Pike River Coal – modern mine design

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Abstract

The Pike River Coal Company is set to develop the Pike River Coal Mine in the Paparoa Ranges of New Zealand's South Island. The mine will be developed to extract a coking coal deposit of the Brunner Seam, some 46km north-east of Greymouth, using a combination of continuous miners and hydraulic extraction.

The mining area is located within Department of Conservation (DOC) land and is adjacent to the escarpment of the Paparoa Range and the Paparoa National Park. As such, the major restriction to planned extraction is protection of:

- The western escarpment;
- Vertical and sub-vertical rock faces;
- Permanent water courses;
- Significant vegetation; and
- Steep slopes.

The mine will use its elevation advantage to hydraulically flume coal from the working faces to the pit bottom area where it will be slurried to approximately 35% density of solids and pumps down a slurry line to the coal prep plant some 10.5km down the Pike River Valley. The coal will be sold on the export market as a high quality coking coal for international steel making.

Introduction

The Pike River Coalfield is located on the West Coast of the South Island of New Zealand. It is located on the top of the Paparoa Range between Mount Hawea (1,189m), and Mount Anderson (1,069m), approximately 46 km north east of the coastal town of Greymouth.

The Pike River coal lease has been explored, contemplated, drilled, cored, sampled, planned and plotted over actively for at least the last thirty years. Access to the seam and a suitable method of extraction have prevented earlier development of the mine. In the early 1990s New Zealand Oil and Gas, a publicly listed NZ company, acquired the lease and set about the process of gaining resource consents and access agreements. The planning of the mine has been through a number of iterations in line with the submissions of the Assessment of Environmental Effects (AEE). The most recent review of the plan and the mining methodology has resulted in lifting the mine's planned production from 0.65 Mtpa to 1.3 Mtpa.

Approval was finally gained in October 2004 to develop the mine which holds New Zealand's largest deposit of high fluidity coking coal.

PRCC intends to develop this resource as a low ash, high fluidity, coking coal. The mine is to be developed using a combination of technologies that have been successfully implemented in New Zealand ie. road header/continuous miner development and hydraulic monitor extraction.

Following Board approval, the last quarter of 2005 will see significant work packages let to develop the road access infrastructure, the underground stone drift, the pit bottom coal works, the surface infrastructure, the coal dewatering plant and the mine-to-export port coal transport system.

With an average rainfall at site of some 6304mm and mine location within Department of Conservation land, the construction and operation of the mine will present some significant challenges for the Pike River team. First coal is expected in mid 2006 and full production a year later.

This paper gives an overview of the proposed Pike River Coal Mine and also introduces some of the mine planning parameters which have effected the "final" mine plan.

Location

Pike River coalfield is located on the top of the Paparoa mountain range about 46 km northeast of the port town of Greymouth on the West Coast of the South Island, New Zealand.

