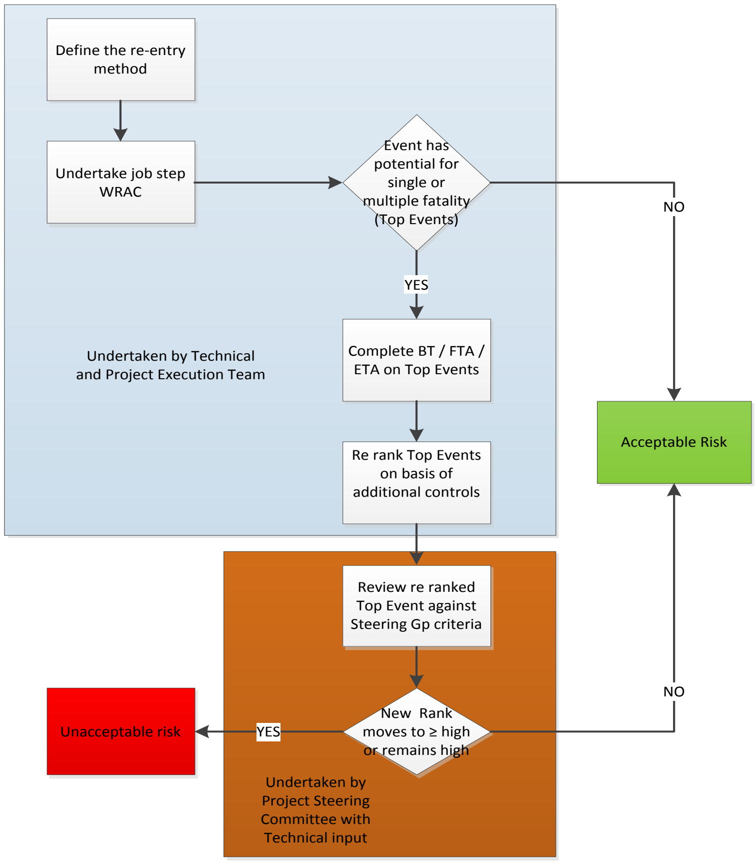


Figure 8: Risk Assessment Process

Top Events - Bowties Analysis, Fault Tree Analysis and Event Tree Analysis

52. A Bowties analysis considers a single event and then identifies all the contributing factors that are required to be met for the event to occur. In addition, the outcomes that may occur if the event is realised are also identified along with the steps that may be taken to mitigate the impact of the event and outcome.

53. A more detailed process, referred to as the FTA, may be used to determine the combination of factors that need to occur for an event to be realised and to identify appropriate controls to reduce the likelihood of the event occurring to an acceptable level. The FTA process was extended through the use of ETA to determine what escalation factors might exist if, despite all the controls that are implemented, the event does occur. In implementing these controls, further hazards may be created and these in turn need to be assessed using appropriate tools to determine whether or not the associated risk lies within acceptable limits.

54. It must be noted here that detailed and effective risk assessment is an iterative process covering identification, controls (both current and proposed), testing and reviewing effectiveness, independent review and if required circling back to re–do any step.

Risk Assessment Timetable & Participants

55. The entire risk assessment process and the proposed controls have been the subject of review at several stages, both using the internal project team, internal and external experts, and at the conclusion of the exercise, by independent technical experts reporting to the Steering Committee. A number of meetings / workshops have been conducted to develop and refine the risk assessment associated with the project. These meetings / workshops may be summarised as follows:

Completion of initial WRAC for re-entry project	**July 2013;**
Review of Rocsil placement and drill holes	**6-7 November 2013;**
Review of re-entry phase only	**17-18 February 2014;**
Initial FTA assessment	**14-16 May 2014;**
Full FTA review	**9-13 June 2014;**

- Included External Expertise independent of prior
- Note full review of initial work

Completion of FTA review and start ETA **30 June & 1 July 2014;**

- Did not include full team from June work

Completion of ETA and Bowties **21-23 July 2014**.

- Did not include full team from June work

Formation and commencement of Steering Committee review **5 August 2014**

56. The risk assessments were attended by a combination of internal and external subject matter experts. The list of participants and their record of attendance is as follows:

Name	Role / Position	Company	July 2013	Nov 6 - 7 2013	Feb 17 – 18 2014	May 14 – 15 20 14	Jun 9 – 13 2014	Jun 30 - Jul 1 2014	Jul 21-23 2014
Jonny McNee	Geologist / South Island Coal Quality Manager	SENZ		✓					
Trevor Watts	General Manager	NZ Mines Rescue	✓	✓	✓	✓	✓	✓	✓
Ian Judd	Mine Manager Pike River	SENZ	✓	✓	✓	✓	✓	✓	✓
Mark Pizey	GM Pike River Project / HSE	SENZ	✓	✓	✓	✓	✓		
Tjaart Heersink	Mechanical Engineer PRM	SENZ	✓	✓	✓	✓	✓	✓	✓
John Rowland	Consultant	Dallas Mining Services P/L	✓	✓	✓	✓	✓		
Bernie McKinnon	Consultant	Promin Pty Ltd	✓	✓	✓	✓	✓		
Roy Moreby	Consulting Ventilation Engr	Morvent					✓		
Sally McPhee	Senior Consultant (Facilitator)	Jim Knowles Group		✓					
Jim Knowles	Principal (Facilitator)	Jim Knowles Group	✓		✓		✓		
Tony Forster	Chief Inspector of Mines (Observer)	Worksafe	✓				✓		
Nigel Slonker	Inspector of Mines (Observer)	Work Safe					✓		
Ron McKenna	Consultant	Ronald L McKenna & Assoc	✓		✓				

Robin Hughes	Ventilation Engr	PRM	✓		✓	✓	✓	✓	✓
Lloyd Steward	Ass Project Mngr	SENZ	✓		✓	✓	✓	✓	✓
Steve Bell	SI Operations Mngr	SENZ	✓		✓	✓	✓		
Matt Coll		NZ Mines Rescue			✓	✓	✓	✓	✓
Dave Connell		NSW Mines Rescue					✓		
Eric Klements	Operations Manager	WMS		✓					
Chris Allanson	Director (Facilitator)	HMS				✓	✓	✓	✓
Peter Read	Detective Inspector	NZ Police			✓				

Table 1: Risk Workshop Attendee List

SECTION 4: EVALUATION BY THE PROJECT STEERING COMMITTEE

57. As noted above, the Project Steering Committee's role in the risk assessment process was to consider and constructively challenge the Execution team plan and commission any necessary technical reviews of the project and controls. Each is dealt with in turn below.

Risk Assessment Review Methodology

58. The Project Steering Committee reviewed the Execution team plan and controls using the SENZ HSMS and the Mining Industry Guidelines MGD1010 and 1014[4]. In making their assessment of the Execution team plan the Steering Committee utilised the following criteria:

58.1 **Omission of credible incidents or accidents:** has due consideration been given to identification of all high consequence events which could result from a single failure of equipment, or a single human error. Have all potential accident scenarios been identified and fully considered?

58.2 **Unwarranted optimism:** is there an optimistic view on safeguards that exist or that are proposed?

58.3 **Use of Risk Assessment to justify a predetermined position or decision:** has the risk assessment been used to justify a previously made decision or an existing situation? Have the data or assumptions been adjusted to produce a result that will be acceptable to management?

58.4 **Omission of common mode failures:** are there situations where several apparently independent “barriers” can be weakened by a single cause common to them all and have combinations of failure been considered?

58.5 **Difficulty of estimating the likelihood of human error:** are there situations where human reliability is critical to a safe outcome and if so are there back-up hard controls available?

58.6 **Consideration of historical events of similar nature when reviewing estimation of likelihood:** consistent with the requirements of MGD1010, has there been consideration of similar events occurring in the past in similar situations or environments that would materially impact the perception and assessment of likelihood?

59. This review process also identified three main initial issues for the Steering Committee.

59.1 The first was the importance of taking into account additional information based on the historical record of similar events occurring in the past.

59.2 The second was the adequacy of the controls proposed to manage the risks identified.

[4] NSW Government Publications: *MGD 1010: Minerals Industry Safety and Health Risk Management Guideline*; Jan 20911 & *MGD 1014: Guide to reviewing a mine risk assessment*; July 1997

59.3 The third was information that was made available that conflicted with the generalisation that the Drift was developed in "solid rock" and was "no different" to a rock tunnel.

Historical Record of Similar Events

60. The Steering Committee considered that additional information based on the historical record of similar events having occurred in the past needed to be obtained and included in the assessment of the likelihood of the event occurring.

61. This is on the basis that a number of the events considered as part of the risk assessment have occurred previously in mining operations in New Zealand and overseas, and this information is pertinent to the consideration of the likelihood of them occurring. For the purposes of their review, the Steering Committee used the following Risk Matrix as a guide (**Figure 9 – next page**).

Control Adequacy

62. In its review and challenge of the adequacy of the proposed controls called for in the Execution Team's plan and the team's subsequent judgement on the levels of residual risk, the Steering Committee noted that:

62.1 At the WRAC stage a total of **11** specific hazards were identified with a raw risk ranked as being **HIGH** and **15** were ranked as **MEDIUM**.

62.2 Following the completion of the WRAC and the application of the actual and proposed controls, the number of **HIGH** risk hazards reduced to **2** and the number ranked as being **MEDIUM** went to **22**[5].

62.3 Further risk assessment work using Bowties, Fault Tree and Event Tree Analysis identified further controls that could be implemented. These controls further reduced the number of hazards with **HIGH** risk to **0** and the number ranked as **MEDIUM** went to **24**.

63. The levels of risk reduction were large and warranted detailed review via the process outlined in paragraphs 51.1 - 51.6. The movements in assessed risk for these hazards are summarised in the charts in **Appendix 3**. Note the subsequent re-rating of the residual risks post the Steering Committees final review.

64. As a consequence of the sequential application of control measures through the detailed risk assessment process, what were initially 24 (26) hazards that were initially ranked as high were reduced to zero hazards still ranked as high or above. All risks were reduced to medium or low. This sequential reduction was the subject of analysis by the Steering Committee, which has, with technical input as required, completed the final step in the risk assessment process.

65. To clearly understand the impact of the proposed controls and then critically evaluate the effectiveness and consequent residual risk, the following methodology was used by the Steering Committee:

65.1 For each re-entry task where the risk process identified a consequence of a single fatality or greater the initial or raw risk was noted and reviewed for assumptions made.

[5] The total number of hazards evaluated dropped by two at this stage (from 26 to 24). The hazards not considered at this and subsequent stages relate to the entry to the Drift by non-project personnel. This will be only undertaken in the event forensic material is discovered and will be subject to its own risk assessment if the need arises.

65.2 The residual ranking based on the implementation of the controls identified in the WRAC process was then recorded together with the residual risk that emerged as a result of the detailed FTA/ ETA and Bowtie processes.

65.3 The levels of re-ranking and the proposed controls were then critically evaluated via the methodology outlined in paragraphs 51.1 – 51.5.

65.4 Residual Risk Levels were then identified based on the judgement of adequacy of the controls, historical implications on likelihood assessment, the impact of human error and the technical advice of experts.

Likelihood definition based on historic data

	CONSEQUENCE								
	Insignificant	Minor	Moderate	Major	Catastrophic				
	1	2	3	4	5				
Safety	First Aid Injury	Medical Aid Injury	Lost Time Injury (LTI)	Fatality	Multiple Fatality				
Environment	Local environmental damage, within the fence and within systems	Contamination or damage sufficiently large to impact the environment, but without permanent effects. Single exceedance of statutory or prescribed criterion	Limited loss of discharges of known toxicity, recovery of limited damage within one year. Repeated exceedance of statutory or prescribed limit	Severe environmental damage requiring extensive measures to restore polluted or damaged environment. Extended exceedance of statutory or prescribed limits over 2-5 years	Persistent severe environmental damage or severe nuisance extending over a large area. Damage cannot be rehabilitated. Duration of harm >5 years				
Value	<$5,000 (e.g. 100 tonnes lost production)	$5,000 - $50,000 (e.g. 100 – 1,500 tonnes lost production)	$50,000 - $500,000 (e.g. 1,500 – 15,000 tonnes lost production)	$500,000 - $2M (e.g. 15,000 – 50,000 tonnes lost production)	>$2M (e.g. >50,000 tonnes lost production)				
Reputation	Little internal or external attention and/or customer issue raised	Workforce attention, limited external attention and/or customer complaint	Repeated complaints, regulatory notification, negative stakeholder or media attention and/or customer attention	Significant negative perception of shareholder or key stakeholder and/or customer disruption	Shareholder or key stakeholder outrage and/or loss of key customer	LIKELIHOOD			
RISK RATING	M – 50	M – 10	H – 15	VH – 20	VH – 25	Over 90% chance	**Expected**	Could occur within months or has occurred in Mining or a similar heavy industry in the last months	5
	M – 4	M – 8	H – 12	H – 16	VH – 20	Over 75% chance	**Likely**	Could occur annually or has occurred in Mining or similar heavy industry in the last year	4
	L – 3	M – 6	M – 9	H – 12	H – 15	Around 50% chance	**Reasonably Expected**	Could occur in 2 – 5 years or has occurred in Mining or a similar heavy industry in the last 2 – 5 years	3
	VL – 2	L – 4	M – 6	M – 8	H – 10	Around 10% chance	**Unlikely**	Could occur within 5 – 20 years or has occurred in Mining or a similar heavy industry in the last 5 – 20 years	2
	VL – 1	VL – 2	L – 3	M – 4	M – 5	Less than 10% chance	**Conceivable but rare**	Occurs less than once every 20 years or has occurred in Mining or a similar heavy industry in the last 20 years	1

Figure 9: Risk Matrix

Assessment of Actual Strata and Gas Conditions Inbye of Hawera Fault

66. The Steering Committee noted the general perception of the strata conditions being that of a solid rock tunnel and instigated further review to ascertain the actual strata and gas conditions in the drift. (**Figure 10 – next page)**

67. Evidence indicated:

- Presence of a 4m thick coal seam, and beyond **(Figure 11 – next page)**;
- a further 6-10m of very poor ground, and beyond;
- a further 20m of carbonaceous material, coal and gouge material and;
- High gas levels emitting from horizontal exploratory holes.

The presence of coal and gas emitting strata had generally not been highlighted when considering what appropriate controls could be up until this time.

Review of Seven Remaining Hazards by the Steering Committee

68. Of the 24 hazards identified by the Execution team, seven were subject to further review by the Steering Committee based on the technical data and the risk review methodology outlined above.

69. On examination of the controls proposed, the Steering Committee noted that they were predominantly based on the implementation of soft controls consisting of trigger action response plans (**TARPs**), standard operating procedures (**SOP**) and job hazard analysis (**JHA**). In the hierarchy of risk control the most preferred controls are those that eliminate the risk or engineer the risk out of the system. The least preferred controls are those which rely on procedures or the observance of standard operating practice as these rely on strict observance and the management and reduction of human error. The risk assessment also presumed all the steps set out in these controls would be fully implemented and effective. This was an area of focus.

70. The outcome of the Steering Committee's review is shown in a series of seven tables (Table 2: Steering Committee Review Outcomes) that refer to job steps within the original WRAC (numerical references to two decimal places eg: 32.04). The ranking of these risks has been evaluated by the Steering Committee based on the process outlined above and information contained in advice and reviews.

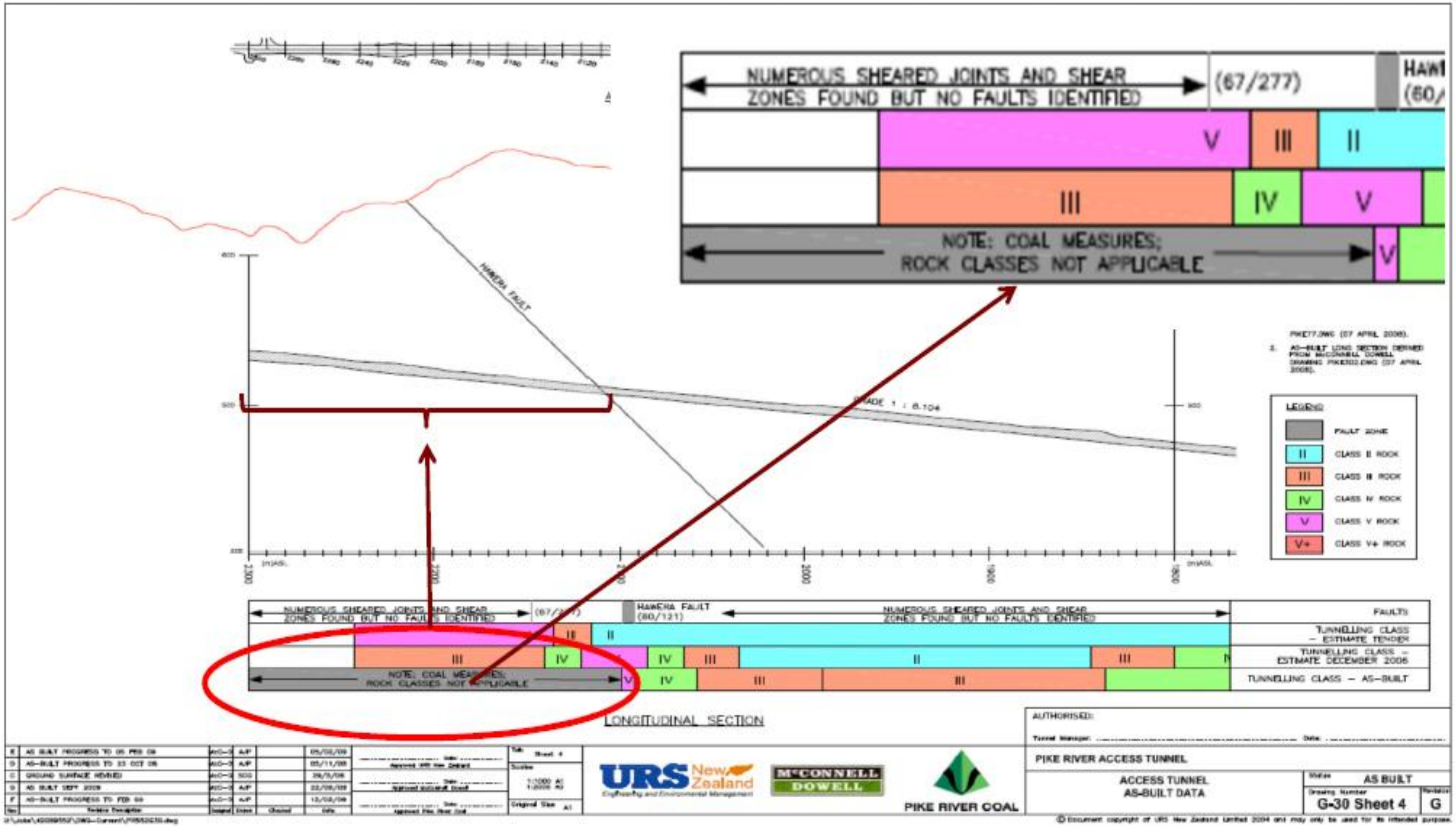


Figure 10: URS “as built” record (note presence of coal measures in last 300m)

2095 m   2098 m   2099 m

Figure 11: A series of photos of strata at 2100m mark showing the intersection of the drift with a coal seam (Paparoa Seam). As the face of the drift advances, it passes through the seam which moves from the bottom right of the face to the left hand side of the drift face. Note loss or ‘arch’ and use of shotcrete as face advances

Table 2: Steering Committee Review Outcomes

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	This refers to the job step identified in the WRAC document	xx.yy – the specific hazard associated with the WRAC job step	The raw or initial risk is recorded	The residual risk ranking post implementing WRAC controls is recorded	The residual risk ranking post implementing the FTA / ETA controls is recorded	Technical Reviews called for	The Steering committee's final residual risk ranking is recorded
Control Summary						The controls that achieve the reduction in risk ranking from the WRAC are noted in **black**. Those controls from the BT / FTA / ETA process result in a significant reduction in risk are recorded in red font.	
Weakness						The Steering Committee's evaluation of the controls is recorded. The impact of these weaknesses is recorded as the Steering Committee's final residual risk ranking. Font in blue in this section relates to final steering committee review.	
Comment						Any relevant comment is entered here	
History						Reference is made to the historical occurrence of events of this type using industry based examples (basis of likelihood ranking in amended risk matrix)	

