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Hydraulic Coal Mining Developments in New Zealand

G J Duncan¹

ABSTRACT

Hydraulic transport of coal has been used for many years on the West Coast of New Zealand to extract small blocks of steeply dipping coal. Recent development at Strongman 2 Mine has seen the use of high pressure monitors to cut coal and a corresponding increase in the scale of production.

This paper provides a brief introduction to hydraulic mining, describes the present system used at Strongman 2 and discusses future potential development.

HYDRAULIC EXTRACTION OF COAL IN NEW ZEALAND

The use of water for the transport of coal underground is recorded as far back as 1927. It became the method of choice for small private operations on the West Coast of the South Island, as it required very little capital investment and allowed small, steeply dipping blocks of coal to be mined competitively with the larger State owned conventional operations. Eventually as pressure on production cost increased and some union resistance was overcome, larger State operations such as Strongman (opened 1939) came to utilise hydraulic transport. This was generally from the face to an underground dewatering station followed by conventional transport to the surface. The use of large centrifugal pumps to complete the slurry journey to the surface also became common practice.

These operations were handicapped by the need for shotfiring to break the coal, the need for numerous production places and the extraction requirements of old workings laid out for conventional haulage, often with many collapsed roadways. Hydraulic transport allowed narrow splits to be driven through pillars in these fallen panels, enabling reasonably safe extraction to be carried out with good recovery ratios.

To trial monitor extraction a system was installed at the established Strongman Mine in 1992, utilising two high pressure pumps, a 200mm high pressure pipeline and monitor face units which had become surplus with the closure of Sunagawa Mine in Japan.

Extraction by monitor of old workings in Panel 3 and the Main East Headings was completed in 1994 and the mine closed.

The trial showed that the hard Strongman type coal could be cut successfully, particularly where significant roof weight was present, and the generally hard roof and floor resulted in high seam recovery and little floor contamination.

Previous shotfiring extraction had resulted in a number of goaf fires as small coal was often left behind after pillar falls. No sign of spontaneous combustion occurred during monitor extraction, due to the washing of fine coal from the goaf, the better recovery achieved, and the quick retreat rate.

While further drilling was carried out on the main Greymouth Coalfield, a smaller block of coal was identified to the east of Strongman Mine and the Strongman 2 Mine was established. The position of the Strongman Mine and the Greymouth Coalfield is shown in Fig.1

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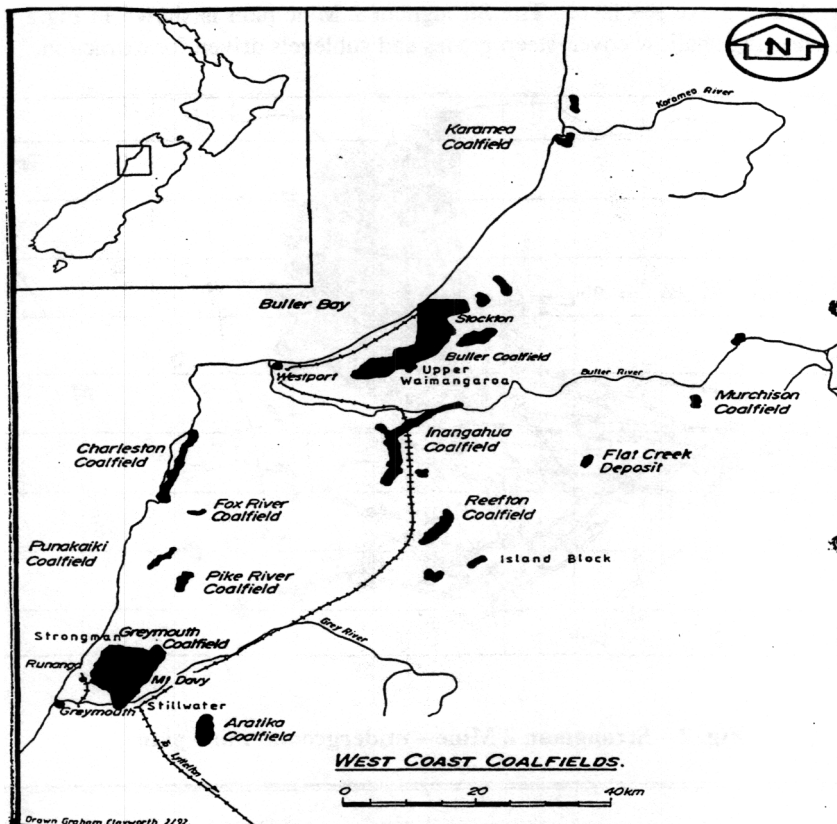


