Productive Partnership – Advanced Blasting Technology at Newlands Coal Mine

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In late 2008 Xstrata Newlands Coal Mine in Central Queensland and Orica Mining Services engaged in discussion to investigate methodologies to change their current mining practices and overcome the issues in the mining of steeply dipping coal seams, the associated coal loss risk and to assist in improving mining productivity. A strategy was developed and it was determined that through-seam blasting was essential to the success of winning the coal from the Wollombi Pit at Newlands.

The successful implementation of through-seam blasting in Wollombi Pit has produced blast results which have allowed for alternative and improved mining methods, increases in excavator production rates, successful management of coal recovery and increased shot size. The result has been an overall reduction in the total costs of the mining process.

The implementation of electronics and baby-decking in the single seam dragline operation at Suttor Creek Pit, has allowed changes in drill and blast design parameters. Cast results have been maintained at greatly reduced powder factors, through timing un-achievable with a non-electric initiation system. The coal seam has been left intact and production rates of the two draglines have been maintained above budget.

The focus on drill and blast management at Newlands, combined with technology, has demonstrated the ability to substantially improve overall mining results and provide considerable financial benefit to the operation, through blast results that have been tailored to suit the operational requirements.

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Introduction

Newlands Open Cut is a coal mine located approximately 130 kilometers (81 miles) west of Mackay in the Northern Region of the Queensland Bowen Basin, in Central Queensland, where it produces both steaming and coking coal for export. The mine currently has two active pits; The Wollombi pit contains 4 mineable coal seams, which range from 2.6 to 9.6m (8.5 to 31.5 ft) in thickness, at a depth of up to 180 metres (591 ft) and utilizes a truck and shovel fleet, consisting of predominantly 3x Leibherr 996 Excavators for waste removal. The Suttor Creek pit is a conventional strip mining pit, which contains both a Marion 8750 and a Bucyrus Erie 1370 for removal of overburden.

A truck shovel boxcut was started in the Wollombi pit in February 2008, after the pit was initially developed by a series of dragline strips. The dragline strips suffered both low-wall and highwall failures due to steeply dipping coal, poor ground and wet conditions. Due to the dip of the coal within the pit, which range up to approximately 23 degrees in the North Eastern corner (Figure 1), the initial drill and blast method produced suboptimum results for both blasting and excavation, due to the varying geological strata's.

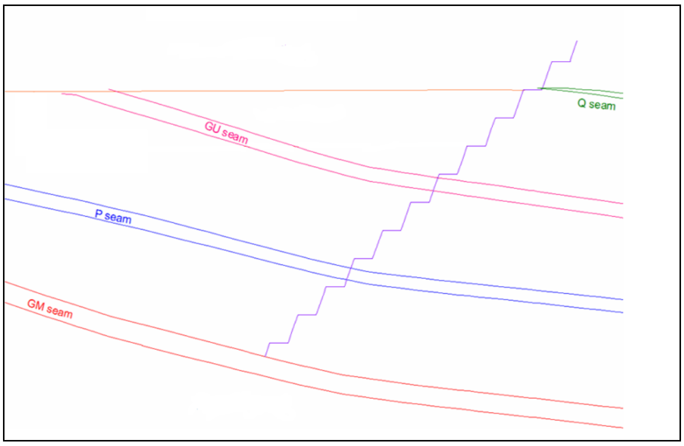

Figure 1 – Wollombi Pit Coal Seam Layout & Photo of Seam Dip

The initial process was to drill and blast down to the top of the coal seam or design RL, allowing sufficient standoff distances from the geological coal model surfaces, to prevent blast damage. The waste material would then be extracted, along with the coal. Once the coal had been extracted however, there would commonly be a large, un-blasted wedge of material left behind (Figure 2). As the surface of the wedge would be at approximately the same grade as the coal seam, a large amount of preparation prior to the next drilling process was required. Due to the steep dip of the wedge surface, this would also prevent drill holes being placed in optimum positions and hence result in a large amount of oversize in the proceeding blast (Figure 3).

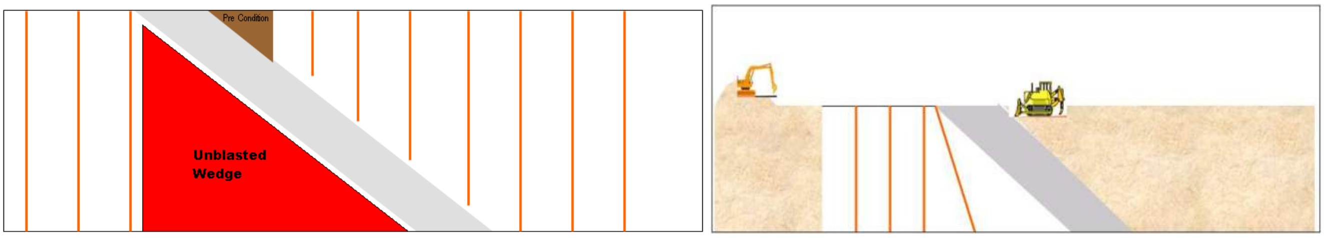

Figure 2 – Previous Drill and Blast Method

Due to the significant oversize in the blasts, combined with the increased amounts of drill bench preparation required and the downtime associated with firing each small ‘wedge’ blast, production rates had decreased dramatically and were having a significant impact on the efficiency of the operation. It was decided that both the blasting and mining methods needed to change in order to improve the operation and meet increased coal forecasts.