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
	Re-ventilation of drift via grizzly	34.04 – Re-ignition of coal OB Plug	8M	8M	4M		8M (min)
Control Summary						• Gas Chromatograph for borehole gas analysis • TARP • Coal never transported via belt • Emergency sealing • Determine if borehole liner is grouted on PRDH35	
Weakness						• Coal measures between fault and plug • Suspected spon comb in Slimline shaft and the potential for heat affected coal all the way to the stone. This could easily re-ignite upon re-ventilation of the drift	
Comment						• Men not in drift • Has implications later in project based on stopping and starting ventilation when men are entering drift • Possibly as high as 12H	
History						• Huntly East • Blakefield South after re-ventilating	

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team enters drift	37.01 – Hit by fall of ground	12H	8M	4M	Investigation of conditions IB fault Independent Geotech review	20VH
Control Summary						• Strata Management Plan • Geotechnical Assessment • TARPs • Limited Access Procedure • Identify what support is required **when found** • SOP's for support and checking • Tunnelling Geotech in mine	
Weakness						• Going out under un-verified strata during reconnaissance – reliance on visual inspection & inability to reach roof from ground to test & scale roof during recon stage. Current best practice for scaling high roof involves the use of purpose-designed mechanised scalers. • Heavy reliance in original support design of arched profile in coal measures and gneiss. Profile not achieved so support design cannot have been realised. • Evidence of Pike River not carrying out operations in accordance with design already identified by Royal Commission, therefore low confidence in existing support. • Evidence exists in the inbye zone of ground support being non-compliant – not to design and over break from blasting. • Difficulty assessing the current state against the Q Rating System (QRS) due to shotcrete and other obstructions and the nature of the gneiss. • Very poor ground strength/ conditions inbye of the Hawera Fault. • Heat affected ground and supports. • Complacency at end of re-entry process, which corresponds with worst conditions and highest risk. • No temporary roof support (TRS) identified in re-entry process. • Unacceptable to go in without definitive support plan and work it out on-the-job. Geotechnical advice that ground support inbye the Hawera Fault is highly questionable. • Tunnel was designed on QRS, however its condition is and will be unverifiable. • Independent geotech review of ground support design in gneiss could not	

	determine definitive FOS rating for this area (could only determine it as a moderate tunnel support design).
Comment	• Advice suggests steel setting required IB of the Hawera Fault - Large cost risk ($500k – $2m). Plus significantly increased exposure to people to hazards • Will also require re-support programme for entire length of drift if unverifiable.
History	Austar (recent and CAG), Spring Creek, Dartbrook, Ulan #3

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team Enters Drift	37.02 – Ignition in drift from layering	10H	5M	5M	Review of presence of gas from fault.	10H
Control Summary						• Advance ducting • Use of brattice	
Weakness						• No consideration of frictional ignition from re-support activities • Windblast caused by a fall of roof in the mine workings causing gas to be expelled into the drift, in an uncontrolled way, where people are working • Gas in fault and leading up to fault • Complexity in controlling N2 and Vent Q • Fragility of plug – unable to verify until inspected • Assumption that transition from full methane to full Nitrogen to respirable atmosphere is effective in every part of the drift and Pit Bottom in Stone	
Comment						• Note “multiple” exposure	
History						• Moranbah North • Oakey Creek • Pike River	

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team Enters Drift	37.03 - Irresp. Atmosphere	8M	8M	4M	Technical review of Ventilation and complexity	5M (min)
Control Summary						• Vent ducting • CABA • Backup gen set • TARP for falling back • Venturi on BH • Fan protection	
Weakness						• Windblast/ fragile Rocsil plug • Only suggests single person exposure – should be multiple people • Evidence that ventilation system was adequate during development of drift used as indicator that fans and ducting will be adequate for re-entry, yet gas load on vent system now is higher than initial development. • Has not considered earthquake (although advice is UG not real risk – Portal and bores / area) • Fire effects on pillars are likely to have reduced their integrity further to already compromised design where FOS was reduced when mined due to W/H ratio variations from design.	
Comment						• Could argue 10H – High risk	
History						• Fatality at Grasstree Mine in recent history • Incident at Newlands • CO_2 expelled by goaf fall at Dartbrook	

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team Enters Drift	37.04 – Dislodge Infras / debris	12H	8M	4M		8M
Control Summary						• Develop JHA for "as found" conditions • Review MRS stepping height • JSA, SOPs and Geotech Eng	
Weakness						• Calls to amend "Stepping height" for MRS • Congestion at top of drift will be escalated • Escalates risk for escape • Conducting RĀ's "on the run"	
Comment						• Key issue in entrapment	
History						• West Wallsend debris zone was extensive • Pike River • Huntley West	

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team Enters Drift	37.06 – Persons trapped by FOG	4/8M	8M	8M	Drill hole locations / refuge practicality Refuge. 600mm borehole practicality	10H
Control Summary						• SMP • **Develop** recovery procedure for entrapped personnel • Pull testing regime • Form IMT if it happens • Get as-builts • Recon zones	
Weakness						• Should be Multiple – should have been 10H initially not 8M. • Original WRAC calls for geotechnical assessment once access has been gained, in which case people have already been exposed to the risk. • Geotechnical assessment has been undertaken on as-built data, which has determined progress inbye of the Hawera Fault could require levels of ground support which is not financially viable. • We know from when the Drift was driven the area inbye of Hawera Fault is very poor ground. Fall of ground IB of fault has a high risk of ventilation interruption. • History of instability at portal entry, which could be exacerbated by seismic activity or heavy rainfall. • Recovery is reliant on secondary recovery method which cannot be mobilised in time (4 to 6hrs duration of BG4) or practically in the required place • Life support relies on continuous supply of breathable compressed air via pipelines through fall. There is a risk of damage to the pipe from the fall itself. • Life support in part relies on PRDH35 or proposed PRDH52 300mm borehole (too small for recovery) & access there-to (requires travelling through debris zone and un-verified roof conditions). • Limited surface drill sites - rules out providing independent breathable compressed air supply to refuge chambers via dedicated boreholes. • Independent air supply via borehole would be subject to damage from harsh conditions on top of hill • Entrapment control identified using existing pipes in drift. It is known that pipes are damaged and the plan was to go forward 100m. If pipes damaged, there is no air available if fall occurs	

		• Refuges only in stubs (every 500m approximately) • Controls generally administrative and reactionary (ie form IMT)
Comment		• Not consistent at initial rating • Not robust enough logic in refuge / BH's • If significant ground support is required it is likely to require a metre-by-metre approach & potentially disturb forensic information &compromise purpose of re-entry.
History		Bosnia, Beaconsfield, Chile, Ulan #3 (not trapped but twice had failure), Oakey, North Goonyella)

	WRAC Step	Hazard	Initial Rating	Residual Rating	Post BT / FTA / ETA	Review	Evaluation
Assessment Team			Full RA Team	Full RA Team	RA Team	Steering Committee	
	Team Enters Drift	37.07 – Persons trapped by fire	10H	10H	5M	Time for explosion of products of combustion Reversible fans / hard ducting	12H
Control Summary						• Fire suppression on gear • FOB • Fire fighting capability • Men not in front of diesels • Diesels travel together and no more than 50m apart	
Weakness						• No second egress. Not acceptable to have to advance inbye through debris field and un-verified roof conditions to inbye borehole • Long auxiliary ventilation system (forcing) where personnel escape in polluted atmosphere • Can't do with 2x vehicles • Need to be able to reverse ventilation • Difficulty in estimating the likelihood of human error (ref MDG1014) – applicable to maintaining conformance with "all-in/ all-out" rule, maintaining maximum diesel separation, etc. • Air in breathable compressed air pipeline/ ducting will be heated and potentially too hot to breathe	
Comment						• Note multiple exposure reduced to single exposure as with controls only 1 person can be caught IB fire	
History						• Spring Creek • Dartbrook • West Cliff • US mine cement truck fire • US Tunnel fire	

Independent Technical Review

71. To assist in the evaluation process identified above, technical assistance was obtained by the Steering Committee in the areas of geotechnical engineering, ventilation and process control to assist in the review of the risk assessments (the reports are attached as **Appendices 4 & 5**). Each is dealt with in turn below.

Independent Geotechnical Report

72. The **Independent Geotechnical** report was prepared by Rob Thomas, Underground Coal Practice Leader of Golder Associates Pty Limited. The report's scope was to assess:

72.1 The adequacy of the support design methodology utilised during the construction of the tunnel, with particular reference to the design standards commonly used in the civil tunnelling industry.

72.2 The adequacy of the reported as-built ground support.

72.3 The adequacy of the installed ground support from the perspective of a single-entry driveage that (i) has to varying degrees been adversely affected by at least four explosions and a fire, and time-dependent weathering and (ii) will need to consider the possible impact of an earthquake.

72.4 The ability to assess the adequacy of the installed ground support during re-entry.

72.5 Possible remediation measures that may be required upon re-entry.

72.6 The potential for a significant rush of air as a result of a collapse in the inbye mine workings and, in doing so, the consequential expulsion of a noxious or explosive mixture of gas into the tunnel.

73. The findings from the geotechnical report are summarised below.

Support Design Methodology

74. The Q-index used is a) an appropriate method of ground support design in hard jointed rock masses, as per the gneiss encountered on the outbye side of the Hawera Fault and b) appears to have been applied to an acceptable standard.

75. The Q-index appears to have been applied in a manner that is broadly appropriate to the design requirements commonly associated with a life-of-mine access tunnel.

76. Potential deficiencies in the design methodology include a) despite the presence of several distinctly weaker zones of strata, the use of a consistent ESR or safety requirement factor does not conform to the recommended use of the Q system and b) the inability, due to the lack of transparent information, to verify the Factors of Safety associated with any potential block or stress induced failure.

77. As the rock is both inherently softer and bedded, it is debatable as to whether or not a) it was appropriate to use the Q-index in the Coal Measure section of the tunnel and b) rely on the retention of an arch in the crown of the tunnel.

78. In regard to any comparisons that can be drawn to the design standards typically applied to a civil tunnel, accepting the deficiencies noted above, the main points of note are a) the majority of the tunnel located in the gneiss has almost certainly been supported to a standard that would have been acceptable in what could be termed a “moderate risk” civil structure (e.g. water tunnels, pilot tunnels and access drifts into large openings), b) critically, this does not include road or railway tunnels where the risk of human exposure to falls of ground is of heightened concern and c) the support installed in the Coal Measure section of the tunnel has almost certainly not been designed to an acceptable standard.

The Adequacy of the Installed Ground Support

79. An adequate type and density of ground support (including rock bolts, steel mesh and where appropriate, 50mm of shotcrete in areas where some form of skin or weathering protection was deemed necessary and around 150 to 250mm of shotcrete in those areas where an added level of structural stability was deemed necessary) appears to have been installed in the gneiss section of the tunnel.

80. Whilst a reasonably high density of roof support (including cables and shotcrete) was installed in the Coal Measure section of the tunnel, it is of note that a) considering the absence of any quality roof monitoring or mapping data, it is difficult to make a definitive comment on the adequacy of the support, b) as mentioned previously, in those areas where it was not possible to maintain an arched profile in the roof, the adequacy of the installed ground support (in particular the shotcrete) is debatable and c) the highly faulted and folded sequence of thin coal seams and mudstones would almost certainly be susceptible to some degree of time dependent deterioration.

81. In regard to the quality of the installed ground support, several concerns are of note from the engineer’s daily reports, including occasions where a) the shotcrete was often applied too far outbye of the face, to an insufficient thickness of <150mm and / or was noted to have cracked and needed to be repaired, b) the cables in the Coal Measure section of the tunnel were either installed too far outbye of the face, not grouted for several days and / or the incorrect grout was used, c) the roof bolts (especially around the fault located between 1050 and 1072m marks) did not achieve the required anchorage capacity and from the available information, it is not clear what remedial actions were taken as a result of this, d) a large number of the 2.4m long roof bolts installed in the Coal Measure section of the tunnel were not installed with the correct length of resin capsule and as such, are almost certainly not fully encapsulated, e) the spacing between the roof bolts (in particular in the Coal Measure section of the tunnel) was too large and therefore not to the design standard, f) the roof bolt testing was not completed to the required standard and there is no or little information available with regard to the quality of the applied shotcrete (both in terms of mix strength and thickness), g) the length of the shot holes (again in the Coal Measure section of the tunnel) and hence the length of the excavation inbye of the 15 October 2014 last completed row of roof support exceeded the recommended standard and h) the monitoring stations were not always installed to the correct standard.

Adequacy of the Current Ground Support

82. High temperatures from fires can cause significant material damage in tunnels and can lead to enhanced cracking in the immediate roof strata and spalling of the shotcrete and mesh degradation. Further to this, the experience gained from both the Southland and Blakefield mine fires in NSW suggests that it is not possible to rule out some degree of significant fire related damage to the roof (including falls of ground) in the weaker Coal Measure strata.

83. The issue of weathering is of particular concern in regard to a) the faulted area located between the 1050 and 1072m marks and the Hawera Fault where a significant amount of clay was encountered between the heavily faulted material and b) the Coal Measure section of the tunnel where a significant amount of mudstone and thin coal seams were encountered in the roof.

84. Documentation of earthquake related damage indicates that surface structures are typically more extensively damaged than tunnels. The reasons for this include a) the fact that ground motions are amplified as they pass from bedrock to the surface, b) tunnel linings and the rock surrounding the tunnel are in compression and, in doing so, restrict the amount of movement and c) the relatively small dimensions of tunnels compared to buildings, mean that their natural frequency is generally less than the ground motion frequency.

85. Furthermore, whilst it is not clear as to whether or not the support design considered the risk of earthquake related damage, accepting that the installed ground support typically comprises of shotcrete, bolts and mesh, it is reasonable to conclude that these support elements will provide adequate surface pressure to restrain any ground motions associated with a seismic event. However the effectiveness of these support measures will be strongly dependent on a) the source distance of the earthquake from the tunnel opening, b) the current condition of the tunnel (in particular in the weathered material located around the mouth of the tunnel and the heavily faulted zones in the tunnel) and c) whether or not the slip occurs on a fault (such as the Hawera Fault)

Ability to Assess the Adequacy of the Ground Support during Re-entry

86. In order to assess the adequacy of the ground support installed in the gneiss, the roof will need to be re-mapped and a new Q-index determined. This process will be difficult in areas which have been meshed and will not be possible in those areas where the roof and / or sides have been covered with shotcrete.

87. In regard to the Coal Measure section of the tunnel, any assessment of roof stability during re-entry will be very difficult. Points considered in this regard include a) the likelihood that most if not all of the tunnel has been covered with shotcrete and b) it is not necessarily reasonable to assume that the very weak rock types encountered in this part of the tunnel will exhibit measurable or visual signs of deformation that would otherwise indicate that the roof is at a critical level of instability.

88. A point of note is the likely inability to sound and bar down any loose material that may be present in the roof or sides of the tunnel from a safe position.

Potential for a Significant Rush of Air as a Result of a Collapse in the Inbye Mine Workings

89. Accepting that the majority of the roof in the in seam roadways located on the inbye side of the 2300m mark was supported with a reasonably high density of 4, 6 or 8m long cables, it is nonetheless of note that in most areas a) the roof was dominated by a variable and weak sequence of coal and carbonaceous mudstone and b) mapped in a poor condition.

90. Whilst the pillars were designed to be in a stable long-term condition, a) due to problems with the floor, a large number of the roadways were driven to a height of 4 to 5m and not the assumed maximum height of 3.5m and that as a result b) this will have compromised the stability of the ribs.

91. Considering the above in conjunction with the almost certain destructive influence of the explosions and the fire, it is reasonable to assume that the integrity of the roof has been compromised and as a result it is not possible to rule out the possibility that a large-scale roof collapse could occur during the proposed re-entry of the tunnel.

Independent Technical Review of Proposed Pike River Mine Drift Re-entry Plan and Associated Risk Management

92. The independent **Technical Review of Proposed Pike River Mine Drift Re-entry Plan and Associated Risk Management** was prepared by Dr Dennis Black, Principal Consultant of PacificMGM, Mining and Gas Management Consultants. Its scope was:

92.1 Carry out a technical assessment of the proposed re-entry plan to determine its robustness and thoroughness of control identification.

92.2 Develop a verification plan to ensure all controls identified are integrated into the Operational Management Plan.

92.3 Test the TARPS, controls and Management Plan for the project.

92.4 Evaluate, via fire simulation software, the potential outcomes of a diesel fire in the Drift, and how long it would take for a potentially explosive mixture of gases to be produced. This would indicate how long men have to escape (assuming they were on the outbye side) before a potential explosion could occur.

92.5 Assess the practicality of exhausting ventilation as a control for UG Fire related risks.

92.6 Provide an assessment of the project complexity and inherent risk.

93. This scope was developed on the basis that the full risk assessment and evaluation process was completed. At the time of the development of this report, the risk process is in an iterative stage and was not taken to completion as it was identified that some of the risks identified were potentially insurmountable. Therefore points 85.2 and 85.3 were not completed. The findings for the remaining points were in summary:

93.1 There are over 600 control actions, both existing and new that are needed to be incorporated into a management system. These all need to be thoroughly tested, personnel trained and supervision established. This was considered high risk.

93.2 The reliance on the effectiveness of the single Rocsil plug, the complexity of the ventilation and gas management controls, the need to manually adjust processes, the nature and accessibility of the key areas and risk of damage to infrastructure and services due to inclement weather was considered high risk.

93.3 The evaluation of the potential development of an explosive atmosphere due to a diesel fire determined that it was not possible under the circumstances modelled for this to occur. The scenario was a fire at 2000m, surface fan off, 125mm inbye borehole open. CO reached 6.65% (explosive limit is 12.5%) in 3.59hrs and levelled out.

93.4 Exhausting ventilation is a viable option as a control for the risk of fire in the Drift. Rigid ducting >1000mm would be required. Further risk assessment would be required to assess the impact of negative pressure on the outbye side of the Rocsil plug.

SECTION 5: CONCLUSION AND RECOMMENDATION

94. 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 as having high residual risks associated with them (details of each risk are noted in each risk evaluation in Section 4). These four areas are:

94.1 Strata failure;

94.2 Gas / ventilation management;

94.3 Complexity of risk controls; and

94.4 Subsequent entrapment.

Strata Failure Summary

95. Whilst the rock mass classification methodology used is appropriate and it is likely the section of the drift outside the Hawera Fault has been adequately supported to a standard appropriate for a permanent opening in a mine, the support in the Coal measures section of the Drift was "almost certainly not designed to an acceptable standard".

96. Study of the geotechnical engineer's daily reports during construction reveals there to be substantial evidence that ground support standards were not adhered to and that significant problems were experienced during the construction phase.

97. The highly faulted and folded sequence of thin coal seams and mudstones in the section of Drift in bye the Hawera Fault would almost certainly be susceptible to some degree of time dependant deterioration. The fault intersected at approximately 1050m contained clay materials which will also be likely to have deteriorated with time.

98. Various sections of the Drift have been exposed to elevated temperatures either at the time of the disaster or subsequently during the work to extinguish it. Australian experience shows that it is impossible to rule out some degree of significant damage to the roof in weaker Coal Measures and to resin anchoring systems used in support.

99. The proposed controls to manage the risks associated with strata and roof conditions rely on a verification system that puts people at risk. Roof condition is to be assessed using scaling bars followed by close examination by the Geotechnical Engineer from a man basket on the loader. Both processes will expose the people undertaking the task to additional risk. It is concluded that the roof support integrity cannot be safely assessed adequately to give the assurance required.