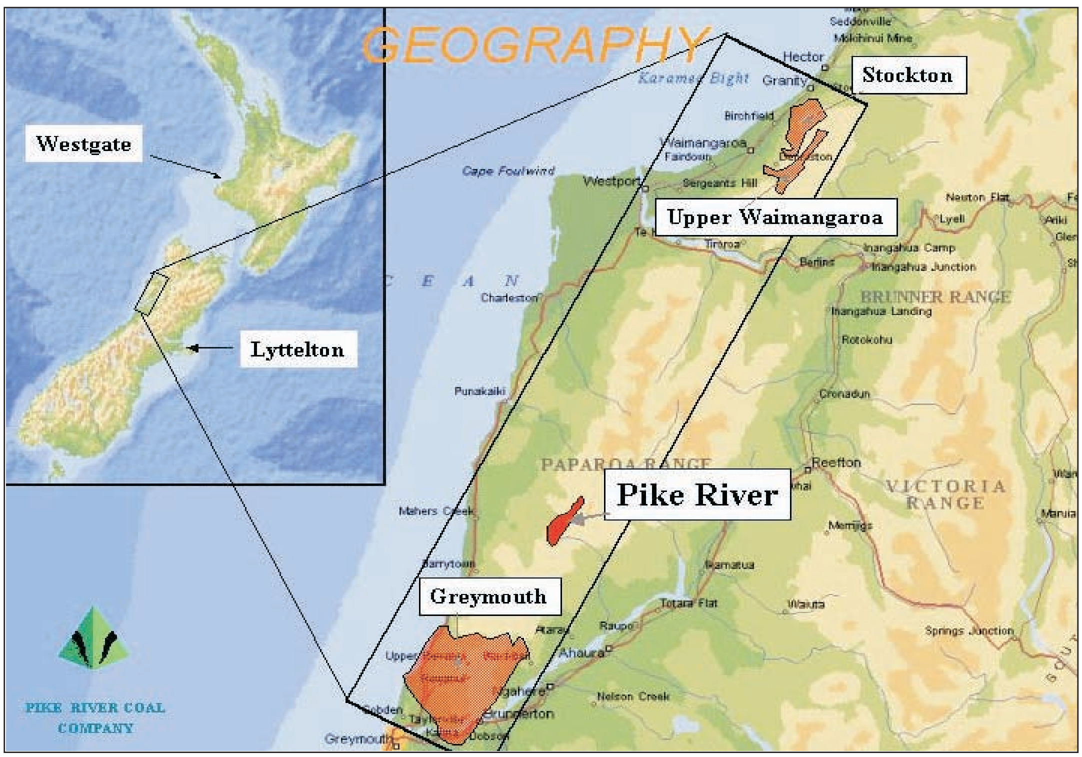

Figure 1. Location of the Pike River Coalfield

Ownership

New Zealand Oil & Gas Limited ("NZOG") is the majority shareholder in Pike River Coal Company (PRCC) with minor shareholdings held by 31 private New Zealand and Australian shareholders.

Geology

The Pike River Coalfield contains two coal measures sequences, the Eocene (Tertiary) aged Brunner coal measures and the Cretaceous aged Paparoa coal measures.

Both coal measures are exposed on the western escarpment for approximately 6km providing a good reference point for calculating coal resources. The Brunner coal measures are the same coal measures as those at the Buller Coalfield. Typically they have only one, thick, continuous coal seam that has low ash content and low sulphur in the middle and base of the seam trending higher towards the roof of the seam.

The deeper Paparoa coal measures were formed in a lacustrine environment and as a consequence the coals have low sulphur content. At this stage, the Paparoa Seams have not been included in the current mine planning. The Pike River coal deposit has been uplifted about 800m above sea-level and is truncated on its western margin by a scarp and on its eastern margin by a reverse fault, the Hawea Fault. The seam dips from the outcrop to the Hawea Fault at inclinations varying from 11 degrees to 20 degrees to the east. Small normal northeast-trending faults intersect the seam, but generally the seam thickness exceeds the throw on the faults.

The coalfield has been extensively mapped along the outcrop of the seam and on the surface of the coalfield where rocks are exposed in stream beds. A typical cross section is shown in ***Figure 2***.