Figure 3 – Oversize from Previous Blasting Method

Project Outline

It was identified that the use of through-seam blasting in Wollombi Pit could remove the presence of the un-blasted wedge of material, allowing for flat benches requiring less preparation for drilling and a smoother mining process. Further to this, it was identified that larger blasts and significant drill and blast savings were possible. It was identified that changes to drill and blast designs in Suttor Creek pit could also help to reduce blast costs, whilst maintaining, if not improving, dragline productivity and cast percentages, whilst reducing blast related coal damage.

A Site Scoping Study was able to map the process changes required, along with potential improvements and associated cost impacts of each. A Value Tree was then created and used to display the potential cost savings associated with the improvements. A service whereby Orica personnel were integrated with Xstrata Newlands Technical Service Team was proposed to deliver drilling and blasting on flat benches, increased blast size, improved production rates and increased coal recovery.

The Key Performance Indicators for the service was that within 6 months, the following benefits would be achieved

- Implement through-seam blasting
- Increase excavator dig rates by 10%
- Measure coal loss and reduce to acceptable limits
- Increase blast size to an average of 300,000bcm (390,000 bc yd)
- Optimize Orica equipment loading and utilization

Project Implementation in Wollombi Pit

The service began in November 2008, with the introduction of through-seam blasting in the Wollombi pit. Geological data from the pit was analysed, to determine the rock properties of each of the various materials between the coal seams. From this detailed analysis, extensive blast modeling was conducted. Varied standoff distances were modeled for each of the coal seams and blast damage criteria assessed to determine the appropriate stand-off distances for each coal seam and rock type (Figure 4). Appropriately selected stand-off distances would prevent damage to the coal seams, whilst ensuring that optimum fragmentation was achieved to help improve excavator production rates.

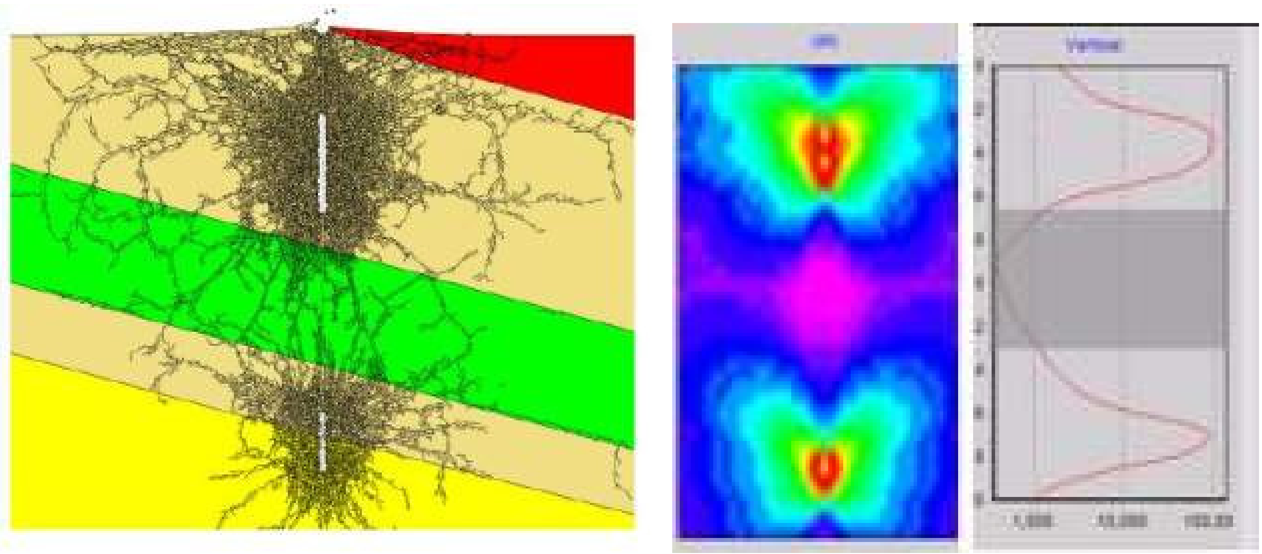

Figure 4 – Blast Damage Modeling

Once adequate stand-off distances had been determined, blast design parameters (Figure 5) were selected to enable each rock type, both above and below the coal, to be targeted with a powder factor similar to previous blasting history at Newlands.