Gas / Ventilation Management Summary

100. The proposed solution to re-ventilating the Drift and maintaining a respirable working environment in the Drift without increasing the risk of any spontaneous combustion inbye the plug, is technically sound. However, the reliance on a single plug of fragile material is considered high risk[6]. The management strategy also relies on multiple factors that are each subject to significant risk, including the supply of nitrogen, the ability to manage barometric change, the integrity and

[6] Technical Review of Proposed Pike River Mine Drift Re-entry Plan and Associated Risk Management; Dr D Black, Oct 2014, at p (v).

maintenance of the monitoring and control systems and absence of catastrophic events such as roof fall causing windblast.

101. The nitrogen supply is via a 75mm polyethylene line some 2.5kms long laid on the ground in steep terrain and unprotected from material falling on it. The supply must be regarded as tenuous due to the potential damage the line may suffer in the steep terrain along the route to the injection site. In addition there is a history of failure of electrical supply to the site compromising the continuous supply of nitrogen to the injection point. While the failure of the nitrogen supply and the management of the methane in the Mine itself is unlikely to lead to immediate catastrophic failure, a combination of this control failing with a second risk being realised (eg fire on mobile plant) would compromise the safety of persons engaged in the re-entry work.

102. Modelling has been undertaken to determine the likelihood of an explosive atmosphere being created as the result of accumulation of products of combustion in the event a vehicle caught fire. The modelling shows that whilst CO accumulates in bye the site of the fire and increases to +/- 7% after 3.6 hrs it does not continue to increase and does not reach an explosive range (12%). However, the presence of products of combustion will present very significant risk to persons both in bye and out bye the site of the fire, depending on the management of the forced ventilation.

Complexity of Risk Controls Summary

103. The success of the project relies on the development of adequate procedures to address all of the 600+ control actions and ensuring all personnel involved understand their requirements and correctly implement the planned actions and comply with all procedures. It is the view of the Steering Committee that this complexity is in itself a risk to the safe completion of the re-entry project.

104. The execution plan for the project relies heavily on human behaviour and compliance with agreed plans. If there is a 10% chance of a procedure or control failing then, in this situation with over 600 controls identified, it is conceivable that 60 plus procedures could fail. Such an occurrence would significantly increase the risk to personnel engaged in this project.

105. As the distance from the portal increases the risks are escalated as a consequence of the increase in distance to safety. The principal area of concern as a result of this escalation is the duration of exposure to the risks. It has been predicted that, based on the weather delays of up to 70% of the time, the project could take as long as 6 months. In addition, as the re-entry progresses into the area outbye PRDH35, it is known from camera work undertaken since the explosions that there is a substantial debris field in the drift of +/- 500mm high which will impede progress and present new and unquantifiable risks to the personnel involved. This is also exacerbated by the requirement to have the surface ventilation controls manned at all times the Drift is occupied, and the difficulty of meeting this requirement on a continual basis due to surface weather constraints and the fragile nature of the hard control to manage ventilation and gas in the Mine.

106. Common mode failure is considered to be high risk. For example poor weather not only affects capability of controls, but also represents a high risk to the infrastructure and services required for the project to be safely executed. It has been established that there is generally only a 30% chance of being able to service the grizzly borehole site (majority of the ventilation control). This risk, put in combination with a simultaneous event in the Drift represents a high risk. The nitrogen line, a key element of the ventilation controls is laid on the ground in unstable terrain and has suffered damage since installation necessitating repair. Electrical supply to the site is dependent on the maintenance of the line that is installed through the surrounding beech forest and which is prone to damage during wind events which may also damage communications with the shaft collar area (borehole control site).

Subsequent Entrapment Summary

107. The controls offered to address entrapment of persons in bye a fall of ground or vehicle fire are limited to:

- The use of multiple airlines;
- The use of compressed air breathing apparatus (**CABA**);
- The presence of a refuge chamber (if located inbye the fall or fire); and
- “Retreat” to the PRDH35 or 52 to secure an ongoing air and communications option.

108. The airlines are subject to damage from both fire and a fall of ground. This risk is mitigated by the facts the airlines are large and in one case protected by the conveyor structure. In certain stages of the inspection beyond the ventilation, it cannot be made certain that the pipes are all intact and the correct fittings are available. It is considered likely that significant damage will have occurred to the air lines at and inbye the Pit Bottom in Stone where significant lengths of pipe were suspended by chain and cross the Drift from side to side.

109. The use of CABA and the refuge chamber is limited to the capacity of the units concerned, neither of which will sustain life for the likely period required to recover persons trapped in an environment that becomes irrespirable.

110. The absence of a second means of egress for personnel working in a situation where they become entrapped is, in this project, a serious risk escalation factor. It must be noted here that the project covers entry into approximately 2300m of drift. If no second means of egress is available, men may be required to survive for a significant period without any real certainty of their successful recovery.

111. There is no opportunity to develop emergency drill sites for the evacuation of personnel via large diameter bore holes. The existing site at PRDH35 is inadequate to support a rig of sufficient size to drill a 600mm hole and other sites to the east (out bye the plug) are limited to areas of suitable terrain and where a rig may be located. The practicality of locating a rig into a drill site limits the potential of this recovery method and in itself has many risks associated with the exercise.

112. The “retreat” to and use of the boreholes (PRDH 35 and 52) for air, communications and supplies will require men to pass through an area of potentially unstable (or fallen) ground where there is a known and significant debris field, thereby exposing them to additional risk or indeed an impossible situation of a roof fall or impassable debris field. This is considered an optimistic control for a foreseeable risk.

Overall Summary and Recommendation of the Steering Committee

113. SENZ has been contracted to determine whether a technically feasible, safe and financially credible means of re-entry to the Drift is possible. The process undertaken to determine each of these criteria has involved project design and iterative risk assessment undertaken with input from SENZ staff and independent technical advisors throughout. The final review of the risk assessment has been completed by the Steering Committee formed to make a recommendation to the Health & Safety Committee of the Board of Directors.

114. Based on the review of the risk assessment process that identifies four areas as continuing to have high residual risks associated with them, the findings of the Steering Committee are that:

114.1 The proposed re-entry methodology for the Nitrogen Injection Option is "technically possible". Measures required to address these unacceptable risks will be associated with significant cost. The establishment of a second means of egress, or the installation of full ground support, will cost well in excess of the project budget[7] and therefore fails the test of being “financially credible”. In addition the implementation of such controls will require significant investment of time which may compromise the integrity of the Rocsil plug (if installed at that stage) and hence the ventilation management control mechanism.

114.2 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. In some cases the proposed controls do not achieve a satisfactory level of risk reduction and the residual risk lies at a high or possibly very high status. Many controls are “fragile” and susceptible to failure due to factors outside the immediate control of the operators. The risk assessments demonstrate it is impossible to categorically manage all risks to a level of residual risk that is acceptable.

115. The Steering Committee are therefore of the opinion that, 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.

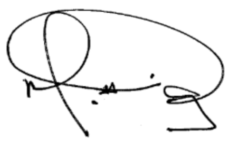
[7] SENZ's 2011 estimate of the cost of developing a second means of egress was around $90 – 105M, with estimated ground support costs based on a fully supported roadway of a further $5k/m.

This report has been prepared for the Health & Safety Committee of the Board of Solid Energy New Zealand Limited by the Pike River risk assessment Steering Committee. The report has drawn on the project description and associated risk assessments together with technical reports provided to the Risk assessment teams and specifically to the Steering Committee.

The Steering Committee comprised:

Mr Dan Clifford; CEO Solid Energy New Zealand:

Mr Mark Pizey; Group Manager: Environment and Community, Solid Energy New Zealand;

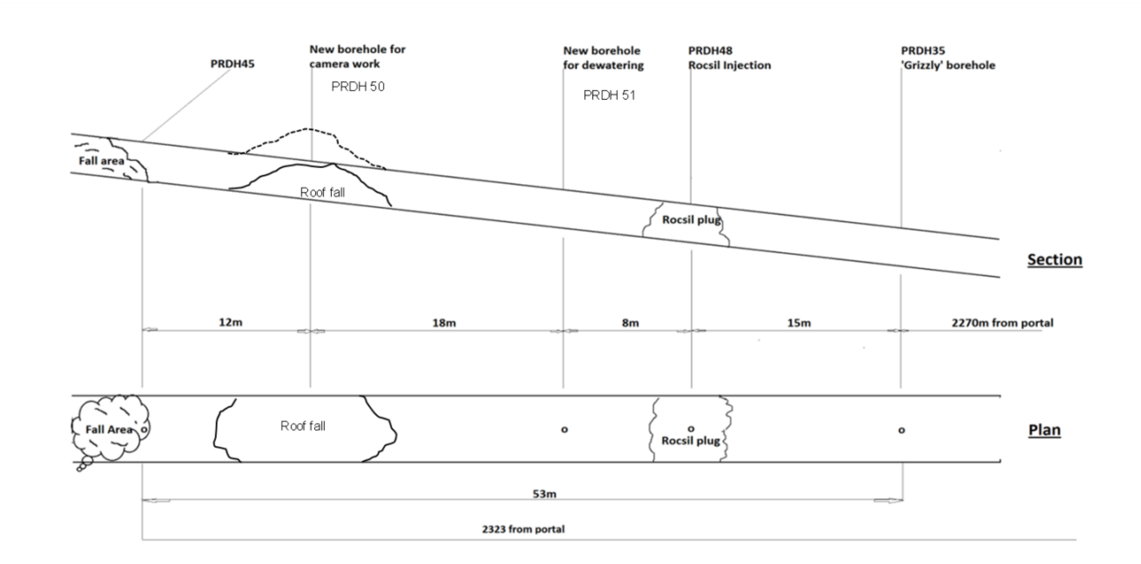


Mr Bernie McKinnon; Principal, Promin Pty Ltd.

4 November 2014

APPENDIX 1

CROSS-SECTION OF THE DRIFT AT ITS TOP END & LOCATION OF BOREHOLES



APPENDIX 2

DETAILED RE-ENTRY METHODOLOGY FOR NITROGEN INJECTION OPTION

Methodology / Concept

The Drift is sealed at the 170m mark and infrastructure has been installed up to this point. A +200 litre/sec nitrogen generating plant is installed on site and nitrogen supply lines have been installed to the 170m seal and to PRDH51 just inbye the Rocsil plug site.

The first stage of the project would be to inject nitrogen at the 170m seal whilst releasing methane from PRDH35. Once nitrogen reports to the collar of PRDH35, this hole would be sealed and PRDH47 (inbye the mine workings) would be opened to permit the release of methane from the mine workings proper as the nitrogen is injected from the portal and PRDH51. Once nitrogen reports to a monitoring point inside the mine workings proper, the Rocsil plug would be inserted and the nitrogen injection at the portal would be stopped, while the injection at PRDH51 would be maintained to ensure a positive pressure is maintained on the inbye side of the plug.

At this stage, project personnel would spend time analysing and adjusting the mine ventilation status over a period of time to gain assurance that a stable environment could be maintained during fluctuations in climatic conditions. During this period, a large diameter borehole (300mm) (PRDH52) would be drilled to intersect the Drift outbye the plug location. This would be used to re-ventilate the Drift (purging it of nitrogen). Once confidence in the capacity to manage the Mine environment is gained, the Drift would be re-ventilated to fresh air (from the surface fan) by opening PRDH52 to establish a ventilation circuit from the 170m seal. The re-ventilation would be undertaken through the creation of a pressurised chamber between the portal doors and the 170m seal. Following replacement of the nitrogen atmosphere with fresh air and the removal of the 170m seal, the Mine would be continuously monitored to ensure the relative pressure inbye the Rocsil plug could be maintained higher than that in the Drift to ensure no ingress of air (oxygen) to the Mine workings proper, while still maintaining a respirable atmosphere in the Drift.

On completion of the re-ventilation, Mines Rescue personnel would begin a cyclic examination and recovery of the Drift. The cycles involved would comprise an examination on foot of a length of up to 100m from the last point of recovery. The team would carry appropriate gas monitoring equipment and closed circuit breathing apparatus. The examination would include a visual/physical and initial geotechnical assessment of the ground conditions, the presence of any forensic evidence and the clearing of an access track as required. Once the examination is complete, ventilation ducting would be brought forward from the last recovered point for a distance of 50m and an auxiliary ventilation circuit established to this new recovered point. This, in turn, would be followed by the extension of the required services (air lines, water take-offs, monitoring equipment and communications). An additional geotechnical assessment (undertaken by a Geotechnical engineer) would be performed up to the point of the recently advanced ducting and services. Once these steps are complete the cycle would be repeated to recover a further 50m of Drift.

At any point that the Drift is initially deemed impassable, whether it be from debris, obstructions or the condition of the Drift roof and sides, the recovery would stop and the remedial steps and recovery would be the subject of a re-assessment.

The Mines Rescue team would be supported by SENZ technical resources including a geotechnical engineer, mechanical and electrical engineers and other specialist personnel as required. All such personnel would be required to have undergone CABA training. Ventilation ducting, pipework and other consumables would be transported to the recovered point using an EIMCO loader and men would be transported using an SMV personnel carrier.

Four robots, that were abandoned during post explosion survey work, are located in the Drift and would need to be removed. In addition, a Juggernaut loader, which is located 1600m from the portal, would need to be removed to allow further access to the Drift when using diesel vehicles.

Once the Drift has been recovered to the furthest extent possible (potentially up to the Rocsil plug just beyond PRDH35) a permanent seal would be constructed at a suitable location and the nitrogen injection at PRDH51 would cease.

On completion of the forensic examination of the Drift, the Drift would be sealed by way of a permanent seal inbye the portal and long term site monitoring established.

APPENDIX 3

RISK ASSESSMENT RESIDUAL RISK TRENDS

WRAC initial risk ranking

	UNDERGROUND STEPS (30-47)						
	CONSEQUENCE						
Risk Rating	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	LIKELIHOOD	
	M - 5	M - 10	H - 15	VH - 20	VH - 25	Expected	5
	M - 4	M – 8 39.01, 39.03	H – 12	H - 16	VH - 20	Likely	4
	L - 3	M - 6 34.03, 39.06	M - 9 31.01, 36.01, 38A.02, 39.04, 39.05, 42A.01, 44.03, 47.04	H – 12 34.02, 34.05, 34.06, 35.01, 37.01, 37.04	H – 15	Reasonably Expected	3
	VL – 2 40.04	L - 4 38.01, 38.02, 39.02, 39.07, 40.03	M - 6 38A.01, 40.01, 40.02, 45.03	M - 8 33.01, 34.04, 37.03, **37.06**, **37.08**, 41.01, 42.02, 43.01, 44.02, 45.01, 45.02, 47.01,	H – 10 37.02, 37.07, 42.01, 41A.02, 44.01	Unlikely	2
	VL - 1	VL - 2	L - 3	M – 4 37.05, 47.02, 47.03	M – 5	Conceivable but Rare	1

WRAC residual risk

	UNDERGROUND STEPS RESIDUAL RISK TABLE (30-47)						
	CONSEQUENCE						
Risk Rating	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	LIKELIHOOD	
	M - 5	M - 10	H - 15	VH - 20	VH - 25	Expected	5
	M - 4	M - 8	H – 12	H - 16	VH - 20	Likely	4
	L - 3	M – 6 34.01, 39.01	M – 9 31.01, 36.01, 38A.02, 42A.01, 44.03	H - 12	H – 15	Reasonably Expected	3
	VL – 2 40.04	L – 4 34.03, 38.01, 38.02, 39.02, 39.06, 39.07, 40.03	M – 6 32.01, 38A.01, 39.04, 39.05, 40.01	M - 8 33.01, 34.02, 34.04, 34.05, 34.06, 35.01, 37.01, 37.03, 37.04, **37.06, 37.08**, 39.03, 41.01, 42.02, 43.01, 44.02, 45.01, 45.02	H - 10 37.07, 41A.02	Unlikely	2
	VL - 1	VL - 2	L – 3 40.02, 45.03	M – 4 37.05	M – 5 37.02, 42.01, 44.01	Conceivable but Rare	1

Post Bowtie

	UNDERGROUND STEPS RESIDUAL RISK TABLE (30-47)						
	CONSEQUENCE						
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	LIKELIHOOD	
Risk Rating	M - 5	M - 10	H - 15	VH - 20	VH - 25	Expected	5
	M - 4	M - 8	H – 12	H - 16	VH - 20	Likely	4
	L - 3	M – 6 34.01, 39.01	M – 9 31.01, 38A.02, 42A.01, 44.03	H - 12	H – 15	Reasonably Expected	3
	VL – 2 40.04	L – 4 34.03, 38.01, 38.02, 39.02, 39.06, 39.07, 40.03	M – 6 32.01, 36.01, 38A.01, 39.04, 39.05, 40.01	M - 8 33.01, 34.02, 34.04, 34.05, 34.06, 35.01, 37.01, 37.04, **37.06**, 39.03, 41.01, 42.02, 43.01, 44.02, 45.01, 45.02	H - 10 37.07, 41A.02	Unlikely	2
	VL - 1	VL - 2	L – 3 40.02, 45.03	M – 4 37.03, 37.05, **37.08**	M – 5 37.02, 42.01, 44.01	Conceivable but Rare	1

Post FTA / ETA

	UNDERGROUND STEPS RESIDUAL RISK TABLE (30-47)						
	CONSEQUENCE						
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	LIKELIHOOD	
Risk Rating	M - 5	M - 10	H - 15	VH - 20	VH - 25	Expected	5
	M - 4	M - 8	H – 12	H - 16	VH - 20	Likely	4
	L - 3	M – 6 39.01	M – 9 31.01, 38A.02, 42A.01,	H - 12	H – 15	Reasonably Expected	3
	VL – 2 40.04	L – 4 34.01, 34.03, 38.01, 38.02, 39.02, 39.06, 39.07, 40.03	M – 6 32.01, 36.01, 38A.01, 39.04, 39.05, 40.01, 44.03	M - 8 34.06, **37.06**, 41.01, 43.01, 45.02	H - 10	Unlikely	2
	VL - 1	VL - 2	L – 3 40.02, 45.03	M – 4 33.01, 34.02, 34.04, 34.05, 35.01, 37.01, 37.03, 37.04, 37.05, **37.08**, 39.03, 42.02, 44.02, 45.01,	M – 5 37.02, 37.07, 41A.02, 42.01, 44.01	Conceivable but Rare	1

Post Steering Committee

	UNDERGROUND STEPS RESIDUAL RISK TABLE (30-47)						
	CONSEQUENCE						
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5	LIKELIHOOD	
Risk Rating	M - 5	M - 10	H - 15	VH – 20 37.01	VH - 25	Expected	5
	M - 4	M - 8	H – 12	H - 16	VH - 20	Likely	4
	L - 3	M – 6 39.01	M – 9 31.01, 38A.02, 42A.01,	H – 12 37.07	H – 15	Reasonably Expected	3
	VL – 2 40.04	L – 4 34.01, 34.03, 38.01, 38.02, 39.02, 39.06, 39.07, 40.03	M – 6 32.01, 36.01, 38A.01, 39.04, 39.05, 40.01, 44.03	M - 8 34.06, 41.01, 43.01, 45.02, 34.04, 37.04	H – 10 37.02, 37.06,	Unlikely	2
	VL - 1	VL - 2	L – 3 40.02, 45.03	M – 4 33.01, 34.02, 34.05, 35.01, 37.05, 37.08, 39.03, 42.02, 44.02, 45.01,	M – 5 41A.02, 42.01, 44.01, 37.03	Conceivable but Rare	1

APPENDIX 4

GEOTECHNICAL CONSIDERATIONS ASSOCIATED WITH THE PROPOSED RE-ENTRY INTO THE PIKE RIVER MINE TUNNEL

15 October 2014

Mr Dan Clifford
Chief Executive Officer
Solid Energy New Zealand
PO Box 1303
Addington
Christchurch
New Zealand

Report No. 1413417-145-R-Rev0

Dan

Re: Geotechnical Considerations Associated with the Proposed Re-entry into the Pike River Mine Tunnel (Confidential and Legally Privileged)

This assessment will address the key geotechnical factors which need to be considered as part of the proposed re-entry into the access tunnel in Pike River Mine.