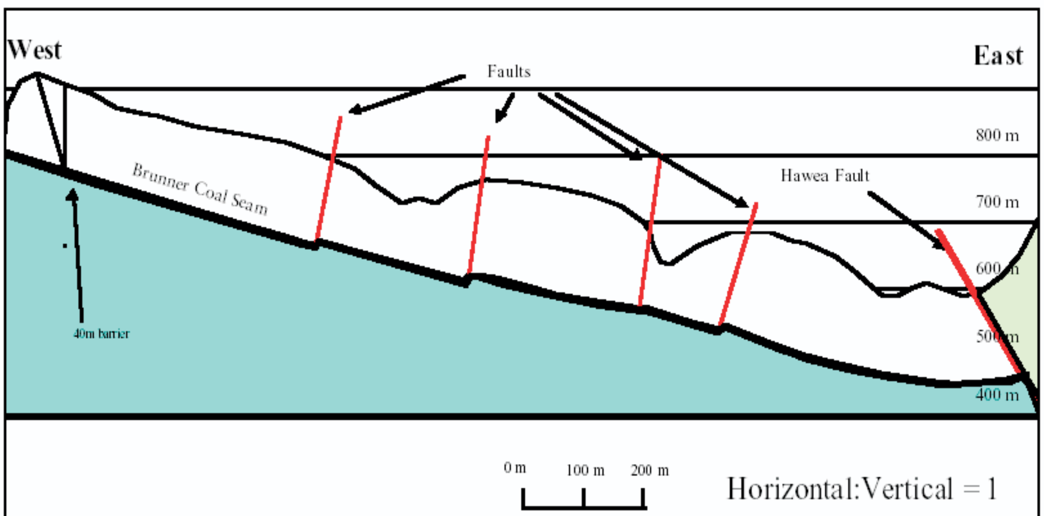

Figure 2: Natural scale cross-section of the Pike River Coalfield.

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The main seam, the Brunner Seam, is present throughout the coalfield and varies in thickness from about 2m to more than 13m. The true seam thickness is generally in the range 4m to 9m. The coal analysis data indicates that the Brunner Seam has a typical profile of both ash and sulphur increasing from the floor to the roof. The coal is usually a hard bright coal with occasional mineral bands (carbonates), and visible pyrite usually towards the top of the seam. There are no recognisable or continuous coal plies or claystone partings within the seam. The seam has been sampled in arbitrary intervals of between 0.5 and 2.0m.

Pike River Brunner Seam coal is a hard coking coal, with a number of favourable characteristics (i.e. very low ash and phosphorus) that give it a competitive advantage over many coking coals. The middle and base of the seam have low to very low levels of ash and sulphur in the coal, along with very high fluidity (+45,000 ddpm). The high fluidity levels are retained for periods well in excess of 1 year.

Mine layout

The geological modelling has been carried out using Minex software, dividing the Brunner Seam into five horizons (although some of the horizons do not exist over the entire target area). Mine planning and scheduling has been undertaken with XPAC software. This has resulted in a powerful model that provides more accurate predictions of coal production quantity and quality.

The mine has been designed to have a minimal environmental impact through:

- Underground mining;
- Access through a stone drive (tunnel) and transport of coal in a steel slurry pipeline; and
- Mine planning to ensure no adverse effects on the land surface from subsidence.

The mine layout has taken into consideration several key surface features that require varying degrees of protection from mining induced subsidence. The key surface features are:

- **West facing escarpment** – subsidence protection for the escarpment is intended to minimise the likelihood of failure of the escarpment, which would result in toppling of the cliffs making up the escarpment. The Mining Control Zone (MCZ) for the protection of the west facing escarpment is determined by a zone extending from the crest of the escarpment or boundary of the Paparoa National Park by 20m (horizontally) plus a distance equal to 26.5 degrees angle of draw from the top of the escarpment or boundary of the Paparoa National Park to the coal seam;
- **Internal rock faces** – a significant internal rock face is defined as a vertical to sub vertical face of rock of greater than 25m in height. Three significant internal rock faces have been located within the target area. The MCZ's for significant internal rock faces are determined by extending from the faces by 20m plus a distance equal to 26.5 degrees angle of draw from the top of the face to the coal seam;
- **Permanent watercourses** – protection of watercourses is required to prevent disruption to surface drainage patterns and associated micro-environments, as well as to prevent excessive quantities of water reporting to the underground workings. The important consideration here is to prevent the formation of large cracks that could provide a hydraulic connection between the surface and the underground workings;
- **Steep slopes** – subsidence protection for steep slopes is intended to minimise the likelihood of slope failure. A steep slope is defined as a slope having a slope angle of more than 32.5 degrees and a length or height greater than 100m. The MCZ's for steep slopes are determined by a 26.5 degrees angle of draw from either side of the steep slopes to the floor of the coal seam;
- **Significant vegetation** – aimed at protecting areas of vegetation of significant value and/ or high sensitivity to ground tilts and strains; and
- **Paparoa National Park.**

The current surface features have been identified from aerial photography and a digital topographic model that provides contours at 5m interval (down to 2m in low vegetation cover areas).