Fig. 1 – West coast coalfields

STRONGMAN 2 MINE

The Strongman 2 Mine is situated north of Greymouth on the West Coast of the South Island. It produces approximately 360,000 tonnes per annum of low ash (5%), Bituminous high volatile B rank coal (Ro max 0.72, Sulphur 0.25%).

To date coal has been sold to Japan and South America as thermal coal. There is now a strong demand for the coal as semi-soft coking coal in Japan. Approximately 5% is sold as graded domestic product and a further 10% to the cement industry.

The exported coal is railed to the port of Lyttelton on the east coast of the South Island (220km) and shipped in Panamax size vessels. Very high internal freight costs, a high exchange rate and falling thermal prices have put pressure on the operation. The operation has become the lowest cost underground producer in New Zealand, while also maintaining the highest extraction ratio of any underground mine.

The operation utilises hydraulic coal cutting at the face for pillar extraction and hydraulic transport on the seam floor and in flumes to remove the coal to the surface. All the present workings are to the rise of the surface access allowing coal and water to flow from the mine to a surface dewatering plant. The water is then recirculated via a high pressure pump to the coal face. Development of the mine is by mechanical means with transport to the surface by flume using low pressure water.

Resources in the block presently being mined amount to 4 million tonnes with indicated reserves of 20 million tonnes on the mining licence. The geology of the mining area is typified by a very wide range of seam gradients up to 70°, a number of north - south trending normal faults, and areas of very low surface cover, with outcrops to the north. Seam thickness also varies from less than 2m to 15m.

The mine is accessed via a 4km, 1 in 8 grade road from the coastal highway. The topography is extremely rugged and the elevation of the portals is 412m above sea level. The Strongman 2 Mine plan is shown in Fig.2. A typical seam cross section is shown in Fig.3, showing shallow cover, steep grades and sublevels driven for extraction.