As part of this assessment, various sources of information were used including, URS's design reports, URS's face mapping reports, McConnell Dowell's daily engineer reports and monitoring and mapping data collected during the development of the tunnel and the neighbouring in seam workings (see **References**).

On the basis of the above, the main points of note with regard to the construction of the tunnel can be summarised as follows (see **Figure 1** for a copy of the tunnel plan):

- **The tunnel construction commenced in late 2006 and was completed in late 2008.**
- **The tunnel is approximately 2300m long and was driven as a single-entry excavation.**
- **The tunnel is an incline and outbye of the 1200m mark was driven at a variable grade of 1 in 11 to 1 in 41, and inbye of the 1200m mark, at a consistent grade of 1 in 8.**
- **Outbye of the 2100m mark the tunnel was driven through metamorphic gneiss and inbye of the 2100m mark, in sedimentary Coal Measure strata.**

- **The transition between the gneiss and the Coal Measure strata is controlled by a 500 to 600m throw thrust fault called the Hawera Fault** – note: the Hawera Fault a) dips outbye and as such, hades over the Coal Measure section of the tunnel and b) is aligned at a near 45 degree angle to the strike of the tunnel.

- **The surface topography and as such, the Depth of Cover, is highly variable and (i) in the gneiss, the tunnel reaches a maximum of depth approximately 180m at the 1000m mark and (ii) in the Coal Measures, a maximum depth of approximately 150m at the 2210m mark** – note: in and around the Hawera Fault the Depth of Cover is approximately 150m.

- **Due to the inherent competency of the gneiss, on the outbye side of the Hawera Fault the tunnel was driven with a drill and blast technique and on the inbye side of the fault, with a combination of drill and blast and roadheader** – note: in the Coal Measure section of the tunnel, the contractors had to revert to drill and blast on several occasions on account of mechanical breakdowns with the roadheader and the excessive hardness of the floor.

- **The majority of the tunnel was driven to a nominal width of 5.5m and a nominal height of 4.5m** – note: a) the only notable exceptions to this include the first 50m of the tunnel, which was driven to a nominal width and height of 6m and the various intersections formed up in the Pit Bottom in Stone section of the tunnel and b) although outside the scope of this assessment, it is nonetheless of note that a number of high and wide drives were also formed up off to the side of the main tunnel in the Pit Bottom in Stone.

- **A fall of ground has been reported in the Coal Measure section of the tunnel at or around the 2300m mark.**

Considering each of the above in conjunction with the numerous explosions and the fire which occurred in the inbye mine workings in late 2010 and the four years since during which the tunnel has been sealed-up, the main points to be considered as part of this assessment can therefore be summarised as follows:

- **The adequacy of the support design methodology utilised during the construction of the tunnel, with particular reference to the design standards commonly used in the civil tunnelling industry.**

- **The adequacy of the reported as-built ground support.**

- **The adequacy of the installed ground support from the perspective of a single-entry driveage that (i) has to varying degrees been adversely affected by at least four explosions and a fire, and time-dependent weathering and (ii) will need to consider the possible impact of an earthquake.**

- **The ability to assess the adequacy of the installed ground support during re-entry.**

- **Possible remediation measures that maybe required upon re-entry.**

- **The potential for a significant rush of air as a result of a collapse in the inbye mine workings and in doing so, the consequential expulsion of a noxious or explosive mixture of gas into the tunnel.**

1.0 The Adequacy of the Support Design Methodology Used During the Construction of the Tunnel

(i) The Q-index used is a) an appropriate method of ground support design in hard jointed rock masses, as per the gneiss encountered on the outbye side of the Hawera Fault and b) appears to have been applied to an acceptable standard – note: a) the Q-index is one of the most common rock mass classification systems used for the design of ground support in hard rock tunnels and caverns throughout the world and b) the support recommendations from the Q-index are based on data collected from thousands of examples of tunnels and other civil engineering case studies.

(ii) The Q-index appears to have been applied in a manner that is broadly appropriate to the design requirements commonly associated with a life-of-mine access tunnel – note: the design of the ground support has been appropriately classified as a "Type C: permanent mine openings, water tunnels, pilot tunnels, drifts and headings for large openings" with an Excavation Support Ratio (ESR) value of 1.6.

(iii) However, potential deficiencies in the design methodology include a) despite the presence of several distinctly weaker zones of strata, the use of a consistent ESR or safety requirement factor does not conform to the recommended use of the Q system and b) the inability, due to the lack of transparent information, to verify the Factors of Safety associated with any potential block or stress induced failure – note: a) a low ESR indicates the need for a high level of safety, while higher ESR values indicate that a lower level of safety is acceptable, b) that said, an ESR value of 1.3 is sometimes adopted for critical components of mine infrastructure and high traffic areas and an ESR value of 1 for very weak rock types, c) as with most empirical models, the Q-index should preferably be used in conjunction with other methods of support design including in this case, block stability assessments and rock mass simulation models and d) whilst the ESR is similar to a Factor of Safety, it does not provide any information on the forces (both driving and restraining) acting on possible rock wedges, and therefore it is not clear whether the capacity of the reinforcement system is appropriate to the encountered ground conditions.

(iv) As the rock is both inherently softer and bedded, it is debatable as to whether or not a) it was appropriate to use the Q-index in the Coal Measure section of the tunnel and b) rely on the retention of an arch in the crown of the tunnel – note: due to the inherent weakness of the strata, it was not always possible to retain an arched profile in this section of the tunnel and in doing so, it is reasonable to assume that in these areas this would have compromised the overall effectiveness of the support design (in particular the shotcrete).

(v) In regard to any comparisons that can be drawn to the design standards typically applied to a civil tunnel, accepting the deficiencies noted above, the main points of note are a) the majority of the tunnel located in the gneiss has almost certainly been supported to a standard that would have been acceptable in what could be termed a "moderate risk" civil structure (e.g. water tunnels, pilot tunnels and access drifts into large openings), b) critically, this this does not include road or railway tunnels where the risk of human exposure to falls of ground is of heightened concern and c) the support installed in the Coal Measure section of the tunnel has almost certainly not been designed to an acceptable standard – note: a) of particular concern in regard to the Coal Measure section of the tunnel is the consistent use of an ESR of 1.6 and as will be detailed in the following sections of the report, the absence of Rib Reinforced Shotcrete Arches, the quality of the support installation and the absence of any quality roof monitoring data and b) one other deficiency from a civil engineering perspective in both sections of the tunnel is the longevity of the installed support, in particular the use of black bolts in preference to galvanised bolts and the use of resin anchored bolts in preference to cement grouted bolts.

2.0 The Adequacy of the Installed Ground Support

(i) An adequate type and density of ground support (including rock bolts, steel mesh and where appropriate, 50mm of shotcrete in areas where some form of skin or weathering protection was deemed necessary and around 150 to 250mm of shotcrete in those areas where an added level of structural stability was deemed necessary) appears to have been installed in the gneiss section of the tunnel – note: a) the only area of possible concern in this section of the tunnel would be in and around the fault encountered between the 1050 and 1072m marks where a significant amount of clay and associated shears were encountered and b) the mapping reports suggest that this fault is aligned at an unfavourable near 20 degree angle to the tunnel.

(ii) Whilst a reasonably high density of roof support (including cables and shotcrete) was installed in the Coal Measure section of the tunnel, it is of note that a) considering the absence of any quality roof monitoring or mapping data, it is difficult to make a definitive comment on the adequacy of the support, b) as mentioned previously, in those areas where it was not possible to maintain an arched profile in the roof, the adequacy of the installed ground support (in particular the shotcrete) is debatable and c) the highly faulted and folded sequence of thin coal seams and mudstones would almost certainly be susceptible to some degree of time dependent deterioration – note: a) accepting that the strata in the majority of the Coal Measure section of the tunnel was (due to the presence of the Hawera Fault) dipping at angles of >20 degrees to the horizontal, unlike a hard jointed rock mass (like the gneiss), in bedded sedimentary strata the roof tends to buckle or sag to some degree prior to it reaching a critical level of instability, b) the daily reports indicate that in some areas in the Coal Measure section of the tunnel, the roof and sides were showing signs of deformation and / or cracking of the shotcrete almost immediately after driveage, c) it is generally regarded that for shotcrete to work to its optimum capability and in doing so, confine and support the roof, an arched profile must be maintained, d) in areas, up to 180mm of side wall closure was measured several weeks after the tunnel was developed, e) the Q method of ground support suggests that in weak rock types (as per that encountered in the Coal Measure section of the tunnel), a much greater use of shotcrete (in particular the use of Rib Reinforced Shotcrete Arches) and cement grouted rock bolts would probably have been appropriate and f) accepting that the Rock Mass Ratings (RMR) in most coal mines range between 35 and 60, the reported RMR's on the inbye side of the Hawera Fault were as low as 10 to 20.

(iii) In regard to the quality of the installed ground support, several concerns are of note from the engineer's daily reports, including occasions where a) the shotcrete was often applied too far outbye of the face, to an insufficient thickness of <150mm and / or was noted to have cracked and needed to be repaired, b) the cables in the Coal Measure section of the tunnel were either installed too far outbye of the face, not grouted for several days and / or the incorrect grout was used, c) the roof bolts (especially around the fault located between 1050 and 1072m marks) did not achieve the required anchorage capacity and from the available information, it is not clear what remedial actions were taken as a result of this, d) a large number of the 2.4m long roof bolts installed in the Coal Measure section of the tunnel were not installed with the correct length of resin capsule and as such, are almost certainly not fully encapsulated, e) the spacing between the roof bolts (in particular in the Coal Measure section of the tunnel) was too large and therefore not to the design standard, f) the roof bolt testing was not completed to the required standard and there is no or little information available with regard to the quality of the applied shotcrete (both in terms of mix strength and thickness), g) the length of the shot holes (again in the Coal Measure section of the tunnel) and hence the length of the excavation inbye of the

last completed row of roof support exceeded the recommended standard and h) the monitoring stations were not always installed to the correct standard.

3.0 The Adequacy of the Current Ground Support

(i) High temperatures from fires can cause significant material damage in tunnels and can lead to enhanced cracking in the immediate roof strata and spalling of the shotcrete and mesh degradation. Further to this, the experience gained from both the Southland and Blakefield mine fires in NSW suggests that it is not possible to rule out some degree of significant fire related damage to the roof (including falls of ground) in the weaker Coal Measure strata – note: critically in this regard is a) the fact that up to 8m of coal is located in the roof in the far inbye end of the tunnel and b) the inbye end of the tunnel would have been located the closest to the fire and as such, would have experienced the highest temperatures.

(ii) The issue of weathering is of particular concern in regard to a) the faulted area located between the 1050 and 1072m marks and the Hawera Fault where a significant amount of clay was encountered between the heavily faulted material and b) the Coal Measure section of the tunnel where a significant amount of mudstone and thin coal seams were encountered in the roof – note: the camera which was lowered down Borehole PRDH 35 indicates free flowing water in one section of the roadway.

(iii) Documentation of earthquake related damage indicates that surface structures are typically more extensively damaged than tunnels. The reasons for this include a) the fact that ground motions are amplified as they pass from bedrock to the surface, b) tunnel linings and the rock surrounding the tunnel are in compression and in doing so, restrict the amount of movement and c) the relatively small dimensions of tunnels compared to buildings, mean that their natural frequency is generally less than the ground motion frequency.

Furthermore, whilst it is not clear as to whether or not the support design considered the risk of earthquake related damage, accepting that the installed ground support typically comprises of shotcrete, bolts and mesh, it is reasonable to conclude that these support elements will provide adequate surface pressure to restrain any ground motions associated with a seismic event. However the effectiveness of these support measures will be strongly dependent on a) the source distance of the earthquake from the tunnel opening, b) the current condition of the tunnel (in particular in the weathered material located around the mouth of the tunnel and the heavily faulted zones in the tunnel) and c) whether or not slip occurs on a fault (such as the Hawera Fault).

4.0 The Ability to Assess the Adequacy of the Ground Support during Re-entry

(i) In order to assess the adequacy of the ground support installed in the gneiss, the roof will need to be re-mapped and a new Q-index determined. This process will be difficult in areas which have been meshed and will not be possible in those areas where the roof and / or sides have been covered with shotcrete – note: a) from the as-built drawings, it is estimated that around 75% of the tunnel located on the outbye side of the Hawera Fault has been covered with shotcrete, b) of critical concern in this regard is the faulted section located between the 1050 and 1072m marks and c) compared to sedimentary strata, it is not appropriate to rely solely on roof deformation mapping, as failure in this more massive and much stronger rock type is typically associated with sudden slip along pre-existing joints or mining induced fracture planes.

(ii) In regard to the Coal Measure section of the tunnel, it is again assessed that any

assessment of roof stability during re-entry will be very difficult. Points considered in this regard include a) the likelihood that most if not all of the tunnel has been covered with shotcrete and b) it is not necessarily reasonable to assume that the very weak rock types encountered in this part of the tunnel will exhibit measurable or visual signs of deformation that would otherwise indicate that the roof is at a critical level of instability – note: as a general rule a) weak and / or structurally altered sedimentary rock types cannot tolerate large amounts of displacement before any beams that may be present in the roof start of breakdown and as such b) can reach a critical level of instability after 10 or so mm's of displacement.

(iii) Another point of note is the ability to sound and bar down any loose material that may be present in the roof or sides of the tunnel from a safe position – note: of concern in this regard are a) the height of the roadway and b) the point that if this operation is conducted out of some form of man-basket, the ability to ensure that any loosened material will not fall back onto the operator.

5.0 Potential for a Significant Rush of Air as a Result of a Collapse in the Inbye Mine Workings

(i) Accepting that the majority of the roof in the in seam roadways located on the inbye side of the 2300m mark was supported with a reasonably high density of 4, 6 or 8m long cables, it is nonetheless of note that in most areas a) the roof was dominated by a variable and weak sequence of coal and carbonaceous mudstone and b) mapped in a poor condition – note: in the Pit Bottom in Coal area of the mine (see **Figure 1**) a) the mapping often reported cavities up to a height of 500mm to 1m and guttering up to a height of 300mm and b) the roadways intersected several faults and associated joint swarms.

(ii) Whilst the pillars were designed to be in a stable long-term condition, it is of note that a) due to problems with the floor, a large number of the roadways were driven to a height of 4 to 5m and not the assumed maximum height of 3.5m and that as a result b) this will have compromised the stability of the ribs.

(iii) Considering the above in conjunction with the almost certain destructive influence of the explosions and the fire, it is reasonable to assume that the integrity of the roof has been compromised and in doing so, it is not possible to rule out the possibility that a large-scale roof collapse could occur during the proposed re-entry of the tunnel.

6.0 Conclusions and Potential Remedial Measures

(i) The length of tunnel located on the outbye side of the Hawera Fault is probably in an acceptable condition for the purpose re-entry, but may require some remediation measures, in particular in and around those areas affected by geological structure.

Possible remediation measures could include spot bolting and mesh and in the faulted area located between the 1050 and 1072m marks, the re-application of shotcrete.

(ii) In regard to the Coal Measure section of the tunnel located on the inbye side of the Hawera Fault, it is reasonable to assume that a) localised roof falls may need to be recovered and / or sections of roadway will need to be re-supported and b) in extreme circumstances, large-scale rib-to-rib roof falls will need to be recovered and / or the roof and the associated supports will be in such an enhanced stage of degradation that it will not be appropriate (or indeed practical) to reinforce the roof and as a result, the tunnel may have to be re-supported with steel-sets or shotcrete.

Considering the inherent weakness of the strata, possible remediation measures could include re-bolting and meshing, the installation of additional 8 or 10m long cables or steel-sets and some form of pump packing between the sets and the rock.

If a fall is encountered, the best case scenario will be to muck out the fall and install steel-sets or alternatively, re-consolidate the fall material, excavate the fall material and re-support the new roadway with steel-sets. Alternatively, again due to the inherent weakness of the strata, it is not possible to rule out the possibility that it may be more appropriate (from both a safety and cost perspective) to drive a new roadway around the fall.

(iii) The above said, the most significant risks that need to be considered as part of any proposed re-entry into the tunnel include a) the potential for a roof fall outbye of the working area and the associated entrapment of operators on the inbye side of the fall and b) the potential for a roof fall in and around the working section either while the area is being inspected or secured with additional support – note: a) due to the inherent weakness of the roof strata, of particular concern in the Coal Measure section of the tunnel is the potential lack of any measurable, visual or audible warning that may precede an impending roof fall and b) if upon inspection this is deemed a significant concern, this will reduce the reliance on soft controls such as monitoring and mapping and in doing so, elevates the importance of harder controls such as additional ground support.

Yours sincerely,
GOLDER ASSOCIATES Pty Ltd

Rob Thomas
Underground Coal Practice Leader

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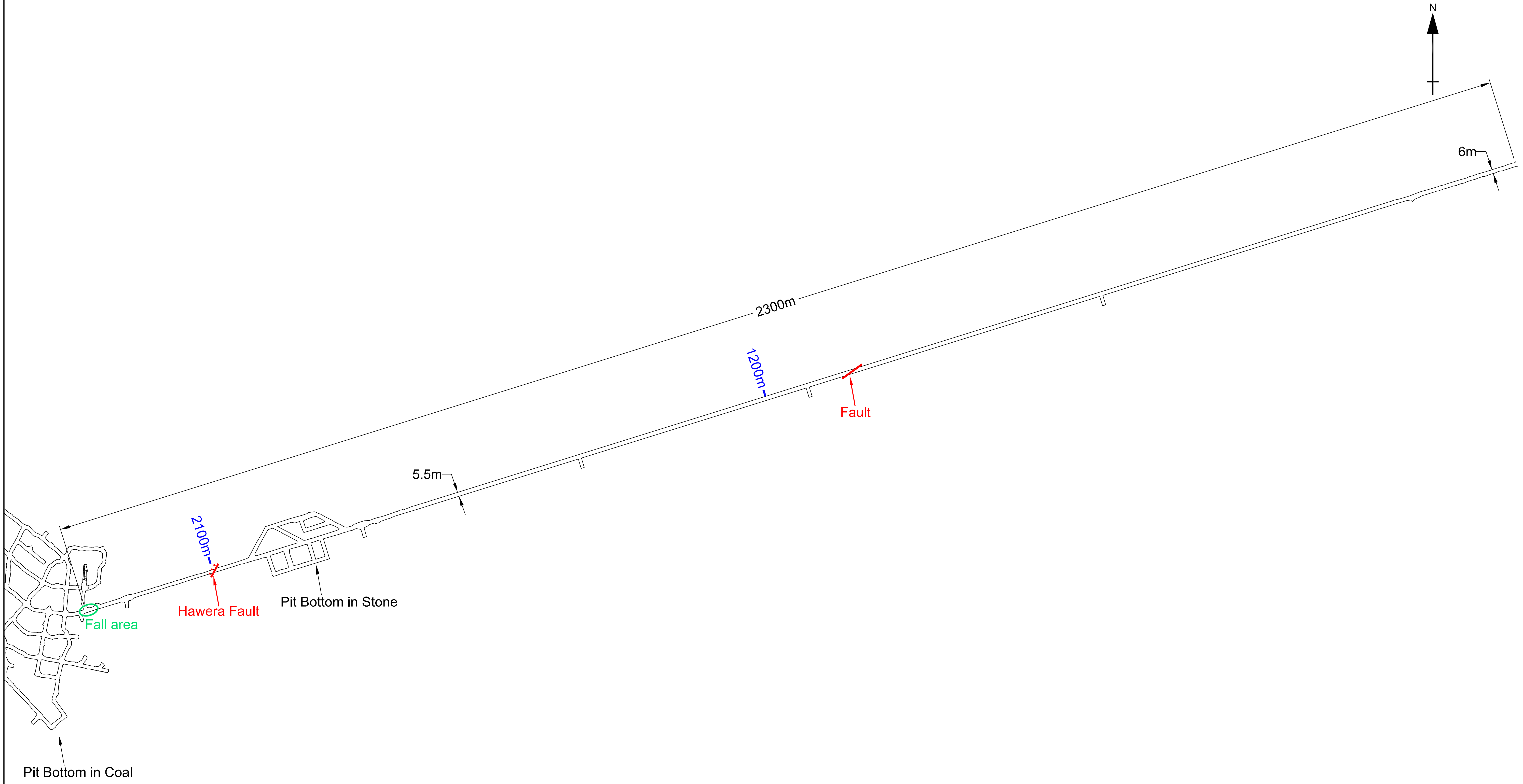

Engineer:	R. Thomas	**Client:**	Solid Energy New Zealand
Drawn:	K. Eagle	**Title:**	Copy of Pike River Mine Plan Showing the Location of the Access Tunnel
Date:	15.10.14		

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Ref:	1413417-145-R	**Revision No:**	0
Scale:	NTS	**Figure No:**	1

APPENDIX 5

TECHNICAL REVIEW OF PROPOSED PIKE RIVER MINE RE-ENTRY PLAN AND ASSOCIATED RISK MANAGEMENT

CONFIDENTIAL AND LEGALLY PRIVILEGED

PacificMGM

Mining and Gas Management Consultants

ABN: 83 095 263 871

TECHNICAL REVIEW OF PROPOSED PIKE RIVER MINE DRIFT RE-ENTRY PLAN AND ASSOCIATED RISK MANAGEMENT

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OCTOBER, 2014

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GENERAL NOTICE

EXECUTIVE SUMMARY

Since acquiring the Pike River mine in July 2012, Solid Energy New Zealand (SENZ) has assigned a dedicated project team to investigate and develop a plan to re-enter the drift section of the mine. The project team has utilised risk identification and assessment processes to identify hazards and list appropriate controls, both existing and new, to be effectively implemented so as to reduce the risk of injury and damage to both people and equipment during each stage of the project.