The relationship between the width of mining panels and the depth of cover offers a means of controlling surface subsidence impacts. By controlling panel width to less than the maximum bridging width for any given overburden depth, surface subsidence can be maintained at low levels. Above maximum bridging width, subsidence is less than maximum but is difficult to control within tight limits because of natural variability. In wide panels, full subsidence can be expected.

In the particular circumstances of the Pike River Project, there is a special requirement to maintain overall stability of the overburden strata against en masse, down-slope movement. The potential for this movement is a result of the consistent seam dip toward the east. Mining will tend to cause down-slope and down-dip movement of the overburden strata. If coal is fully extracted from a down-dip area, there is potential for mass movement of the overburden strata into the mined area with potential to adversely impact on the Island Sandstone escarpment forming the western edge of the lease area.

To maintain overall panel stability, subsidence control pillars located between adjacent extraction panels are oriented up and down the seam grade, rather than across the grade. While more inconvenient from a mining perspective, an upslope-downslope alignment of the leave-in pillars will reduce the potential for overall down-slope movement of the overburden. These pillars are spaced so that the intervening panels are of the appropriate width for the intended level of surface subsidence. The pillars are intended to be of sufficient size to remain stable in the long term.

Mine layout controls

The stone drive will intersect the Brunner Seam adjacent to an existing drill hole. Pit bottom development in coal will include approximately 720m of coal development to provide access for essential services including power, fluming transport, coal slurry holding pens and emergency water sump. Main headings will be developed from the pit bottom area to provide access to the initial mining areas to the west of pit bottom.

The mine layout has been designed to meet a range of criteria which includes:

- Integration with selected mine access;
- Resource recovery – the layout has been designed to maximise resource recovery within the available area, whilst protecting key surface features;
- Maintain flexibility within a complex structural environment;
- Optimise coal quality – over the area sulphur exhibits variability within the seam;
- Optimising the mined product and to provide a product that matches marketing specifications;
- Provision of services – layouts have been designed to adequately provide for the required services, i.e. men and materials transport, coal transport, ventilation, pumping, power, compressed air etc.

Mine development

PRCC intends to take advantage of the seam gradients within the mine and utilise hydraulic transport of coal. This therefore necessitates a number of drivage principles, including:

- Roadways will be driven to the rise at gradients that enable the efficient transport of coal by gravity. Typically, fluming grades should be greater than 4 degrees and less than 12 degrees. Optimum fluming grade (depending on flume material), is generally about 5 degrees.
- Maximum roadway gradients will also be determined by the maximum practicable grades at which development machinery can operate;
- To maximise panel recovery, entry to the panel should be at the lowest practicable point. Additionally, roadways should be driven as low in the seam as possible to maximise recovery of coal on the rise side; and
- In some cases it will not be possible to develop all areas to the rise. In these cases a suitable method of dip working will be employed.

Underground roadways will be driven to a width of 5m and an average height of 3m. Actual roadway shape and dimensions will vary with cutting equipment, duty, longer term requirements, ventilation, installed services etc. Development rates for continuous miners and road headers will vary with roadway grade. Roadway width may vary (i.e. be narrower) in the extraction zones to increase development rates and increase extraction to roadway coal ratios.

Scheduled coal production commences at pit bottom in late 2006, utilising a single development unit. Once pit bottom drivage has been completed a second development unit is operated in tandem with the first to drive main headings. A roadway is driven in a north westerly direction from pit bottom to hole out at the surface at an area of low depth of cover as soon as possible. This provides an additional intake airway. At this point a third development unit is added to carry out additional development drivage.