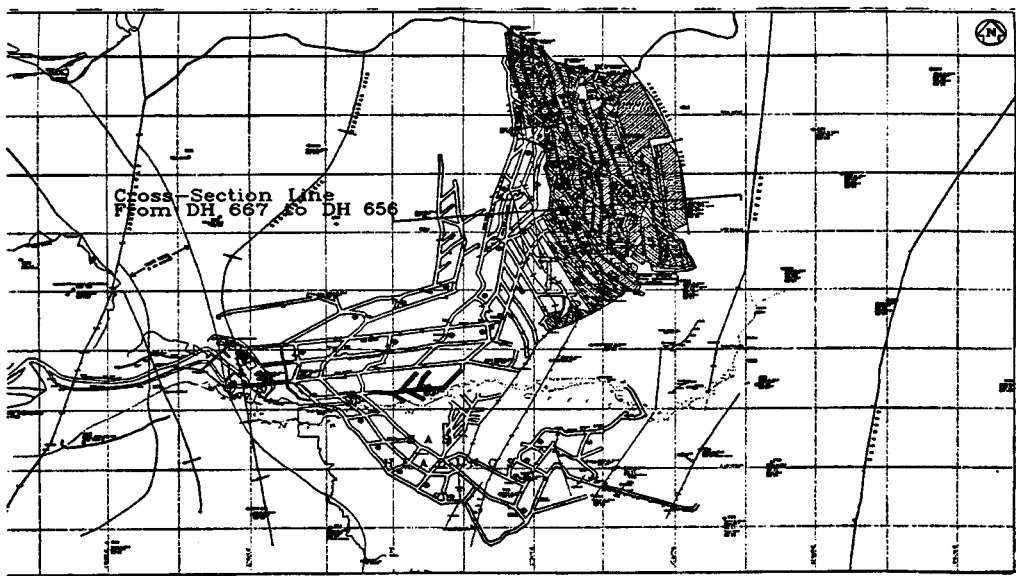


Fig. 2 – Strongman 2 Mine – underground mine plan

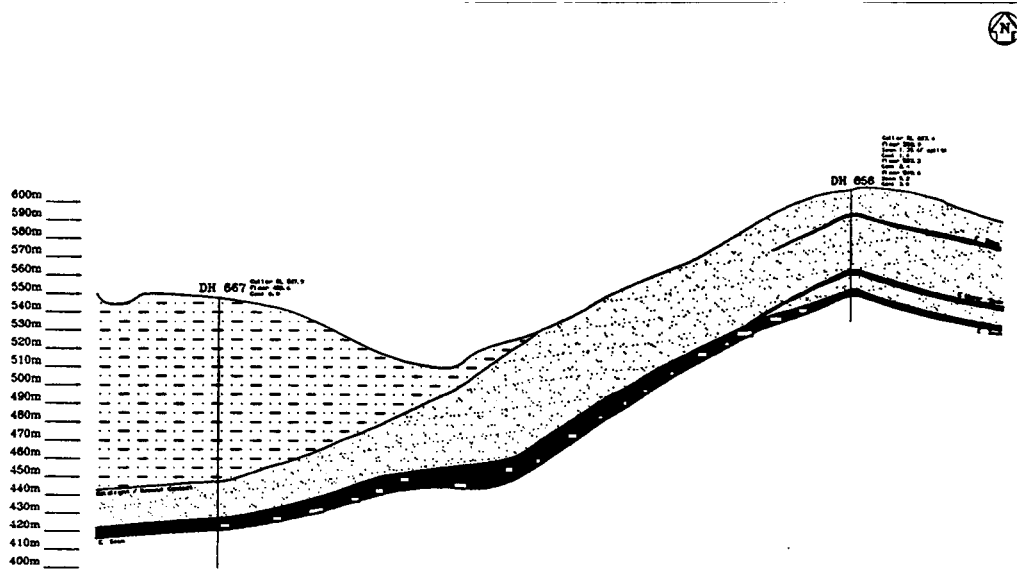


Fig. 3 – Strongman 2 Mine – Cross-section: E Seam

DEVELOPMENT OPERATIONS

Underground development at Strongman 2 began in 1994 and has included these components.

1. Initial stone drivage to access the coal of three 50m long drifts using an Anderson RH25 Roadheader loading into an Eimco 913 LHD. The 24 tonne RH25 was stretched to its limit cutting the 50 MPa rock, and a 35 tonne Mitsui S125 has proved more successful in later stone drivage.
2. Coal drivage to the rise using a Mitsui S125 Roadheader and 4.0m³/min of low pressure water to transport the coal. Grades of up to 1 in 3 were traversed and, with good roof conditions, advance rates of 23m were achieved in an eight hour shift. The steep grades and washed-out roadway behind the roadheader made material transport to the face by diesel equipment difficult.
3. Considerable roadway development has also been carried out utilising the high pressure monitor water to cut the face. This has been in very steep seam conditions unsuitable for mechanical equipment. The narrow roadways require minimal support but materials and supplies must be manhandled. This development was limited to the face area or sublevel roadways.

The present method of coal drivage is a 12CM6 Joy Continuous Miner loading into a 15SC Joy Shuttle car. The coal is trammed up to 200m and discharged into the coal and water flow from the monitor extraction area. This method has two major advantages, short dip development is possible and diesel material vehicles can transport equipment direct to the face, as the roadways are not washed out.