The project team initially used the Workplace Risk Assessment and Control (WRAC) process that identified 243 hazard/threats from the 49 separate job steps in the project. The WRAC process listed a further 586 control actions, 218 existing and 368 new control actions, to be implemented to reduce project risk. Subsequent Fault Tree Analysis (FTA) and Event Tree Analysis (ETA) methods were used to assess ten (10) high risk event scenarios, with the FTA process identifying 143 control strategies, each with specific control actions.

The specific challenges for SENZ mine management will include:

a) ensuring all identified control actions are effectively captured and incorporated into the project design, management plans, standard operating procedures, trigger action response plans, etc.;
b) communicating and training all personnel involved in the various stages of the project to ensure they are aware of the details of each task, the hazards and the required control actions; and
c) managing and controlling the actions and behaviours of all personnel involved in the various stages of the project to ensure compliance with the management plans, procedures and TARPs.

Given the potential interaction of a number of risk factors it is believed that this project is complex and fragile and has a high level of residual risk. Specific residual risk factors include:

- Developing adequate procedures that effectively address all of the 600+ control actions and ensuring that all personnel involved understand their requirements and correctly implement the planned actions and comply with all procedures;
- The project is located in remote wilderness that is known to be inaccessible approximately 30% of the time. Interruptions and delays during project execution are therefore inevitable. The planned project duration of 9 weeks could conceivably increase to at least 27 weeks;

- Vital services, such as the nitrogen supply line, have been laid in wilderness and remain essentially unprotected and exposed to damage from rock falls / landslide, falling trees and possible flooding. In the period since the nitrogen line has been installed it has already been damaged. Should a period of bad weather lead to damage of a service line(s), those services may not be available for at least several days. Attempting to trek people into the area to effect repairs, particularly in bad weather, presents a whole new level of risk or injury or even death;
- Given the limited number of personnel planned to execute the multiple inter-related tasks, the project relies heavily on human behaviour and compliance with agreed plans and procedures. Should the project execution deviate off plan, possibly in bad weather conditions where communication and / or monitoring may have been interrupted, it is unknown if individuals will respond appropriately so as not to make the situation worse. If there is a 10% chance of a procedure or control failing then in this case, with 600+ controls, it is conceivable that 60+ procedures and controls could fail;
- The effectiveness of the Rocsil plug to separate the drift from the mine workings is not confirmed and there is a definite risk of leakage. Given the expected extended duration of the project, the Rocsil will be exposed to a wet environment for an extended period which may further reduce the integrity of the plug seal.

A preliminary assessment of the potential to utilise exhausting ventilation instead of forcing ventilation indicates that it would be possible to achieve +15m^3/s air flow in the drift provided rigid duct of at least 1.2 metre diameter was connected to the current ventilation fan and extended into the drift during re-entry.

The potential impact that a diesel machine fire in the drift may has on ventilation and the accumulation of explosive gases was also considered. Preliminary modelling of an LHD fire at 1,000m and 2,000m in the drift was undertaken. The results indicate that turning the fan off within 5 minutes following the start of the fire reduces the smoke and gases present outbye the site of the fire and reduces exposure of people evacuating toward the portal. In all cases the modelling indicated that potentially explosive gases (CO) would not ever reach the lower explosive limit and therefore no risk of explosion. The modelling does rely on a number of combustion assumptions and in due course further detailed modelling and analysis of potential fire scenarios is recommended.

At the time of the August 2014 site inspection, no procedures or TARPs had been finalised therefore verification that the listed control actions had been thoroughly incorporated into site procedures could not be completed. A significant body of work remains to complete the procedures and TARPs addressing the identified control actions to maintain the safety of personnel, equipment and the environment.

From the assessment completed thus far it is apparent that a high level of residual risk is linked to project execution and the project is reliant on multiple inter-related job steps and control actions that all must be implemented and managed simultaneously. A failure or deviation in one task / control procedure may impact numerous other procedures and controls and there is a risk that multiple procedures could spiral out of control. The fact that the work sites are effectively isolated and located in remote and challenging terrain where weather conditions change quickly and prevent personnel access and halt operations is an example of a significant inherent risk to this project.

1. INTRODUCTION

PacificMGM was engaged by Simpson Grierson Lawyers to undertake an assessment of the proposed Pike River mine drift re-entry plan and associated risk management, with the assessment to include:

- A technical assessment of the proposed re-entry plan to determine its robustness and thoroughness of control identification;
- Development of a verification plan to ensure all controls identified are integrated into the Operational Management Plan (and vice versa); and
- Test the TARPS and Management Plans for the project.

Following meetings at Pike River in August 2014 and a preliminary review of draft procedures and TARPs prepared by the project team, the scope shifted to providing an assessment of project complexity and inherent risk.

2. BACKGROUND

Pike River Mine is an underground coal mine located approximately 47km northeast of Greymouth on the west coast of New Zealand's South Island. The mine is constrained by its setting; located amongst pristine Department of Conservation rainforest, mountainous terrain and challenging geology.

Access to the mine was gained via a single 2.3km long, 5.5m wide x 4.5m high arched profile drift, driven up-dip on an average grade of 1 in 10 in metamorphic rock to intersect the Brunner Seam at its lowest point.

At approximately 1900m a small number of additional roadways known as "Pit Bottom in Stone" were developed for the installation of infrastructure (substations, two dams, pumps, crushers and fuel pod).

On Friday the 19th November, 2010 at 3:45pm an underground explosion occurred at Pike River Mine resulting in the deaths of twenty nine men. Over the ensuing nine days, three more explosions propagated through the mine.

In December 2010 a temporary seal was constructed at the mine's portal after control of the mine fire was gained by inserting two shipping containers into the drift entry to control oxygen ingress. In July of 2011 the New Zealand Mines Rescue Service constructed a block seal in the drift at 170m inbye of the portal. Lockable steel gates have been installed to control access inbye of the portal.

In July 2012, Solid Energy New Zealand (SENZ) took ownership of the Pike River Mine Asset and subsequently established a Project Team for the Pike River Drift Re-entry, which has been tasked with developing a Project Plan to safely re-entry the Drift.

3. ASSUMPTIONS

Assumptions, limitations and qualifications employed in this report are as follows;

1. Opinions given in this report are based on descriptions and documents provided to the author by the SENZ Pike River Drift Re-entry Project Team whilst onsite at the Pike River mine offices during the period Tuesday 12 August 2014 to Thursday 14 August 2014.
2. Unless stated otherwise in this report, the Job Steps, Identified Hazards, Risk Ranking and Additional Controls are assumed to be accurate and appropriate and have not been validated by the author.

4. RISK ASSESSMENT

The purpose of risk assessment is to list the tasks to be performed during the job/project and to identify the various hazards that may exist, or be created, when undertaking each task. Actions are identified, where possible, such that those action, when implemented correctly, serve to address each hazard and reduce the risk to as low as reasonably practicable (ALARP).

4.1 Risk Analysis – WRAC

During two sessions in May and June 2013 a risk analysis was conducted to assess the process of accessing the drift by remote installation of an isolation plug. This risk assessment, facilitated by the Jim Knowles Group, utilised the Workplace Risk Assessment and Control (WRAC) method and followed the guidelines of the Australian / New Zealand Standard for Risk Management AS/NZS ISO 31000 Risk Management – Principles and Guideline 2009[1].

This WRAC identified 49 Job Step Activities that formed the basis for the risk analysis process. The list of Job Step Activities is listed in Table 1. As indicated in Figure 1, the WRAC process identified 243 potential hazards/threats related to the job step and listed a total of 424 existing control and 545 new controls to address the hazards/threats. In condensing the list of actions to remove duplication, the WRAC process identified 218 specific existing controls and 386 specific new controls to be incorporated into the design and safety management systems for the project.

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[1] Jim Knowles Group, 2013. Risk analysis for the access to the drift by the remote installation of an isolation plug.

Verification that all actions have been completed and / or have been incorporated into the safety management system and related management plans, procedures and TARPs has not yet been completed.

Details of the existing and new controls listed in the WRAC are provided in Appendix 1 and Appendix 2 respectively.

Table 1: Job Step Activities identified in WRAC (May-June, 2013)

Job Step Activities	
1	Design plug(s)
2	Develop water management plan for drift
3	Identify plug material
4	Identify drill hole sites (number of holes and location)
5	Geotechnical assessment of drill sites
6	Drill site foot access (communications and drill site preparation)
7	Review emergency procedures for working on the hill
8	Establish weather based rules, Identify weather window
9	Mobilise rigs to site
10	Drill hole into South section and install pump
11	Dewater pit bottom in coal to reduce flow in drift
12	Relocate drill rig to PRDH48
13	Drill holes for remote Plug and camera
14	JOB STEP DELETED
15	Camera work to check tunnel between boot-end grizzly and fall at pit bottom
16	Install and maintain pump behind plug
17	Mobilise equipment for Rocsil
18	Inject Rocsil plug
19	Demobilise Rocsil gear from GrizzlyInstall PSA unit at portal (nitrogen generator)
20	Install nitrogen 100mm line from portal to grizzly (poly)
21	Inject nitrogen
22	Monitoring of gas, water and pressure after installation of plug
23	Demobilise rigs
24	Rehabilitate drill site
25	Install flame arrestor and venturi at Grizzly PRDH35
26	Install compressor
27	Install fibre optic cable for system to control gas flow to PRDH35 from Control Room
28	Design atmospheric monitoring system for drift and grizzly borehole PRDH35
29	RE-ENTRY
30	Men enter irrespirable atmosphere (not rerquired)
31	Install machine doors
32	Install monitoring / communication system in drift during re-entry
33	Open man door
34	De-gas drift via grizzly borehole (PRDH35)
35	Drift atmosphere monitoring (several days monitoring)
36	Remove 170m stopping
37	Entry into drift by geotech engineer and mines rescue personnel
38	Advance monitoring services
39	Advance ventilation
40	Clear robots from drift
41	Remove LHD from drift
42	Re-ventilation pit bottom in stone
43	Install machine doors to secure drift if required
44	Exploration from end of installed ventilation ducting to grizzly borehole
45	Drill through Rocsil plug and install permanent drainage arrangement
46	Install final seal
47	Forensic examination
48	Helicopter operations - fly in personnel and equipment - demobilisation at completion
49	Remove venturi from grizzly borehole and cap the hole
50	Remove pumps from South section

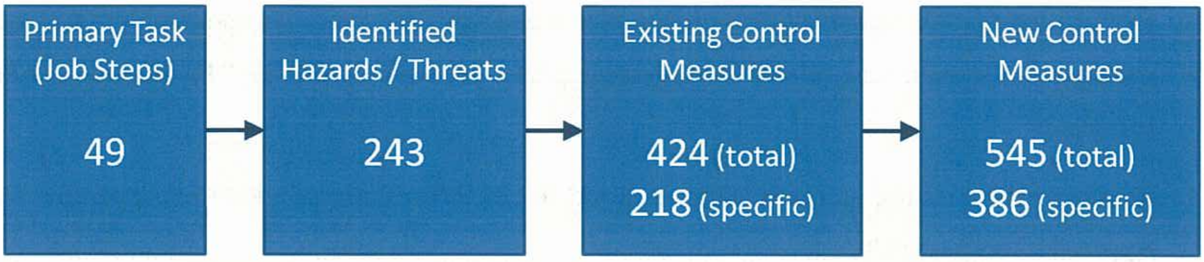

Figure 1: Summary of results from Pike River drift re-entry WRAC assessment (Knowles, 2013)

4.2 Broad Brush Risk Assessment – Re-entry Sequence

In February 2014 a broad brush risk assessment (BBRA), facilitated by the Jim Knowles Group, was conducted to assess the proposed sequence of re-entry into the drift. The risk assessment identified a number of potential high consequence, low likelihood events that required further detailed assessment.

Ten (10) potential high consequence, low likelihood events identified during the BBRA and subsequent SENZ Executive Team review include:

- Gas ignition,
- Fire on mobile plant,
- Entrapment,
- Fall of ground or structure,
- Inrush,
- Person overcome by irrespirable atmosphere,
- Re-ignition of mine fire,
- Adverse health effects,
- Person injured by mobile equipment,
- Helicopter accident.

4.3 Fault Tree Analysis

Between May and July 2014, HMS Consultants Australia facilitated fault tree analysis (FTA) workshops of the ten potential high consequence, low likelihood events (unwanted top-level events) identified during the BBRA. The Pike River Drift Re-entry Project Fault Tree Analysis Report[2] provides the full details of the FTA program that was undertaken.

The FTA methodology was used to systematically identify and document the interrelationship between causes (direct, latent conditions and enabling events) and failure pathways that could lead to the top-level events actually occurring. A key outcome of the FTA process was the

[2] HMS Consultants Australia Pty Ltd, 2014. Fault tree analysis of potential unwanted top level events. HMS1284.

documentation of the control strategies and control measures (inherent, engineering, operation and monitoring controls) the Project Team was planning to implement to prevent the top-level events occurring and additional controls and actions to strengthen preventative control networks. From the 10 top-level events considered in the FTA a total of 143 separate control strategies were identified, each with specific actions. A summary list of identified FTA control strategies is provided in Appendix 3 of this report and a detailed list of all Planned and Additional Controls are provided in the Appendices in the Pike River Drift Re-entry Project Fault Tree Analysis Report (July 2014).

4.4 Event Tree Analysis

The purpose of the event tree analysis (ETA) was to rigorously analyse the circumstances that could prevail if any of the unwanted top-level events occurred so that control strategies and control measures could be proactively developed to mitigate the impacts of any of these events to an acceptable level if they occurred.

The scope of the ETA program covered the following top-level events:

- Entrapment of people in;
  - Reconnaissance Zone,
  - Operating Zone,
  - Recovered Zone,
- Fire on mobile equipment in the drift,
- Gas ignition
- Fall of ground or infrastructure,
- Inrush,
- Person/s overcome by irrespirable atmosphere,
- Re-ignition of mine fire,
- Adverse health effects,
- Person/s injured by mobile equipment,
- Helicopter accident.

The objectives of the ETA program were to:

- Rigorously and systematically analyse the circumstances that would prevail, presuming any of the top-level events had occurred; and
- Document the control measures the Pike River Drift Re-entry Project Team had proposed to implement to mitigate the impacts of the top-level event; and

- Challenge the robustness of the proposed controls and record actions and or additional controls which would be necessary to achieve an acceptable level of risk.

A list of specific actions to be taken by individuals and groups in response to various top-level event scenarios occurring were prepared by the participants in the ETA and are presented in Appendix A to Appendix X of the ETA Report[3].

5. ASSESSMENT OF DRIFT RE-ENTRY PLAN

A high level summary of the job steps involved in re-entering the Pike River drift are listed in the Pike River Re-entry Operations Plan (July 2014). Some of the high level steps, listed below, represent an amalgamation of a number of lower level steps defined in the WRAC document.

1. Degas the drift of methane by purging it with nitrogen (injection through the 170 metre seal and emitting methane out through PRDH35);
2. Continue to degas some of the mine workings, inbye of the drift by continuing to purge with nitrogen through the 170 m seal and/or PRDH51 and emitting methane out through PRDH47;
3. Drill a larger diameter (300mm ID cased) borehole adjacent to PRDH35, identified as PRDH52;
4. Placement of the Rocsil plug via PRDH48;
5. Installation of water pumping equipment inbye the plug through PRDH51;
6. Installation of gas monitoring equipment either side of the plug, via PRDH51 and PRDH35;
7. Re-ventilation of the drift, displacing the nitrogen with fresh air by pressurising a chamber between the outbye machine doors and the 170 metre seal using the capacity of the surface ventilation fan and ducting into the chamber. A regulator will be on the machine door to prevent over-pressurisation. The airlock within the 170 metre seal will be open to displace the nitrogen and force it up the drift and be emitted through PRDH52;
8. Mines Rescue remove the 170 metre seal;
9. Mines Rescue re-enter the drift performing a reconnaissance stage (assessing gas environment, ground conditions, and forensics) and subsequently advancing ventilation ducting, air and water services and communications in a staged nature. Degassing any remnant methane/nitrogen from the remote re-ventilation process will occur as will remedial roadway support as required;

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[3] HMS Consultants Australia Pty Ltd, 2014. Event tree analysis of potential unwanted top level events. HMS1284.

10. Navigate any debris field as required and if determined possible at an assessed risk;
11. Assess the Rocsil plug if accessed, repair if necessary; and
12. Construct a permanent seal in a suitable location outbye the Rocsil plug.

Following the initial WRAC, which developed and risk assessed a list of Job Step Activities (Table 1) the project plan has been varied to include the drilling of an additional 300mm diameter steel cased borehole (PRDH52). It is intended to utilise this borehole to facilitate the purging and re-ventilating the drift. No evidence was found by the author to confirm that the addition of borehole PRDH52 into the project had been considered in any of the risk assessment processes.

It is also noted that the identified high risk events considered in the FTA and ETA assessments, with the exception of helicopter accident, all relate to exposure and risk to personnel following re-entry into the drift.

A significant and potentially complex stage in the project, which appears to have not been thoroughly assessed, is the works relating to establishing and maintaining a safe environment (i.e. safe atmospheric conditions) within the drift and mine workings such that personnel, both on the surface and in the drift, are not exposed to an unacceptable level of risk.

A phenolic foam-based product (Rocsil) has been proposed by the project team to be injected into the drift to form a plug/seal to separate the drift from the inbye mine workings. Rocsil is a brittle, low strength, expanding foam product. The project assumes that injecting Rocsil through a borehole into the roadway will form an effective seal to separate the drift from the inbye mine workings.

While the actual conditions present in the drift cannot yet be verified, it is likely that conditions will deteriorate as the drift approaches the mine workings. It is also probable that elevated risk levels will be present in close proximity to the Hawera Fault and the highly deformed zone inbye of the fault.

6. VERIFICATION OF CONTROL ACTION IMPLEMENTATION

At the time of the site visit (12-14 August 2014) the majority of procedures and TARPs provided for review were in draft form and, in the opinion of the author, required further revision and amendment.