Extraction

Hydraulic monitor extraction has been proven to be the most suited to complex mining conditions on the West Coast of New Zealand and has been selected for the Pike River conditions. The method offers the best recovery in thick and steady dipping seams. It also provides the highest productivity, greatest flexibility and lowest operating cost. As the coal seam is located at a high elevation, almost all coal can be transported using gravity.

Operation of the monitor extraction system will be on the basis of three available units to provide one operating unit, one unit that will be in the process of dismantling and retreat, and a third standby unit that will also be available for production as required.

During hydraulic extraction, it is planned to mine the lower portion of the seam first. This will result in the selective recovery of the better quality coal. A separate working section within the higher plies will then be extracted.

Hydro monitor extraction is scheduled to commence in early 2008, some 16 months after commencement of development at pit bottom. Components in the mine's systems have been designed with a production capacity of up to 1.4 Mtpa, which will include 0.2 to 0.3 Mtpa from roadway development and 0.8 to 1.1 Mtpa from the hydro monitor unit. Planned peak production is up to 1.3 Mtpa.

Mined coal will be flumed to the pit bottom area prior to which some stone dilution will have been removed by stone traps. At pit bottom the coal will be crushed to <35 mm before the coal/water slurry is conditioned to 35% pulp density (i.e. 35% coal, 65% water). The slurry will be transported through a 250mm diameter steel pipeline about 10.6 km downhill to a dewatering complex. At the dewatering complex the coal will be washed, then separated from the water, screened and stockpiled according to its quality awaiting dispatch.

Gas and ventilation

The coal seam has a medium to high gas content throughout the resource area. Methane is the dominant gas at >90%. The trend in content is variable, however a number of earlier samples have been found to be incorrectly tested. Typical of seam gas contents is a low Q_1 value (< 0.5 m^3/t).

Recent sampling has determined a seam gas content of 7.0-7.5 m^3/t at the proposed seam entry location. This is at a depth of 85m. This gas content is considered to be difficult to control by ventilation means alone and in seam gas capture (pre-drainage) will be used as part of the roadway development process. PRCC will aim to reduce seam gas to < $3m^3/t$ prior to mining, however where insufficient lead-time is possible, a maximum content of 6.5 m^3/t will be sought so as not to pollute the intake airways with rib emissions.

Ventilation quantities have been determined for each of the mining sections with minimum air quantities within the roadways to dilute the rib gas emissions assuming a maximum 6.5 m^3/t gas content and a low to moderate seam permeability. The seam also displays variable permeability