All roadway development is supported on 1.8m fully resin encapsulated roof bolts, four bolts to a row and rows 1.5m apart. Roof conditions are generally good with a hard sandstone immediate roof. Steel mesh is used with bolts in friable coal, or in stone drivage. Cable bolts, 4m and 6m in length are being trialled to improve intersection stability as some slabbing of the stone roof occurs. In the thicker seam areas (10m to 15m) development is carried out near the floor to facilitate extraction of top coal with the monitor. Coal ribs stand extremely well and do not require support.

Typical panel lay outs are shown for sublevel and subrise extraction in Fig.4 and Fig.5. Subrise is used for the flat grades and sublevel extraction for steep grades.

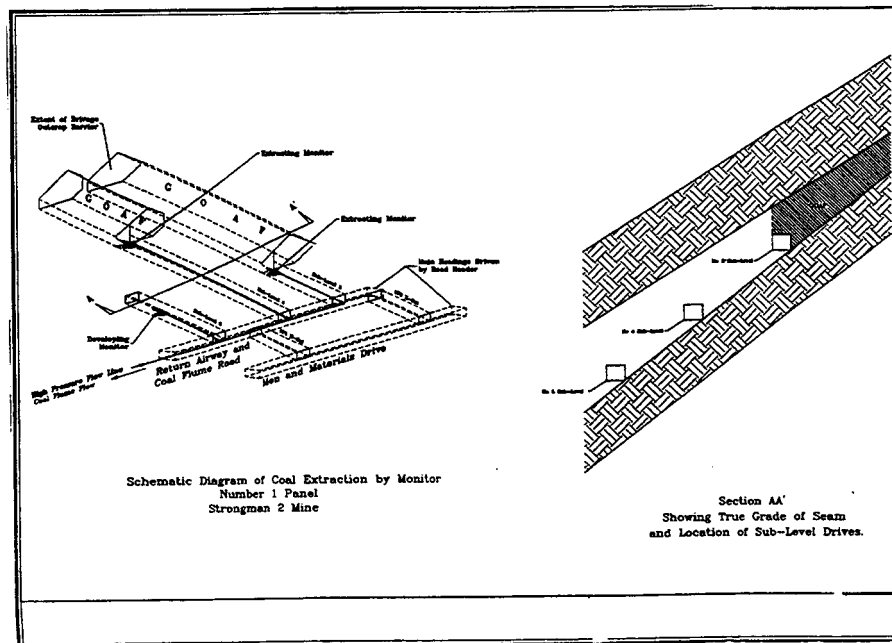


Fig. 4 – Strongman 2 Mine – underground mine plan (sub-level monitor extraction)