Given the significant number of control actions, identified through the WRAC, FTA and ETA assessments, to be incorporated into procedures and TARPs, the documents made available to the author for review (comprising approximately 4 management plans, 12 SOPs, 13 TARPs and 14 JHAs) are insufficient. It is understood that additional safety management documentation is available onsite, however no additional documentations was sighted by the author.

7. TEST TARPS AND MANAGEMENT PLANS

This component of the project scope has not yet been completed due to project documents not yet being finalised.

Draft versions of SOPs and TARPs collected during the site visit have been reviewed and feedback provided to the project team for consideration.

Testing of the effectiveness of TARPs and Management Plans is appropriate following completion of the documents to a satisfactory level of detail and ensuring, through the verification process, that the documents adequately capture and address the recommended controls identified during the risk assessment processes.

8. EXHAUST VENTILATION ASSESSMENT

The use of exhaust ventilation, in lieu of the current planned forcing ventilation design, is a viable option however a number of potential impacts must be considered, which include:

- In the event of a machine fire in the drift during re-entry, products of combustion would be cleared from the drift through the duct thereby reducing personnel exposure;
- In the event of a fire in the main fan unit, products of combustion are unlikely to be delivered into the drift;
- Low pressure created at the inbye end of the duct would tend to draw air / gas into the drift through the inbye borehole (PRDH52) and Rocsil plug respectively;
- Rigid sections of duct (vent tube) would have to be transported into the drift and installed as part of the re-ventilation process;
- In order to achieve a minimum air quantity in the drift of 10 m^3/s the duct size, assuming the reconfiguration and continued use of the existing fan unit, would have to be at least 1.0 metre diameter. Greater than 15 m^3/s air flow would be expected if the duct diameter were increased to 1.2 metre.

9. FIRE MODELLING – DIESEL MACHINE FIRE IN DRIFT

Ventilation and fire modelling was undertaken by Gillies Wu Mining Technology Pty Ltd to assess expected atmospheric conditions in the drift with and without a vehicle fire and to determine the time taken for a vehicle fire to get out of control and reach the point where the concentration of the produced gases become explosive.

The modelling scenarios specified to be evaluated include:

A. An open system with no mechanical ventilation to evaluate the natural ventilation flow condition.

B. Diesel machine fire at 1,000 m along drift during re-ventilation with layflat duct (1.4 m diameter) installed to 1,000 m. Consider natural ventilation effects, evaluate the time for products of combustion to accumulate and reach explosive level at the source of the fire (1,000 m in from portal).

C. Diesel machine fire at 2,000 m along drift during re-ventilation with layflat duct (1.4 m diameter) installed to 2,000 m. Consider natural ventilation effects, evaluate the time for products of combustion to accumulate and reach explosive level at the source of the fire (2,000 m in from portal)

The following sections summarise the results from modelling, reported in *Wu, H W and Gillies, A D S, 2014. Ventilation and Fire Simulation for a Long Drift.*

9.1 Fire Modelling – Scenario A: No Fire Condition

This scenario aims to determine the expected natural ventilation flow within the drift due to natural ventilation effects.

For the purpose of the simulation, it is assumed that air temperature is 15 degrees at the portal, 20 degrees at the inbye end of the drift, and there is no other heat source along the drift. Atmospheric pressures at various locations are calculated from the assumption of 101.3 kPa atmospheric pressure at sea level.

Based on the Ventgraph model simulation, 2.1 m^3/s of natural ventilation flow is predicted with a NVP of 4,277 Pa in the open system condition. The equivalent resistance of the ventilation network is 970 Ns^2/m^8, as indicted in Figure 2.

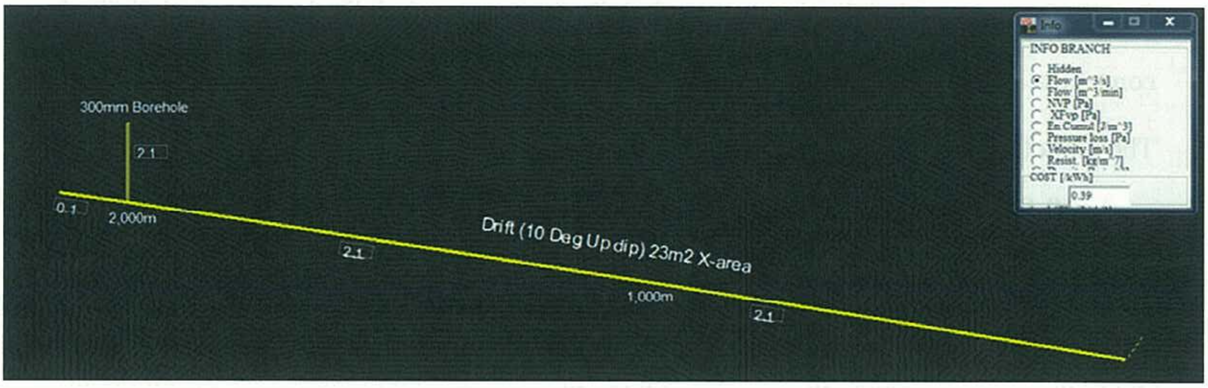

Figure 2: Ventgraph simulated natural ventilation quantity in drift (Wu and Gillies, 2014)

9.2 Fire Modelling – Scenario B: Diesel Machine Fire at 1,000m

Scenario B involves a diesel machine fire at 1,000 m during re-ventilation of the drift with layflat duct (1.4 m diameter) installed to 1,000 m with two 90 kW Sandvik GAL14-900/900 axial fans operating in series. The simulation considered natural ventilation effects, and evaluated the time for products of combustion to accumulate and reach explosive level at the source of the fire (1,000 m in from portal).

Two variants of Scenario B have been considered, the first assesses the impact of turning the main ventilation fan off 5 minutes following the start of the fire and the second assesses the impact of continuing to operate the main fan and ventilating the drift using the forcing ventilation system.

A brief summary of the Scenario B is as follows:

- A diesel machine fire at 1,000 m during re-ventilation of the drift.
- The re-ventilation of the drift uses a layflat ducting (1.4 m diameter) installed to 1,000 m with two 90 kW Sandvik GAL14-900/900 axial fans in series. Ventilation flow at the end of the ducting is simulated at around 25 m^3/s at 1,000 m.
- It is assumed that the vehicle involved is a typical EIMCO LHD. The vehicle has caught on fire at the end of ducting with 25 m^3/s of air ventilating over it. The operators are making their way toward portal.
- All personnel are located outbye of the fire in 5 minutes after the fire started.
- The simulation considered natural ventilation effects, and evaluated the time for products of combustion to accumulate and reach explosive level at the source of the fire (1,000 m in from portal).

9.2.1 Scenario B – Main ventilation fan stopped 5 minutes after start of fire

In this scenario the main ventilation continues to operate for the first 5 minutes following the commencement of the fire after which the fans are turned off.

Figure 3 shows the extent of the heavily smoked zone along with modelled gas concentrations for the initial 2 hour period following the start of the fire.

Modelling of this scenario indicates that the CO levels reach 6.67% at about 3.59 hours (215 mins) and CO levels remained at that level. The CO levels inbye of fire therefore do not reach the lower explosive limit of CO (12.5%).

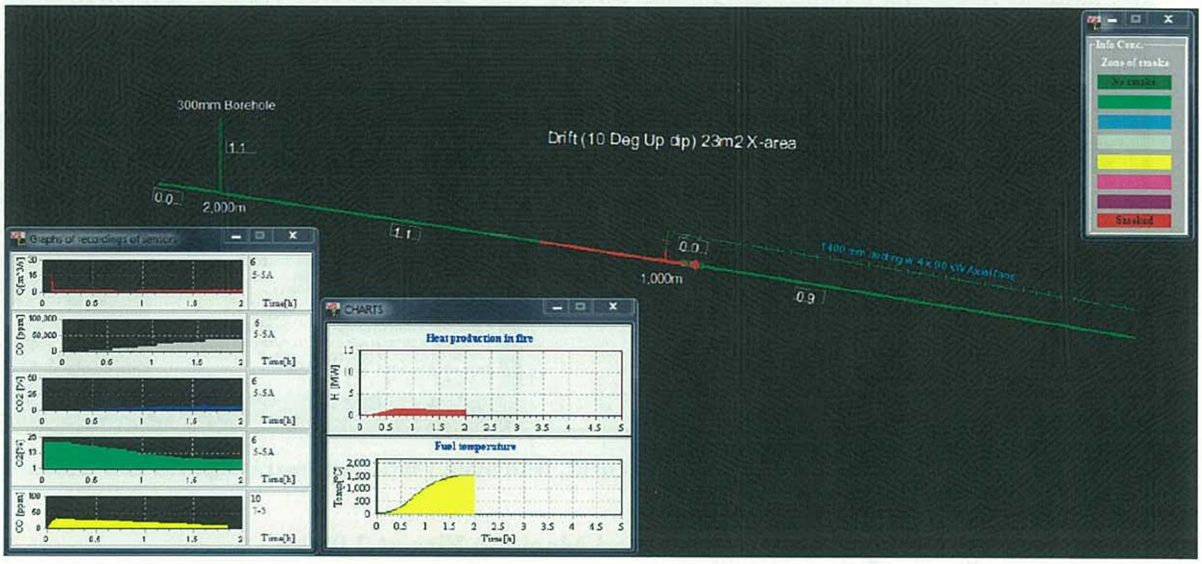

Figure 3: Ventgraph fire simulation at 1,000m in drift, with main ventilation stopped (Wu and Gillies, 2014)

9.2.2 Scenario B – Main ventilation fan continues to operate

In this scenario the main ventilation continues to operate for the duration of the fire modelling, delivering approximately 25 m^3/s, through 1.4 m layflat duct, to the fire site.

Figure 4 shows the extent of the heavily smoked zone along with modelled gas concentrations, for the initial 2 hour period following the start of the fire. The predicted heat outputs from the vehicle fire and expected fuel temperatures over the time are also shown.

With the portal fans on, combustion products of the fire flow along the drift toward the portal. Based on the simulation results, the predicted CO levels downstream of the fire (toward the drift portal) reach approximately 30 ppm at 5 minutes after the fire started, then increase to a dangerous level of 358 ppm after 30 minutes and peaked (stabilised) at around 880 ppm at approximately 1.5 hours after the fire started.

Smoke and combustion products reached the portal at around 15 minutes given the speed of ventilation air flow (about 1.13 m/s). Modelling 25.7 m^3/s of air flow over the fire is sufficient to support and maintain an oxygen rich fire situation during the course of the fire event.

Continuing to operate the portal fans ensures no dangerous gas accumulation at the site of the fire. However, with continued operation of the main fans, combustion products will flow over personnel making their way outbye toward the drift portal.

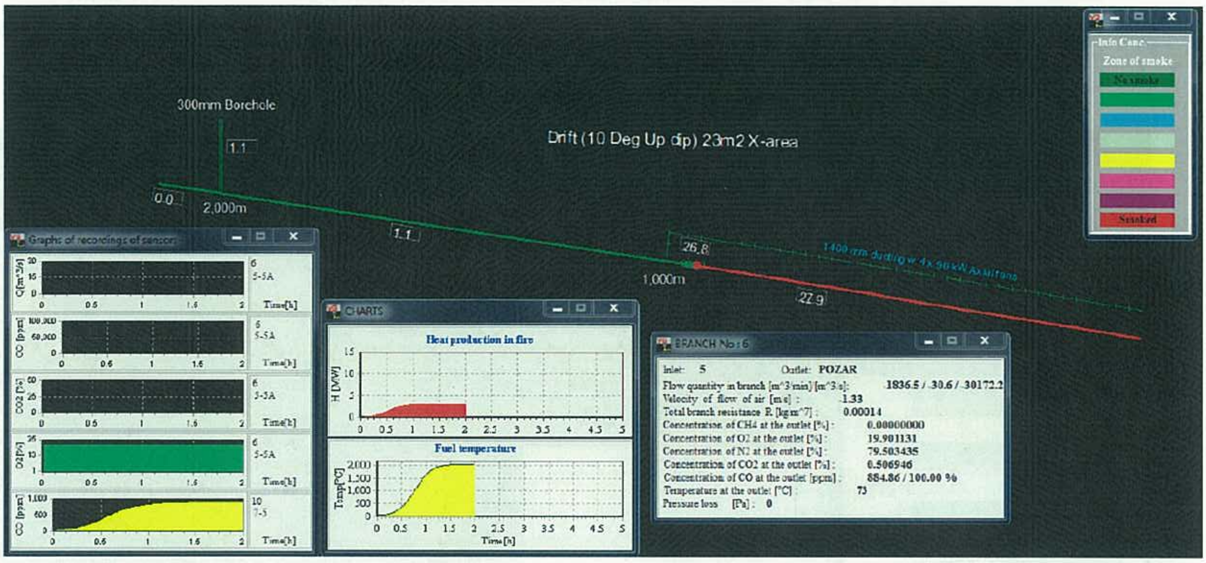

Figure 4: Ventgraph fire simulation at 1,000m in drift, with main ventilation operating (Wu and Gillies, 2014)

9.3 Fire Modelling – Scenario C: Diesel Machine Fire at 2,000m

Scenario C involves a diesel machine fire at 2,000 m during re-ventilation of the drift with layflat duct (1.4 m diameter) installed to 2,000 m with two 90 kW Sandvik GAL14-900/900 axial fans installed in series. The simulation considered natural ventilation effects, and evaluated the time for products of combustion to accumulate and reach explosive level at the source of the fire (2,000 m in from portal). A brief summary of the Scenario C is as follows.

- A diesel machine fire at 2,000 m during re-ventilation of the drift.
- The re-ventilation of the drift uses a layflat ducting (1.4 m diameter) installed to 2,000 m with two 90 kW Sandvik GAL14-900/900 axial fans in series. Ventilation flow at the end of the ducting is simulated at around 20 m^3/s at 2,000 m.
- It is assumed that the vehicle involved is a typical EIMCO LHD. The vehicle has caught on fire at the end of ducting with 20 m^3/s of air ventilating over it. The operators are making their way toward portal.
- All personnel are located outbye of the fire in 5 minutes after the fire started so ventilation fans at portal are turned off.

- The simulation considered natural ventilation effects, and evaluated the time for products of combustion to accumulate and reach explosive level at the source of the fire (2,000 m in from portal).

Figure 5 shows the extent of the heavily smoked zone along with modelled gas concentrations for the initial 2 hour period following the start of the fire. Modelling of this scenario indicates that the CO levels reach 6.67% at about 3.65 hours (219 minutes) and CO levels remained at that level.

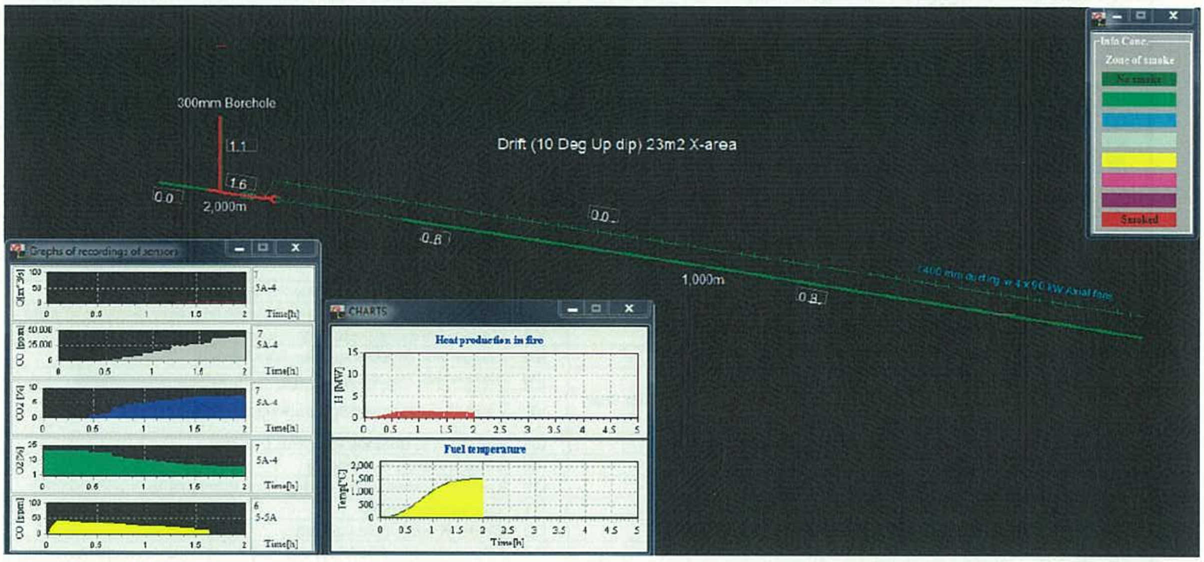

Figure 5: Ventgraph fire simulation at 2,000m in drift, with main ventilation stopped (Wu and Gillies, 2014)

9.4 Fire Modelling – Additional Scenarios

The fire modelling was extended to include two additional scenarios (a) PRDH52 not present/available and borehole PRDH35 (125mm diameter) being used as part of the drift ventilation system, and (b) the inbye borehole(s) (PRDH35 and/or PRDH52) are closed, blocked and prevent ventilation flow inbye of the fire site.