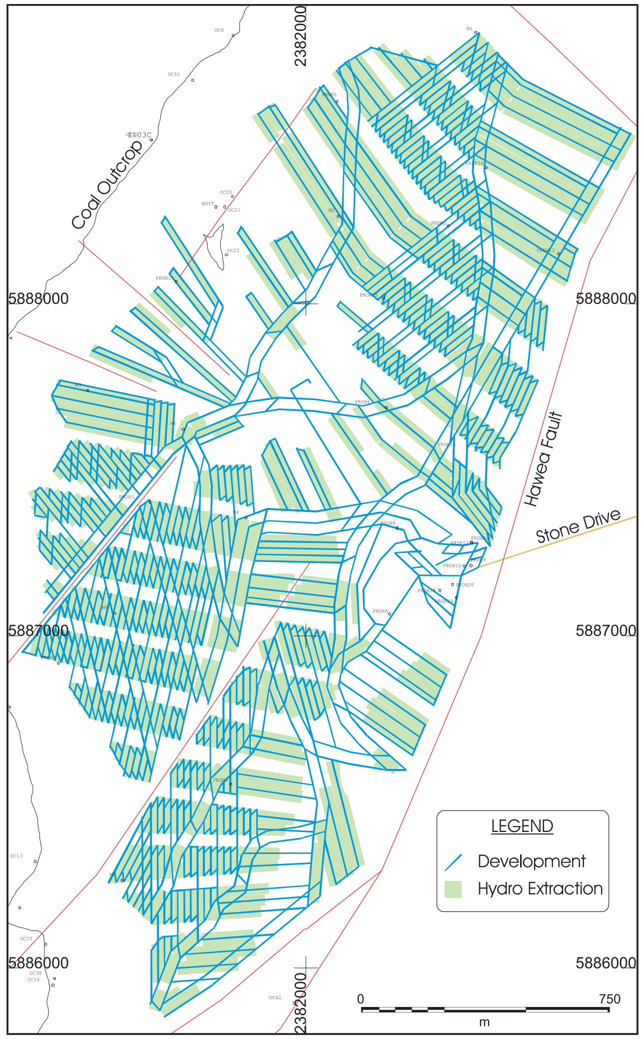

Figure 3. Mine Layout

in region of the Hawea Fault. Similarly the content increases away from the escarpment and with depth. Ongoing assessment is in progress to determine the potential rib side emissions based on reservoir modelling and recent results of adsorption testing. The main fans will be operating within an envelope between 1kPa to 1.6kPa at air quantities from approximately 135 m^3/s to 240 m^3/s. The fans for this duty range will be axial flow fans.

A real time monitoring system will be established for all gas and ventilation parameters underground. The system will report to the mine's control room and will also be web interfaced to allow interrogation by mine officials remotely via the internet. This will display all details of gas monitoring, underground ventilation and main fans, as well as the mine's pumping system.

Human resources

It is intended to operate the mine 3 shifts per day and 7 days per week. The peak employment level will be approximately 150 operations and support personnel. The maximum employment level will provide for 3 development units and a hydro monitor unit, underground services, surface facilities including slurry pipeline, dewatering station and coal load-out facilities. Steady state employment will be achieved with 2 development units and a single hydro unit and employment will be approximately 125.

Developing the Pike River Coal Mine (PRCM) in the current coal industry cycle will also present PRCC with similar challenges as those faced not only by Solid Energy, but by all mining companies in Australasia. New Zealand and particularly the West Coast have a very tight labour market and Australian coal mines, offering substantial rates of pay, are also finding demand for skilled trades and operators is not being met by local supply. PRCC have recruited a Human Resources Manager prior to the commencement of operations to start to address issues including skills requirements, recruitment, housing and infrastructure needs, remuneration packaging, competency development, establishing relationships with other coal producers and education/training providers for combined development of training programmes. Excellent initiatives such as The Digger School by the Tai Poutini Polytechnic should be supported and similar initiatives for underground workers explored.

Conclusions

Pike River Coal will have the advantages and challenges of any new greenfield venture. The advantages being that Pike will not have the shackles of past operational and management errors at the mine; it has a clean sheet to plan, design, construct and operate the mine with state-of-art technical and management systems; the opportunity to recruit and develop a workforce with aligned goals for the project's success; and to achieve benchmark environmental standards for an underground operation. The challenges for Pike will be the effective application of the hydraulic mining technique to achieve consistently high output; recruiting and retaining the above mentioned workforce; and the management of the mine's effect on the surface features and general environment from its operations.

Author

Peter Whittall, a Fellow of the AusIMM, is currently the Mine Manager for Pike River Coal based in Greymouth, New Zealand. Peter has over 24 years experience in the Australian underground coal industry with BHP Billiton and holds a Bachelor of Engineering and Master of Business Administration from the University of Wollongong, New South Wales (NSW). Peter is qualified as a Mine Surveyor, Deputy, Undermanager and Mine Manager in NSW and is currently undertaking transition study to have these qualifications ratified in New Zealand. Peter has managed several underground mines for BHP Billiton in the Illawarra coal field of NSW, including recently the greenfield start-up of the Dendrobium longwall mine in Wollongong.

Peter relocated to Greymouth with his family in February 2005 to manage the Pike River Mine start-up and enjoy the West Coast lifestyle.