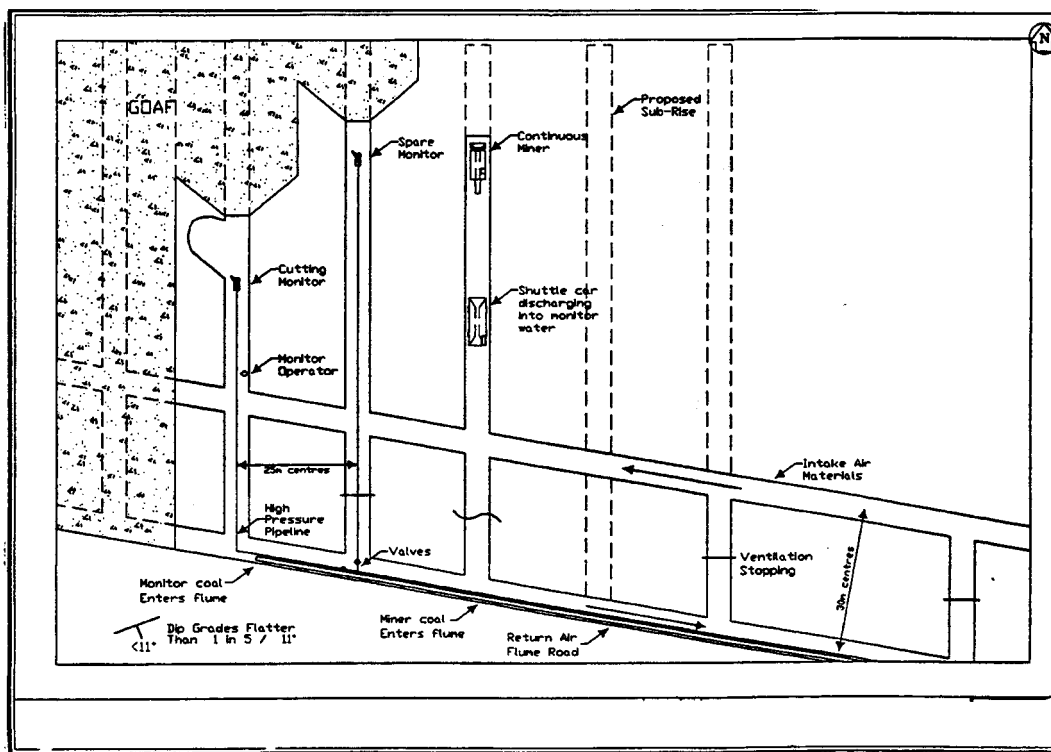


Fig. 5 – Strongman 2 Mine – Underground mine plan (Sub-rise monitor extraction for flat grades)

MONITOR EXTRACTION SYSTEM

The majority of the coal at Strongman 2 is worked using a hydraulic monitor. The coal is cut at the face using a remote control hydraulically activated face monitor. The water and coal flows from the workings, (which are to the rise of the access portals) to the surface dewatering plant. The water is cleaned to approximately 50ppm suspended solids and pumped back through the monitor pump to the face. Cutting pressures of 1.33 MPa and water flows of 5m³/min are utilised.

The process is relatively continuous with the monitor usually cutting for approximately 75% of the shift.

The monitor system was chosen for the following reasons

1. The very steep dipping seams, up to 70°;
2. The thick nature of the seams, up to 15m;
3. The hard nature of the roof and floor making hydraulic cutting and transport viable;
4. The inherent safety of the system, in that no piece of equipment or person is exposed out in the goaf area;
5. Previous experience with hydraulic transport of coal; and
6. Lower capital and maintenance costs of the coal winning and transport system.

The following are problems and issues that emerged once the system was operational.

1. Major surges in flow due to underground blockages were resolved by the use of steel flumes in flatter areas and increasing the capacity of the dewatering plant to handle surges in flow.
2. There was very little weight in the extraction area to assist water cutting, resulting in less than planned cutting rates. Depth of cover is now 90m and increasing.
3. Intersection of unexpected faults requiring stone drirage and modification of mine plans.

MONITOR PRODUCTIVITY

Data

The Monitor system productivity is dependent on three factors: system availability, utilisation and cutting rates. All operating data is analysed to enable improvement in the method of operation. An example of this data is included in the Appendix.

System availability

The key factors that affect the monitor system availability are

1. Six monthly overhauls of the monitor pump rotating assembly, resulting in two weeks downtime;
2. Contaminated water in the recirculation circuit resulting in monitor pump shut down;
3. Leaks in the high pressure face lines, requiring shut down and repair; and
4. Face units damaged or buried after pillar falls.

System utilisation

Key items that influence utilisation of the system are

1. moving the face units back after pillar falls. (Alternative units are set up to enable alternative places to be worked.), and
2. inspecting the face during the cutting process, which requires monitor shutdown.

Cutting rates

The production variable that generally has the greatest impact on productivity is the monitor cutting rate. This is measured as tonnes per minute that the jet of water will cut from the face. This ranges from 0.5 tonnes/min to 1.5 tonnes/min depending on

1. coal hardness;
2. roof weight;
3. cleat direction;
4. cutting distances;
5. pump output pressure; and
6. pump flow.

Coal hardness testing has been carried out utilising the Protodyadanov standard and a good picture of varying hardness through out the present mine workings has been developed. A plan showing coal hardness contours is included in Fig.6.