In both cases the limited and absence of ventilation flow over the fire site, given the assumption that the ventilation fan is stopped 5 minutes following the start of the fire, serves to starve the fire of oxygen limiting both the heat, smoke and gases produced. The results of modelling these two scenarios are provided in the report *Ventilation and Fire Simulation for a Long Drift. Wu, H W and Gillies, A D S, 2014.*

APPENDIX 1: EXISTING CONTROLS LISTED IN WRAC

No.	EXISTING CONTROL	No.	EXISTING CONTROL
1	1 person on guard equipped with BA set as a back-up	76	Fluid nature of Rocsil placement means it will flow around and over
2	10-point Maihak is available at the site	77	Flush system installed on main head (Rocsil)
3	4 to 1 factor of safety for hoses	78	Forensic protocol in place for drift
4	A plan for ventilation shaft site has been prepared	79	FRAS equipment
5	Ability to jettison the load.	80	Gas monitoring continuously conducted.
6	Additional platform in place from previous attempt to seal (2011)	81	Gas monitoring onsite.
7	Alarm system for high O2.	82	GC onsite.
8	All boreholes are positively pressurised (breathing out)	83	Gen sets and floodlights available.
9	All drill holes will be cased holes	84	Generator to be installed and tested by OEM prior to use
10	Appointed project manager	85	Geotechnical assessment to be conducted on re-entry.
11	Appropriate footwear	86	Hand held radios available
12	Appropriate PPE according to SDS	87	Hazardous substance SOP (SENZ)
13	Approved supplier (Boart Longyear & Wallace drilling)	88	Head designed to minimise entanglement (Rocsil)
14	Atmosphere breathing out due to buoyancy pressure of methane.	89	Helicopter company supply a load master.
15	Back-up team at FAB	90	Helicopter company supply a load master.
16	Barometric pressure monitoring.	91	Helicopter evacuation available.
17	Blow out preventer (BOP) installed at site.	92	Helicopter pilot evaluates weather conditions
18	Blow out protection (BOP) and drilling mud in the drill string.	93	Helicopter training
19	Bolted and meshed roof	94	Helicopter training for load slinging.
20	Breathing apparatus onsite at all times with trained person.	95	HHGD
21	Buoyancy pressure of methane (1600-2000Pa) will provide motive	96	HHGD - see shaft sealing RA.
22	Camera examines borehole prior to lowering head (Rocsil)	97	Historical reliability for power supply to Pike River mine
23	Camera surveillance	98	Hoses pre-assembled at pit top prior to transport to application site
24	Capacity of existing borehole	99	Hot work permit in place to deal with any other non-IS equipment
25	Certified and designed landing platforms.	100	Induction process for personnel working on the hill. Includes pump location induction
26	Close scrutiny from a number of agencies	101	Induction process.
27	Coal was never transported on conveyor, only stone	102	Initial survey of hole undertaken with 'disposable' camera
28	Communications will be upgraded with fibre optic cable.	103	Initially tubes will be placed on existing conveyor structure at waist
29	Competence of mines rescue personnel	104	Known (measured) quantity of water coming out of the drift (6-8L/s)
30	Compressed air fan installed at site.	105	Liaison with product supplier Rocsil (WMS)
31	Compressed air fan used for all work around boreholes.	106	Liaison with Rocsil supplier regarding storage requirements
32	Compressed air fan used to dissipate gases in accordance with Shaft Camera Work TRA (conducted 31.01.2013)	107	Limit gas escape through packing the hole with rags.
33	Conduct trial of application (Austar field trial at Austar)	108	Limitation to distance from FAB (~300m)
34	Contraband protocols	109	Limited vehicle movements
35	Contractor approval process	110	Loss of communication with control room results in work ceasing
36	Contractual agreement with SIMTARS.	111	Low vehicle density
37	Data from current monitoring of water at portal	112	MAIHAK equipment installed.
38	Dedicated project team	113	Main coal seam has low propensity for spontaneous combustion.
39	Disposal procedure for empty drums (WMS)	114	Maintenance regime for fans
40	Doors and frame already fabricated ready for use	115	Manual handling procedures
41	Downhole survey tool	116	Manual handling procedures for drums
42	Drift fully supported to a designed standard	117	Men to be withdrawn due to failure of monitoring system.
43	Drift geotechnical database available - drift fully supported when	118	Mine atmosphere is inert (no oxygen)
44	Drilling company has previous experience in drilling in this area	119	Mine survey plans
45	Drilling process has the ability to deviate around steel	120	Mines Rescue pre-entry checks and annual medical checks
46	Drilling SOPs	121	Minimum manning levels required.
47	Effective communication between inbye teams and FAB	122	Monitoring inbye Plug
48	Emergency communication to control room.	123	Monitoring on generator.
49	Emergency communication to control room.	124	New helipad has been constructed at PRDH43
50	Engineered designed dam	125	Nitrogen inertisation protecting area inbye of Plug
51	Equipment and superstructures removed to increase available area	126	No history of roof fall from previous drill holes
52	Examination of Pre-explosion McConnell Dowell strata logging	127	No work on hill during periods of lightning threat.
53	Existing access agreement with DOC	128	Non-return valve on pipeline preventing ingress of oxygen
54	Existing drillers SOP for drilling into methane rich environment	129	NZMR definition of 'Impassable Object'
55	Existing gas analysis equipment can be used	130	One person on guard equipped with BA as a back-up.
56	Existing geotechnical assessment of the ground as well as historical drilling and shaft construction.	131	Only helicopter trained personnel can accept loads.
57	Existing previous drill site to be used.	132	Oxygen deficient environment will prevent any initial exothermic reaction from causing a fire underground
58	Existing SOP for borehole camera work	133	Personal cap lamps available.
59	Existing standard for drilling platform construction.	134	Personnel trained in first aid and first aid equipment on site.
60	Existing walking tracks between drill sites and helicopter pad.	135	Physical inspection pre flying and landing
61	Existing water measurement at portal	136	Physical inspection.
62	Experience and skill of drill operators (slows close to breakthrough)	137	Placement of people when loading and unloading.
63	Experience of installing nitrogen lines at Spring Creek	138	PLC controlled with radio link.
64	Experienced drillers with proven successful track record.	139	Plug site inspected and found to be clear
65	Experienced operators	140	PPE requirements
66	Experienced Rocsil pump attendants.	141	PPE standard for remote operations (gloves, boots, glasses).
67	Fallen team member procedure (O2 therapy unit)	142	PPE.
68	Fan has controls in place to allow reduction of output	143	PRDH45 has tube bundle and real time O2 monitoring.
69	Few ignition sources	144	Pre-entry checks of BGs and team members
70	Fire suppression systems on mobile plant	145	Prepared designated tracks, rope safety lines along steep sections of
71	First aid trained people onsite.	146	Pressure monitoring at grizzly borehole.
72	Fit for purpose equipment	147	Previous drilling history in area indicates no aquifers
73	Fitness for work requirement	148	Previous experience of installing pipeline in the valley
74	Flash back arrestor valve on venturi.	149	Previous experience with lowering gas monitoring lines into mine
75	FLP camera available	150	Previous experienced drillers used.

No.	EXISTING CONTROL
151	Process for storage and temperature controlling 'rehearsed' in 2011
152	Process in place for export to NZ (approx. 4 weeks mobilisation time)
153	Proven history of successful installation of Rocsil products at other
154	Provision of air fan ventilation for all borehole work at the shaft top.
155	Provision of air fan ventilation for all borehole work.
156	Qualified personnel available familiar with conditions.
157	Radio comms protocols
158	Radio communication between pilot and loadmaster
159	Rated and certified lifting equipment.
160	Redundancy in helicopter availability.
161	Redundancy of drill bits
162	Refrigeration facility to be used for Rocsil storage
163	Remotely turn off valve in venturi.
164	Robot cameras have identified conditions up to 1574m.
165	Rocsil maximum setting temperature is specified as 90oC
166	Rocsil procedure SOP-WMS-022 calls for pressure testing of lines prior
167	Routine use of MetVUW.
168	Routine use of MetVUW: no work on hill during periods of lightning
169	Safety around helicopter training and inductions
170	Satellite phone available
171	Scheduled machine maintenance
172	SDS available onsite (Rocsil)
173	Self-search for contraband
174	SENZ audit process
175	SENZ drilling manual.
176	SENZ fatigue and stress procedure
177	SENZ preferred supplier
178	Single entry and or limited access procedure for working in drift
179	Single shift operation
180	Slings with anti-static covering are used routinely.
181	Solid Energy has a preferred list of drilling companies
182	SOP for drilling process which identifies actions to be undertaken prior to drilling ops - checklist and sign-off process.
183	SOP for manual handling on Grizzly platform (SENZ)
184	SOP WMS-022 Rocsil foam application for cavity filling.
185	Spare head and spare parts available
186	Spill limited by size of containers (20L drums)
187	Spill-proof transport container (modified IBC)
188	Stock (Rocsil) required on hand in Newcastle
189	Survival kit at Grizzly Hut
190	SWP working on hill
191	Task rotation required.
192	Telemetric monitoring in grizzly borehole.
193	Temperature controlled storage container will be used
194	Testing and maintenance regime for equipment prior to leaving
195	The helicopter pilot has the ability to jettison the load.
196	The helicopter that is used is fitted with anti-static strips on the blades.
197	The mine uses a reputable and experienced helicopter company.
198	Traffic control via control room
199	Trained and competent personnel at mine.
200	Trained and experience pilot and loadmaster with SOP
201	Trained applicators (Rocsil)
202	Trained, experienced and appointed personnel conduct inspections.
203	Trauma kit available
204	Trials conducted and no erosion observed (1/8/13).
205	Tube bundle line at bottom end of borehole.
206	Underground atmospheric monitoring.
207	Understanding of capability of Rocsil from its previous use at other sites
208	Use experienced personnel (preferred supplier)
209	Use helicopter pilot to establish rules.
210	Use MetVUW website.
211	Use only rated and certified lifting equipment provided by the
212	Utilise external personnel with relevant experience
213	Valve installed on top of borehole to give control of methane.
214	VE and Mechanical Engineer available to interpret data
215	WAH protocols
216	Weather patterns monitored via Met Service / MetVUW.
217	Wheeled stretcher
218	Work is limited to periods of stable weather.

APPENDIX 2: NEW CONTROLS LISTED IN WRAC

No.	NEW CONTROLS	No.	NEW CONTROLS
1	24 hour manning during venturi operation.	76	Develop a program to introduce inert gas with concrete lines if the hole starts breathing in
2	Ability to drill angled hole to correctly locate pump from grizzly platform - eliminates hazard.	77	Develop a TARP to nominate distances (lightning).
3	Ability to grout borehole and redrill if required	78	Develop a recovery procedure for entrapped personnel
4	Access OEM procedure for towing vehicle (Jug-o-naut)	79	Develop an agreed drill plan prior to starting.
5	Acquire PSA N2 nitrogen plant from Spring Creek mine - or alternative (Floxil)	80	Develop and number a lifting load sequence
6	Additional N2 pump to be available as back-up.	81	Develop drilling and breakthrough with Wilson Mining (to be determined by trial) - installing permanent drainage through Rocsil plug)
7	Adequate fuel available.	82	Develop emergency re-sealing process.
8	Alarm at 2.0% O2 (nitrogen supply).	83	Develop geotechnical strata management plan for drift.
9	All holes are to be surveyed	84	Develop JHA for borehole work (reference vent shaft camera work JHA)
10	All controls as per risk assessment from shaft sealing.	85	Develop JHA and SOP for installation of ducting
11	All empty chemical drums to be removed from application site as soon as practicable	86	Develop JHA for dealing with spilled battery acid, if necessary (robots)
12	All personnel will carry CABA gear	87	Develop load slinging protocol.
13	An effective system for attaching pallets to long line from helicopter to be developed and	88	Develop plan of footprint layout for all items to be used at the vent shaft
14	Analyse water and treat if necessary	89	Develop procedure for raising bucket if it is on the floor (Jug-o-naut)
15	Analyse water to determine pH	90	Develop protocols with NZ Police/DOL to conduct underground work following re-
16	Anti-static clothing to be worn	91	Develop SOP for installation of line (nitrogen).
17	Application of Rocsil to be timed to suit seasonal conditions	92	Develop site plan for working area
18	Apply for resource consent	93	Develop TARP for helicopter operation.
19	Appoint competent statutory official to be onsite during drilling operations at least 10m before break through.	94	Develop TARP for installation of machine doors
20	Approved monitoring plan which recognises redundancy to be developed and implemented (review existing AAMP for relevance and application).	95	Develop a logistics sequence (checklists)
21	Assessment to be made of additional equipment which may be required on platform (combined weight)	96	Develop TARP for various parameters for oxygen ingress and methane egress. (Development of TARP undertaken by specialist team)
22	At no time can a flight path pass over a work crew.	97	Develop TARP to nominate distances.
23	Audit established procedures to ensure compliance.	98	Develop TARPS for acceptable N2 generator operation.
24	Audit Helipro load slinging standard AS/NZ standards and amend to ensure compliance.	99	Develop TARPS for reversal of gas flow
25	Automatic shutdown on generator if O2 exceeds a determined level.	100	Develop TARP to ensure that job is suspended when sampling points are lost
26	Back-up generator onsite.	101	Develop Traffic Management Plan
27	Back up compressor on standby to be supplied	102	Duct to be installed on catenary above the conveyor as soon as practicable after initial
28	Back up pump to be included (Rocsil)	103	Earth venturi to avoid static discharge.
29	Back-up sealing material available.	104	Emergency response plan to be rolled out prior to start of the job
30	Boreholes capped on completion.	105	Engineered design required for duty intended (nitrogen line)
31	Boreholes will be sealed if no further use is required.	106	Ensure a pre-detemined water level is managed.
32	Brattice to be used to temporarily manage gas concentrations at pit bottom in stone	107	Ensure a spare pumps is available.
33	Change management process to be conducted.	108	Ensure additional generator onsite with adequate fuel available.
34	Check camera SOP covers potential ignition sources during recovery if lost/stuck in drill	109	Establish FAB inbye
35	Checklist to be developed to identify all pieces of equipment to be removed from site (Rocsil)	110	Establish traffic management rules
36	Chemical awareness training conducted for all non-Wilson personnel involved with job	111	Ensure additional pump available.
37	Chemical toilet installed at site	112	Ensure all loads are in capacity for manual handling.
38	Civilian agencies must be CABA trained and underground inductions have been completed prior to re-entry	113	Ensure appropriate expertise is accessed for particular tasks.
39	Comms will be upgraded with fibre optic cable	114	Ensure back-up t survey tools are available to site
40	Complete installation of rope lines along tracks.	115	Ensure back up compressor is available
41	Conduct a gap analysis on existing program and modify if required.	116	Ensure compressor capability for venturi.
42	Conduct a gap analysis on existing program and modify if required. Identify potential lightning conductors and rectify if inadequate.	117	Ensure dams are emptied once access has been gained
43	Conduct CALS (computer aided laser scanning) to identify features	118	Ensure drill design system works within acceptable deviation tolerances
44	Conduct on-going refresher training and recovery	119	Ensure drill string recovery tool available to site
45	Conduct controlled simulation trials (completed 1/8/13).	120	Ensure drilling company has appropriate manual handling controls.
46	Conduct geotechnical review of site to test for ground stability.	121	Ensure drilling supplier has a robust maintenance program
47	Conduct review to establish that there is not a better alternative form work product available	122	Ensure Rocsil supplier has a robust maintenance program
48	Conduct simulation trial of Rocsil application to determine suitability	123	Ensure drilling equipment is in compliance with MDG35 (hose standard).
49	Conduct technical search for improved camera technology	124	Ensure fire extinguishers located onsite.
50	Conduct trial for installation of ducting to determine safe method	125	Ensure gas drainage stack is earthed adequately.
51	Conduct trial in Australia with Rocsil to develop suitable method (installing permanent drainage arrangement)	126	Ensure mechanical who are delegated to remove LHD are CABA trained
52	Conduct literature search and review its results	127	Ensure non-return valve fitted to the bottom of pump line to ensure the pipeline is full of
53	Compile and make available a reference list from the search	128	Ensure permanent drainage is established through plug prior to building permanent seal.
54	Configuration of monitoring (Maihak) monitoring points to be re-allocated	129	Ensure pilot is briefed on flight path and work plan.
55	Confirmation of existing water flow data	130	Ensure placement of piezometer to measure water levels.
56	Confirm condition of old stock grout on site	131	Ensure products can be supplied in transportable (manual handling) sizes
57	Contractor to provide standards and procedures to principal prior to commencement of work (to be approved) - Rocsil	132	Ensure pump is fit for purpose (e.g. stainless steel)
58	Control room operator present at ALL times.	133	Ensure sump is pumped down low enough to provide at least two days water storage
59	Cut cables and remove (robots)	134	Ensure pump remains inside the casing.
60	Define drop zones.	135	Ensure R70 spontaneous combustion of the Rider seam is completed.
61	Define loadmaster.	136	Ensure redundancy for venturis.
62	Define people placement - no-go zones.	137	Ensure redundancy of monitoring system.
63	Define safe areas for site personnel.	138	Ensure redundancy in comms system - DAC and phone
64	Design suitable anchor system at the top of borehole pump and pump line.	139	Ensure redundant survey tools available on site
65	Design of nitrogen pipeline based on required duty	140	Ensure Pike River survey surface to underground workings is accurate
66	Design monitoring array prior to drilling and boreholes	141	Ensure Rocsil pumping contractor has appropriate manual handling controls.
67	Develop and assess final seal design	142	Ensure SENZ personnel have appropriate manual handling controls.
68	Determine capacity of venturi before it is applied to the task.	143	Ensure sufficient area on platform to stockpile material (helicopter does not fly at night - refer also recommendations for helicopter operations from shaft sealing)
69	Determine load sequencing	144	Ensure sufficient first aid capability on site.
70	Determine mass and dimensions of each robot in drift to enable a strategy can be developed for removal	145	Ensure sufficient stocks of Rocsil on site to complete the plug
71	Determine visible range for underground camera used	146	Ensure that water management plan is developed
72	Determine the size of the equipment that is to be installed in each hole	147	Ensure top of the borehole is sealed around the pump delivery pipe.
73	Determine availability of all underground camera equipment	148	Engage appropriate geotechnical advice prior to commencement of operations
74	Determine PTO fittings on Jug-o-naut to ensure compatibility with Eimco LHD hydraulics	149	Ensure venturi capacity is sufficient to ventilate drift.
75	Develop a Limited Access Procedure for the drift (may already be existing)	150	Ensure venturi of sufficient capacity is installed.