Maximum cutting distances have been reduced from 25m to 15m to improve cutting rates.

Pump output pressures and flow are continuously monitored to determine any dropoff in performance that will affect cutting rates.

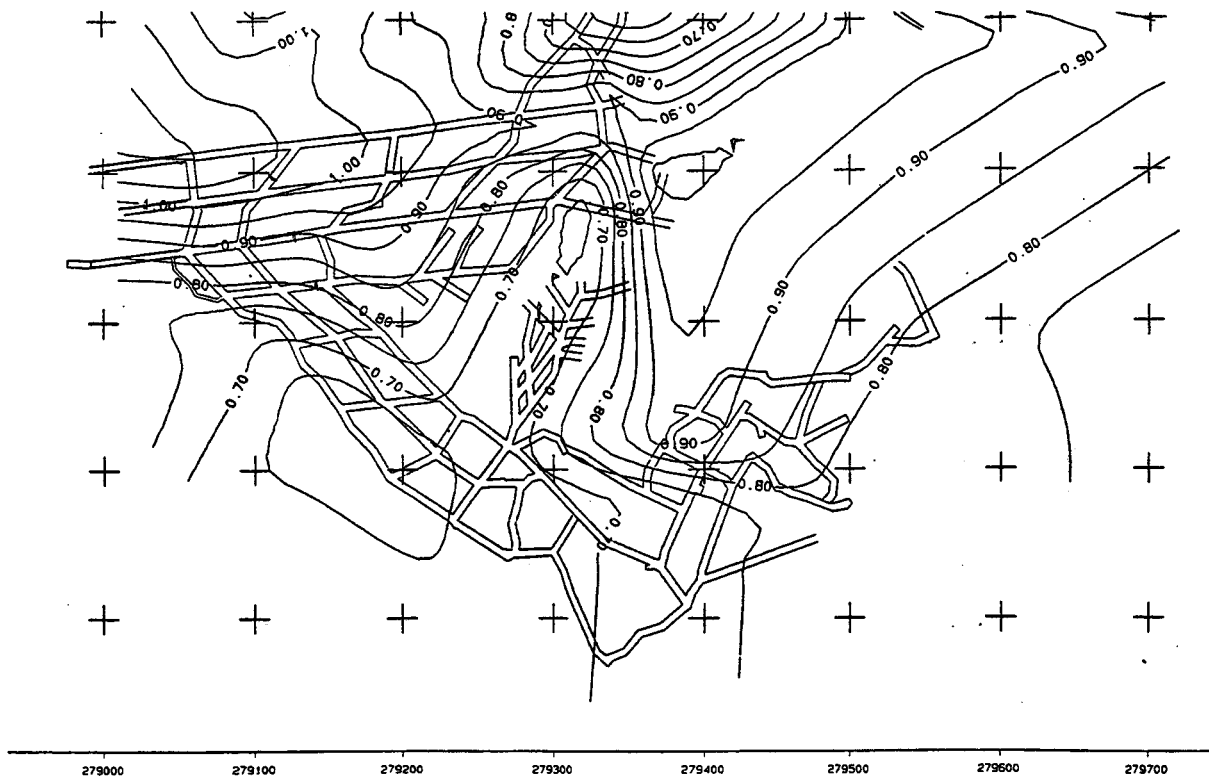


Fig. 6 – Strongman 2 Mine – Hardness contours (Protodyakanov)

HUMAN RESOURCES

The Strongman 2 Mine operates in production mode 24 hours per day, seven days per week, with a short break at Christmas.

All production and maintenance staff work twelve hour shifts, face to face on a three day on, three day off roster system. A total workforce of 85 is involved in mining and loading out operations.

Production and maintenance staff are employed on identical employment contracts; they share equally in a production bonus, and they will carry out either work, depending on their skill levels.

Key points in the employment contract are

1. Hours of work, 12 hours per day face to face;
2. A three on three off, Nightshift, Dayshift roster;
3. Overtime paid for work on rostered days off;
4. Average total gross earnings approximately \$46,000 per year;
5. A production bonus, the rate varying with output per man shift;
6. A redundancy agreement;
7. Six paid union meetings per year; and
8. A two year contract period with a cost of living (CPI) increase after year one.

Since the mine started in 1994, two days have been lost due to industrial stoppage.

The key to this has been

1. A realisation by the workforce of the economic necessity of competing in the international marketplace;
2. The fact that the mine is divided into small shift crews, 10 to 12 workers, has generated a small mine mentality where people feel part of the operation;
3. The Employment Contracts Act, which prohibits strike action outside normal contract negotiations; and
4. A small and flat management structure, committed to open communication with the workforce.

The staff structure is shown in Fig.7

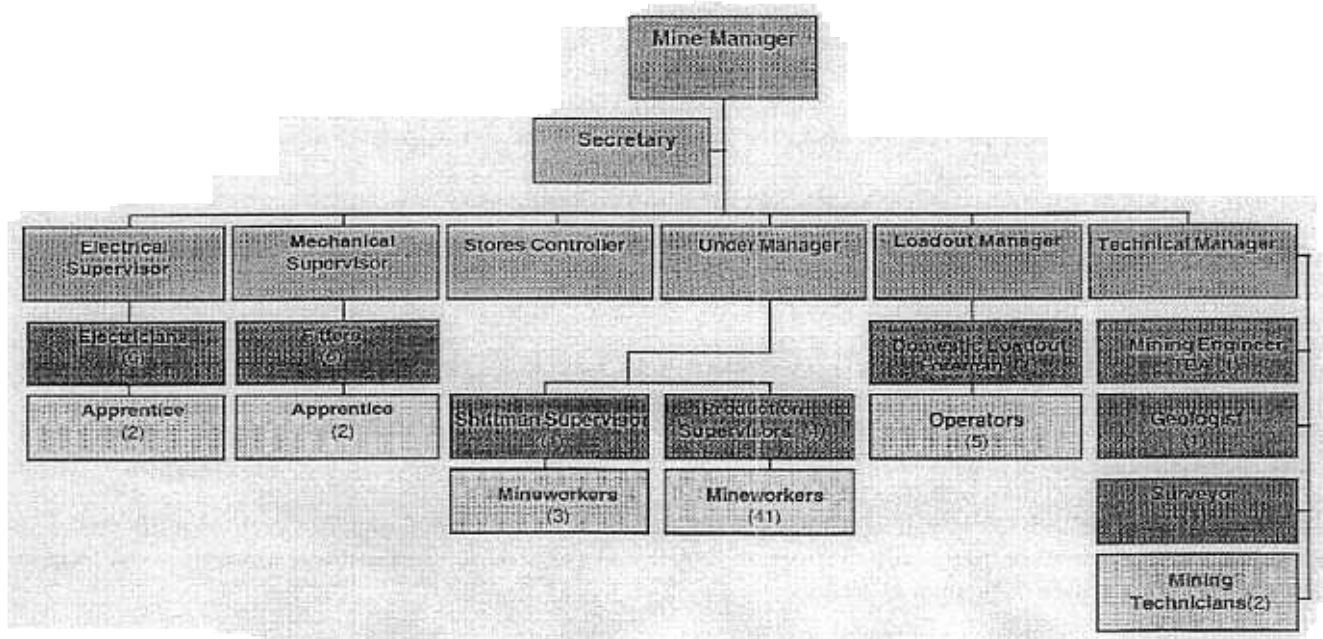


Fig. 7 – Strongman 2 Mine Staff Structure

HEALTH AND SAFETY ISSUES

The key factors affecting health and safety on the Strongman 2 site are as follows:

1. The site works under the Health and Safety in Employment Act 1992, following the repeal of the Coal Mining Act and Regulations. This is based on hazard identification and management, compared to the more prescriptive regulations. The New Zealand Government plans to introduce revised mining regulations some time in the future.
2. Although no methane has been detected in the present working, it is expected as depth of cover increases. The mine is therefore worked as a "Gassy Mine" with all flameproof equipment and operating procedures.
3. The coal is prone to spontaneous combustion and this is aggravated by major breaks to the surface. The action of the monitor in washing all small coal from the goaf and achieving a very high recovery helps off set this propensity to spontaneous combustion. One small fire is active in the goaf, remote from the working faces and is evident from smoke emitting from some surface cracks. The gases emitted are monitored using a surface Maihak tube.
4. Due to the steep seam gradients, access is often limited for men and materials vehicles, requiring manual handling of heavy pipes and equipment. The majority of miners accidents are the result of heavy lifting or slipping on steep gradients.
5. The monitor system is inherently safe due to the ability to cut pillar coal from a distance of up to 25m, allowing the monitor to be kept in a secure position and the operators are situated at least 10m further back.
6. The introduction of high pressure monitor water to the coal face poses a significant hazard, and the operation has to be controlled with strict procedures.

The lost time accident frequency rate per 100,000 man hours is 6.9, the most serious accident to date being a badly crushed finger.

8. The key elements of safety management on the site are:
 - a) a hazard identification and management system built on inspections and total worker involvement in site safety meetings;
 - b) rigorous investigation of all incidents and accidents and follow up to ensure remedial action has been taken;
 -) thorough induction, ongoing training and licensing of operators; and
 - d) the development of a culture that says accidents are not an expected outcome of mining operations.

THE FUTURE OF HYDRAULIC EXTRACTION

Due to the small resource available at the Strongman 2 Mine, it is expected that production will remain at approximately 360,000 tonnes per annum, to extract the remaining reserves in ten years.

Solid Energy New Zealand Ltd is part of a joint venture known as Greymouth Coal Ltd, which is in the process of establishing a large operation, potentially over one million tonnes per annum, to extract a thermal type coal from the Greymouth Coalfield based on monitor extraction.

Solid Energy is also developing the Mt Davy Mine, approximately 5km from Strongman 2. This will extract a high grade coking coal, low in sulphur, for blending with Buller coals (Fig 1). At a depth of 700m, this mine will certainly be the deepest ever developed in New Zealand. The main seam has been intersected by the first 1.1km drive. Work on strata control and managing gas and potential outbursts is being carried out; one outburst has already occurred. The monitor system will be ideal for the extraction of this coal due to the soft nature of the coal and expected high roof pressures. The mine is planned to produce 500,000 tonnes per annum.

CONCLUSION

Although this system of extraction is not used elsewhere in Australasia, it has been proven to be ideal for some of New Zealand's most geologically disturbed coal seams. The small deposits of thick low ash coal have benefited from a system that results in very high seam recovery, exceeding 75%. The low capital cost inherent in the monitor system has allowed the set up of operations in these small blocks of coal and the resultant low operating costs have allowed the operation to compete internationally.

The challenges for the future revolve around improving the availability of the high pressure pumping systems, the improvement in cutting effectiveness and the accessing of these often deep and heavily faulted blocks of coal.

APPENDIX

STRONGMAN 2 MINE MAJOR PLANT – OPERATING DATA EXAMPLE

1	Ebara Monitor Feed Pump	5 stage centrifugal pump 5200 R.P.M 1:3.5 Ebara gearbox 1550kw Toshiba induction motor 5m ³ /min discharge quantity 187 kgf/cm ² max pressure
5	Mitsui Monitor Face Units	
1	Mitsui S125 Roadheader	Weight - 30 tonnes Cutter motor - 125kw
1	12CM6 Joy Continuous Miner	
1	15SC Joy Shuttle Car	
2	Eimco 913 LHD	
2	ERIEZ H.D.S Primary Dewatering Screens	1.4mm Aperture
4	CMI 10 inch Cyclones	
1	Eriez Intensive Dewatering Screen	0.4mm Aperture
1	High Rate Superflow Clarifier	8m diameter
1	Maihak Tube Bundle System	