No.	NEW CONTROLS	No.	NEW CONTROLS
151	Ensure that retained atmospheres in cabinets are purged prior to close examination	226	Mixing hoppers to be fixed to platform (Rocsil)
152	Ensure the use of competent drill personnel - site experienced personnel	227	Monitor amperage of pump at control room.
153	Ensure wind direction indicators are installed onsite.	228	Monitoring system will be installed / advanced in the drift as work progresses
154	Establish gas monitoring in the vicinity of the borehole.	229	Monitoring and TARPs to be developed - to manage ventilation failure
155	Establish hut (and emergency cache) on the hill in the event that weather closes in.	230	Monitor flow rate for egress of Nitrogen and or methane through plug when pressurising the mine workings
156	Existing platform to be checked for structural adequacy and integrity - to be within scopeof engineering services (Parsons Brinkerhoff to 'sign off' - weight information to be obtained	231	Negotiate with DOC as necessary to fell any identified trees
157	Experienced / trained personnel to install ducting	232	New boreholes for pumping to be installed prior to plug installation.
158	Extend MAIHAK down grizzly borehole to gain a representative sample - must be done prior to any activity in drift.	233	No re-entry of civilian agencies until rated seal is installed outbye Rocsil plug
159	Extend pump housing so top remains in borehole casing.	234	No personnel in drift if an uncontrolled accumulation of water occurs behind seal (TARP to be developed)
160	Fall protection on platform to be assessed for adequacy in night work.	235	No personnel in drift if power supply to pump fails.
161	Fibre optic cable will be laid by helicopter and then pulled to ground level by ground teams	236	No personnel in drift if pump fails.
162	Fibre optic cable can be re-laid or repaired if required	237	Observation of seal construction with camera down an adjacent borehole
163	Finalise SOP for working in remote areas.	238	Obtain consent from West Coast Regional Council (WCRC) prior to pumping
164	Fitness selection of personnel	239	Obtain consent from West Coast Regional Council (WCRC) and landowner prior to drilling
165	Formulate strategy for design and installation of monitoring - include procurement requirements to ensure correct and sufficient materials available	240	Obtain nitrogen generation plant to inject nitrogen behind Rocsil plug.
166	Further project plan to be developed and risk assessed should forensic material be identified	241	Option to lay additional 100mm N2 pipeline if needed.
167	Gas monitoring in grizzly hut with automatic shut-off if levels are exceeded.	242	Obtain and deploy a written storage specification for the product (Rocsil)
168	GC of PRDH35 during the degassing of the drift.	243	Obtain project approval before ordering Rocsil product
169	Generator and power supply to pump from grizzly with cable.	244	Obtain a written confirmation that defines the exothermic reaction results expected when constructing Rocsil plug
170	Geotechnical review to confirm no aquifers in the vicinity of the proposed borehole locations	245	Option to advance ventilation if required
171	Helicopter pallet lifting mechanism (pallet tonngs) from exploration group to be assessed for suitability and implemented as appropriate	246	Option to drill additional holes if required
172	HHGD carried by personnel on hill.	247	Option to increase storage temperature (of Rocsil) prior to use, to allow for ambient conditions (cold climate and temp underground)
173	HHGD planned to be used in drift (standard procedure)	248	Option to close door during nitrogen injection
174	Identify from underground objectives where surface location is required.	249	Piezometer control of pump operation to be installed to monitor water levels. (start/stop for
175	Identify potential existing lightning conductors and implement appropriate steps to remove	250	Pike River emergency response plan to be verified and rolled out to any new helicopter
176	Identify potential lightning conductors and rectify if inadequate.	251	Place receiver at grizzly borehole.
177	Identify relevant recommendations from previous Rocsil Risk Assessment (28.09.2011) and	252	Place robots against rib if unable to remove them completely
178	Identify where and what support is required based on SMP and ground conditions as found.	253	Piezometer pipe to be installed
179	If no suitable site is found then plan will be reappraised. (completed - Engineers assessment of grizzly platform) Existing drill site for pit bottom in coal.	254	Plan for ventilation of pit bottom in stone to be developed including monitoring and TARPs - prior to re-entry into the area
180	Improve 6.5km walking track.	255	Plan to clear access route as proceeding; develop JHA prior to commencement of work to include recovery of forensic evidence
181	Improve access track to pump site.	256	Plan to utilise existing mine compressors.
182	Increase inertisation capacity.	257	Plan to use Mines Rescue personnel equipped with breathing apparatus (Rocsil plug repairs)
183	Initial drill site geotechnical appraisal.	258	Plan to take advantage of warmer months for this work
184	Inspection during re-entry to include pull testing of roof supports	259	PLC to be alarmed.
185	Install a valve on top of borehole to give control	260	Potential to increase static pressure in drift.
186	Install south side pump to determine water make from the south section	261	PPE (gloves)
187	Install pump in south sectionworkings, to maintain water levels below RL537 (11m head)	262	Preferred drilling supplier to have redundancy in equipment availability
188	Install new flow meter at the portal	263	Preferred Rocsil supplier to have redundancy in equipment availability
189	Install new monitoring system at portal (water)	264	Prepare pallets of grout for flight (secure bindings)
190	Install a new borehole and pumping system in the south section to reduce water flow.	265	Prepare a suitable floor that remains dry and does not allow water accumulation that may impact on workers
191	Install additional fibre communication line to add phone comms to hill.	266	Procedure for drilling previous holes to be developed by drilling contractor - drill type, bit type and drilling procedure
192	Install additional fibre optic cable for pump control.	267	Procedure to maintain resin level during pumping (review WML Rocsil plug procedure)
193	Install fibre optic cable to improve reliability of communications and control. (ability to swap generators remotely)	268	Process to be to upgrade Rocsil plug prior to extending ventilation up to the area
194	Install pressure transducer and oxygen monitoring (real time) on both sides of Rocsil plug.	269	Provide a chemical wash facility on site prior to pumping (Rocsil)
195	Install remote control valve and controller unit.	270	Provide CABA trained medical support at FAB
196	Install remote flow meter.	271	Provide two forms of communication as a minimum requirement otherwise work ceases
197	Install telemetric oxygen sensors and pressure transducers inbye and outbye remote plug	272	Provision of statutory official to accompany all civilian agencies
198	Install telemetric monitoring for CO	273	Protocol to communicate to pilot where the ground crews are.
199	Install/restore fire fighting capability progressively as recovery of drift progresses	274	Protocols for working on the hill
200	Installation of a second borehole inbye Rocsil site will allow for camera during placement and increased pumping capacity	275	Pump maintenance plan.
201	Installation of strategically placed hut on the hill	276	Pump not powered up until it's in water.
202	Installation of a second borehole inbye Rocsil site will allow for increased pumping ability.	277	Pump to be installed in pit bottom in coal.
203	Integrity of dam wall to be determined by inspection - determine consequences in event of	278	Random auditing of pilot operations
204	JHA to be conducted on installation of flame arrestor.	279	Re-engage SIMTARS for daily monitoring with peer review by appropriate site personnel.
205	JHA to be developed for 'as found' conditions	280	Re-engage SIMTARS for daily review of site monitoring.
206	Liaise over provision of appropriate underground equipment - Civilian agencies	281	Refer #31 - install machine doors.
207	Liaison with DOC to establish nitrogen pipeline	282	Refer Item 48 from this RA.
208	Liaison with Police prior to mine re-entry to establish requirements	283	Refer JHA changing vent shaft cap when valve was fitted.
209	Liaison with product supplier regarding effects on Rocsil with pH levels - supplier to conduct test on product and supply results	284	Refer to #13.01 to #13.14 TRA Tunnel Re-entry (Ch-Ch and Pike)
210	Liaison with Rocsil suppliers regarding availability of product and shelf life	285	Refer to SENZ exploration manual for helicopter work.
211	Liaison with WMS regarding installation requirements for Rocsil formwork and also for future loading on the Rocsil formwork by the concrete. Determination of requirement with supplier to achieve the required outcome	286	Refer to staged re-entry TRA.
212	Liaise with OEM to ensure appropriate removal plan is developed (robots)	287	Refresher course for all personnel likely to be working with suspended loads.
213	Liaise with OEM to determine battery type and number of batteries (robots)	288	Reinstall auto shut and thermal trip down valve on venturi.
214	Limitation on number of personnel in Drift (single entry protocol)	289	Remove potential ignition sources.
215	Locate and utilise a suitable pump with 25mm discharge.	290	Review product packaging to ensure products can be supplied in transportable (manual
216	Locate cameras on both sides of the Rocsil plug to ensure closure around all mine services through the plug	291	Repair existing 2" nitrogen line for compressed air transmission from portal.
217	Locate fuel and generators above flood levels.	292	Reputable contractor to be engaged (Rocsil)
218	Look into Lightning Tracker forecast website.	293	Review and amend NZMR definition of 'Impassable' - consideration to be given whether working in fresh air or under O2
219	Machine to load pallets from TNL building to Workshop area (helicopter landing site) Pond 7 kept available for helicopter landing and setting up lifting gear	294	Review Atmospheric Monitoring management plan and associated TARPs.
220	MAIHAK frequencies and sequence to be included in SOP.	295	Review drilling companies SOP to ensure rig anchoring is provided for.
221	MAIHAK tube on both sides of Rocsil plug.	296	Review Pike River manual handling procedure and modify if appropriate
222	Make use of competent person to perform work	297	Review SOP WMS-022 Rocsil foam application for cavity filling, and modify if required.
223	Manage water level to ensure water will always be covering pump.	298	Review site to determine need to fell trees
224	Measurement of drift water flow post South pump start-up	299	Review TARPS.
225	Mines Rescue staff to receive training in detection of forensic evidence	300	Review existing standards for suitability for site requirements and modify if required

No.	NEW CONTROLS
301	Review the existing SOP developed for camera operation at SENZ Millerton site to ensure it has an appropriate application for the specific task at Pike. Modify the SOP as required to
302	Review previous pumping from the mine to validate understanding of current water make at
303	Review and or develop a procedure for borehole repair, replacement and or drill rig
304	Review Mines Rescue standards and protocols and update as required
305	Review the training program to ensure the importance of secure footing is stressed and amend as required
306	Route selection (nitrogen line) to ensure it is placed on the ground (vallet route preferred)
307	Routine geotechnical monitoring of drill site.
308	Routine maintenance checks before each shift
309	Relocate drill hole to alternative site above flood level - PRDH18 (eliminate hazard)
310	Routine maintenance schedule.
311	Rocsil procedure SOP-WMS-022 to be implemented
312	Scaffold platform to be re-erected to assist with handling of materials and hoses
313	Seek advice from various camera/drilling companies
314	Seek fatigue management plan from preferred drilling company
315	SENZ to give contractor (Rocsil) sufficient notice to allow for allocation of resources and mobilisation (min 5 weeks)
316	SIMTARS to conduct audit of monitoring system.
317	SOP for control room.
318	SOP for monitoring data from relevant areas to be developed.
319	SOP for working with suspended loads.
320	SOP to be developed to determine services required and to define installation standard.
321	SOP to be developed prior to personnel advancing into area inbye PRDH35
322	SOP for re-entry work
323	SOP for work on hill
324	Spare pump available.
325	Spare pump to be located at task site
326	Spare hoses to be included (Rocsil)
327	Spill kits suitable for to be made available on surface and at drill site
328	Stone dust down hole prior to camera to improve reflective surfaces
329	Stop and review project controls through Governance Structure if the pumping system stops/fails through various mechanisms.
330	Stop and review project controls through Governance Structure.
331	Stop the job and review the Option to remotely install concrete seal behind Rocsil plug. (designed concrete seal)
332	Strata appraisal completed during re-entry process.
333	Strata Management Plan
334	Subject drilling contractor to approval process
335	Suitable provisions identified and located in hut
336	Sufficient pressure from nitrogen generation to be provided behind Rocsil plug
337	Supplier to allocate appropriate and competent staff - qualifications to be supplied (Rocsil)
338	Take 5 before all tasks
339	Take cap lamps when on hill for prolonged time
340	TARP for shut-down process.
341	TARPS and procedures to be peer reviewed (Mines Rescue and SIMTARS) and amended as
342	TARPs and procedures to be peered reviewed and amended as required.
343	TARPs to be developed for all activities prior to drift re-entry.
344	TARPS to be developed for ventilation
345	TARPS for monitoring and evacuation to be developed
346	Tarpaulins set up at vent shaft for personnel and grout protection. (Tarpaulin to be installed and constructed such that it does not allow methane accumulation within its area of
347	Task planning to be undertaken and a JHA to be conducted where appropriate
348	Task planning to determine the utilisation of each hole prior to commencement of drilling
349	Team size (6 man teams)
350	Technical advice and evidence of successful Rocsil application from suppliers.
351	Temporary bunding to be provided on platform around pump (Rocsil)
352	Test flow rate in pipeline prior to being connected to mine - to verify design (nitrogen).
353	Test integrity of borehole collar.
354	Thermal blankets to be used to maintain temperature of containers between pit top and
355	Train all workers and contractors in helicopter emergency drills prior to the job starting.
356	Two oxygen sensors for remote plug and pressure transducer.
357	Use alternative system (not necessary to remove mask)
358	Undertake remedial work required by the newly developed SMP.
359	Upgrade evacuation track
360	Use camera holes to ascertain the current nature of water at plug site and in particular its
361	Use gas bags reduce gas escape when cable is through hole.
362	Use of stuffing spool as successfully used in previous applications (contains gases)
363	Use pad at PRDH43 for all landings.
364	Utilise drilling company expertise in hole placement and design.
365	Utilise slotted casing with in the road way (to the floor) to encapsulate pump
366	Use only certified personnel for platform construction
367	Use more than one person when lifting pump
368	Validate the accuracy of survey location
369	Valve to be installed on borehole to enable rapid shut-down of hole should it be necessary
370	Ventilation duct to be advanced with re-entry to dissipate gases
371	Venturi and pipe work installed 60m away from grizzly hut.
372	Verify first aid facilities, evacuation procedures and availability of medical assistance meet required SENZ standard
373	Verify helicopter company's safety management plan meets SENZ standards as minimum
374	Verify survey information
375	Verify using CALS scanning
376	Verify tolerance of Rocsil to grade
377	Verify 2" line is sufficient for compressed air requirements.
378	Verify Stockton lightning procedure (SOP) for suitability.
379	Verify the ability to obtain an IS camera. Ensure suitability of camera for task. Plan to drill additional hole to accommodate camera if necessary.
380	Walking tracks need to be upgraded to reasonable standard.
381	Water management plan to be completed
382	Water level control (piezometer) - pressure or float switches to be installed.
383	Windsock.
384	Work crews to remain in their designated areas.
385	Work to be scheduled to maximise work in daylight hours.
386	Source and review product information from alternative suppliers

APPENDIX 3: SUMMARY OF IDENTIFIED CONTROL STRATEGIES – FAULT TREE ANALYSIS

The following is a list of control strategies identified during the FTA for each of the ten most significant risk categories.

Prevention of gas ignition

Control of ignitable mixtures of gas

- Control Rocsil Plug leakage by controlling pressure differential across the plug.
- Timely control of pressure balance/ gas exchange across Rocsil plug.
- Velocity pressure dissipates with distance and will monitor effects on Rocsil Plug as fan discharge approaches Rocsil Plug.
- Provide N2 plant with adequate capacity to discharge the required flow to the designated boreholes.
- Control quality of N2 injection gas (<2%O2).
- Not to introduce O_2 inbye of the Rocsil Plug whilst making any repairs.
- Blank off outbye end of service pipes progressively as re-entry team advances.
- PRDH47 will be controlled to maintain non-ignitable gas mixture flow (pressure balancing not degassing).
- Remove methane from the general body of the drift prior to commencing re-entry.
- Dilute and safely remove any remaining flammable gas.
- Progressively inspect using HHGDs and re-ventilate.
- Discharge through fit for purpose equipment, including flame arrestors and means of extinguishing any ignition.

Control of ignition sources

- Any grout pump used will be under direct control of a competent operator.
- Operator controls frictional heating during drilling and bolting.
- Heavy equipment will be tailored and or lifted to position with LHD.
- Identify any potential problem areas and rectify before moving. Disconnect Jug-a-naut drive shafts if required.
- Use approved suitably sized mobile equipment for the task.
- Use fit for purpose air fans.
- Drift will be purged of flammable gas before re-entry
- Areas other than drift will be maintained in inert atmosphere.

- Incendive materials will not be permitted underground or tightly controlled.
- Use approved suitably sized mobile equipment for the task.
- Pumps installed in water with run/ stop control.
- No equipment or item taken underground should be capable of generating static discharge.
- Static electricity shall be safely discharged to earth without generating a spark.
- Anti static clothing.
- All electrical equipment taken underground shall be rigidly controlled to ensure that it cannot ignite flammable gas.
- Electrical equipment will be protected from damage and any damaged electrical equipment will be immediately withdrawn from service.
- Transients, induced and stray currents will be safely discharged to earth.
- Prevent flame from propagating down any borehole and into the mine or drift.
- No person will be underground during electrical storms (approaching or for the duration).

Prevention of fire on mobile plant

Control of flammable substances

- No routine refueling of diesel equipment underground.
- Only fit for purpose equipment will be used.
- Only trained, competent and appointed operators operate compliant mobile plant in manner designed to operate.
- Hazardous debris will be removed to provide safe access for mobile plant.
- Hazardous roadway conditions identified and remediated where possible and mobile plant operated according to Traffic Management Plan.
- Maintain OEM design safety standards regarding metal fatigue in relation to fuel tanks.
- Contain and clean up any spillage and segregate from heat sources.

Control of ignition sources

- Equipment maintained in compliant condition.
- Remove accumulations of flammable materials from machine moving parts.
- Well maintained equipment.
- Operated so as not to rub against external structures.
- Temperature monitored and controlled to a temperature insufficient to start machine fire.
- Machine design for duty.

- Enforcement of compliance to clear list of prohibited articles and substances that can be taken underground.

Control of obstructions at portal

- Engineering of portal to withstand seismic events.
- Stabilisation of bank above portal.

Control of obstructions in drift

- Ground support regime.
- Verification & repair of support as advance.
- Provide adequate support for duration of re-entry.
- Minimal disturbance of ground or supports until re-supported or verified by geotechnical engineer.

Control of people entrapped

- Sustain life of entrapped personnel until released.

Prevention of injury by fall of ground or structure

Control of ground and structures

- Ground support regime.
- Verification & repair of support as advance.
- Provide adequate support for duration of re-entry.
- Minimal disturbance of roof and sides and supports until re-supported or verified by geotechnical engineer.
- Minimal disturbance of structures until secured.
- Identify and isolate energy before commencing remediation work.

Control of position of people

- Prevent people from going into unsafe areas.

Prevention of inrush

Control of impounded water to the rise

- Remove hazardous accumulations of water from behind the Rocsil Plug.
- Remove hazard from service pipes before commencing re-entry.
- Maintain levels so water does not overflow from South Section of the mine in event of catastrophic fall of ground.

- Maintain freeboard in the South Section to take water flow from unexpected release from inbye.
- Inspect and drain Pit Bottom in Stone dams if hazardous.
- Free-draining Final Seal design.

Control of personnel in drift

- Underground personnel will not be exposed to inrush danger.

Prevention of person overcome by irrespirable atmosphere

Control of irrespirable atmospheres

- Provide sufficient ventilation to dilute any emissions and verify by testing.
- Provide means for controlling gas exchange through the Rocsil Plug.
- Control gas exchange across the Rocsil Plug through pressure balance and N2 injection.
- Control N2 injection rate according to mine pressure and safely dilute excess.
- Vent excessive mine pressure.
- Degas drift before entering 170m seal.
- Ventilate with a ventilation system providing ample capacity to all areas of the drift.
- Provide reliable ventilation to the drift.
- Minimise opportunity for surface fires to pollute ventilation system.
- Dilute diesel emissions to within statutory limits.
- Establish adequate dilution zone in vicinity of boreholes on surface.
- Safely dilute N2 excess bled off on surface.

Control of personnel

- Detect and ventilate or "No road" area.
- Provide adequate ventilation capacity.
- Control ventilation changes in a degassed environment which has been inspected and monitored.
- Only authorised and informed people permitted access to controlled zones of drift.
- Only authorised and informed people permitted access to controlled areas on surface.

Prevention of re-ignition of mine fire

Control of material prone to ignite

- Control O2 ingress to prevent re-ignition.
- Minimal ventilation pressure differential across any slack coal in drift.

Control of oxygen availability

- Velocity pressure dissipates with distance and will monitor effects on Rocsil Plug as fan discharge approaches Rocsil Plug.
- Not to introduce O2 inbye of the Rocsil Plug whilst making repairs.
- Control Rocsil Plug leakage by controlling pressure differential across the plug.
- Blank off outbye end of service pipes progressively as re-entry team advances.
- Timely control of pressure balance/ gas exchange across Rocsil plug.
- Provide N2 plant with adequate capacity to discharge the required flow to the designated boreholes.
- Timely control of pressure balance/ gas exchange across Rocsil plug.
- Control quality of N2 injection gas.
- Minimal ventilation pressure differential across any slack coal in drift.

Prevention of adverse health effects

Control of health conditions

- Personal protection and test upon re-entry.
- Personal protection and don't interfere with fungal growth.
- Limiting exposure to noise.
- Control hazardous energy sources (injection).
- Identify and control hazards before commencing work tasks.
- Identify, inspect and isolate radiation source.
- Dilute and remove diesel emissions from drift.
- Identify and protect from exposure to chemicals and hydrocarbons.
- Control dust with water suppression and ventilation.
- Protect against lacerations/ abrasions by using FFP equipment and PPE.
- Protect against contact with unknown fluids.
- Monitor and provide appropriate support, regarding psychological effects.
- Prepare, monitor and provide appropriate support.

Control of people

- Appropriate informed people only.

Prevention of person injured by mobile equipment

Control of operation of mobile equipment

- Separation of personnel on ground and operating mobile equipment.
- Maintain adequate separation between mobile equipment.
- Fit for purpose equipment.
- Mobile equipment will be operated within its design capability.
- Provide clear instruction to operators who are fit for work and competent.
- Provide engineering controls to allow means to arrest incorrect equipment operations.

Control of position of people

- Machine does not move any function unless the operator is instructed to do so by the person directly supervising the task.
- Pedestrian has right of way and the vehicle must be stationary.
- All energy sources must be identified and controlled to undertake servicing, maintenance, testing and repairs.
- Minimise maintenance and repairs undertaken in the drift.
- Stationary vehicle during loading and unloading.
- Passengers will wear seat belts during transit.
- No person will be permitted to perform drift re-entry tasks from the top of mobile equipment except for performing necessary maintenance on the machine.
- Work from man baskets is a controlled activity using fit for purpose equipment.
- Operator compartment provides a safe operating position for operator.

Prevention of helicopter accidents

Control of causes of helicopter crashes

- Methane dispersed remote from Helicopter operations.
- Verbal update for each day of helicopter operations and Helipro log book kept.
- All pilots will be fit for duty.
- Verified preferred suppliers only engaged by SENZ for the Pike River Re-entry Project.
- Verified preferred suppliers only engaged by SENZ for the Pike River Re-entry Project (e.g. tender process included commercial capacity to deliver service to standard).
- Only qualified and highly experienced helicopter operators engaged on tasks.
- Helicopter operations will only proceed or be maintained in acceptable weather conditions.
- Only aircraft with rated capacity to perform tasks will be used.

- Loads limited to well within the lifting capacity of machine and factor of safety. Heavy load lifts are pre-planned.
- Lifting and lay-down undertaken in areas clear of obstructions.
- Loads limited to well within the lifting capacity of FFP lifting gear.
- Evaluate load characteristics and sling and fly to safely control swinging.
- Unloading of gear onto prepared designated areas.

Controlling Cause of Passenger Injury

- Persons only board with permission from pilot or Load Master.
- Persons only alight from helicopter with permission from pilot.

Control of causes of Injury from Helicopter Load

- Control of the hook coordinated between the Pilot and Load Master.
- Loads evaluated, slung and lifted appropriately.
- All lifts planned and executed so as not to fail or be dropped.
- Unloading of gear onto prepared designated areas.
- No person in vicinity of active loads except when the Load Master is required to receive hook.