Figure 5 - Advanced Blast Design Techniques

With these appropriate blast parameters that had been determined for each rock type, the blast pattern could be drilled. It was essential that the drilling process be monitored closely, to make sure that all holes were drilled in locations as accurate as possible to design. This would ensure that optimum blast results were achieved, through accurate distribution of explosives throughout the rock.

After the blast pattern had been drilled, gamma logging could take place, to define the location of the coal seam within the blast. The initial blast pattern would be designed using the mine geological coal model, to provide an approximate location of the coal seam and allow for the changing of blast parameters through both the through-seam section, along with adjustment of powder factors to suit the two distinct rock types that would be blasted in the two material types within the blast. Once drilled however, it is essential that the coal seam is defined more accurately, to ensure precise placement of both explosive and gravel decks for coal protection. A gamma logging unit (Figure 6) is utlised to pick up and graph the natural gamma radiation emitted by the rock within the hole. From analysis of the graph (Figure 6), the location of the coal seam can be determined and this could be compared with the initial geological model of the mine, which can often differ quite significantly.

Figure 6 – Gamma Logging unit and Natural Radiation Graph

Once the location of the coal seam had been determined, loading for each of the holes is designed. The creation of loading rules to vary the amount of both charge and length of stemming decks, based on the location of the coal seam within each hole, was critical to the ease of producing a loading design for each of these holes. It was important to ensure that the precise loading designs were followed to prevent damage to the coal seam (Figure 7). Additional assistance and training was required on the bench for the first few months to assist and supervise with this new method of loading, as the site operational team gained experience in both the accurate loading requirements and the extensive record keeping that was essential to the success of the project.

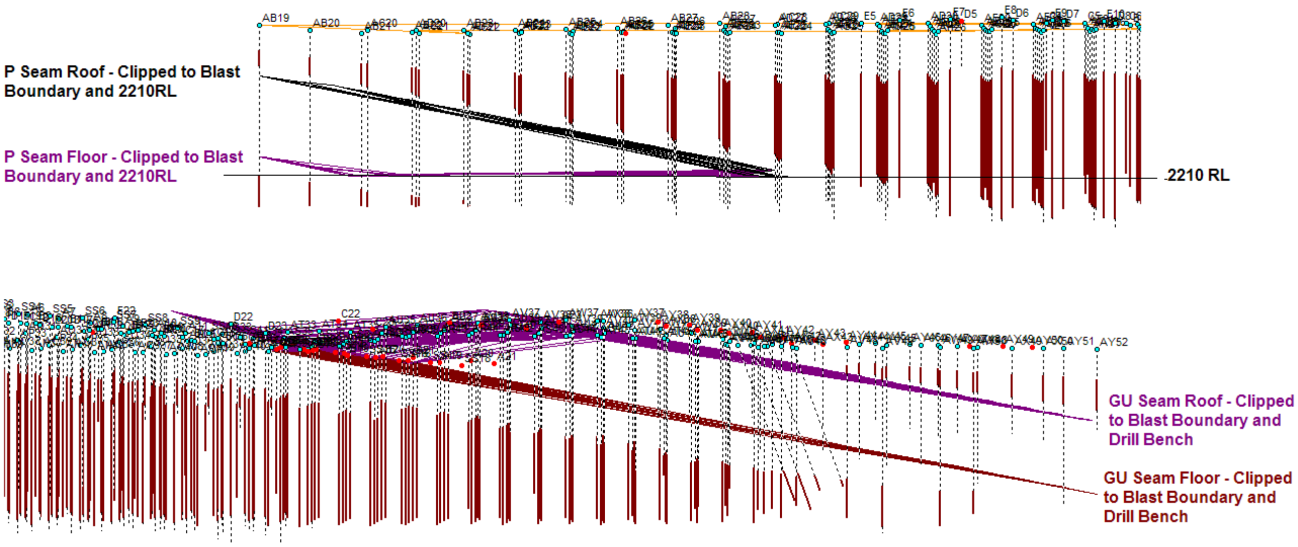

Figure 7 – Through-Seam Loading in Wollombi Pit

The implementation of electronic detonators provided the accuracy to improve fragmentation through the ability to utilize advanced initiation sequencing which is not available with standard non-electric detonators. The use of electronic detonators also allowed for the ability to provide an accurate offset between explosive decks, without the risk of a misfire due to a cutoff, whilst minimizing product stocks in the magazines.

Blast modeling was also conducted to determine the optimum firing direction for the initiation sequence. Both up-dip and down-dip firing sequences were modeled to determine which would minimize the potential for damage and disruption to the coal seam (Figure 8). Firing in the down-dip direction demonstrated a significant reduction in the disruption of the coal seam, due to the confinement that was maintained above the seam when the material below was fired.

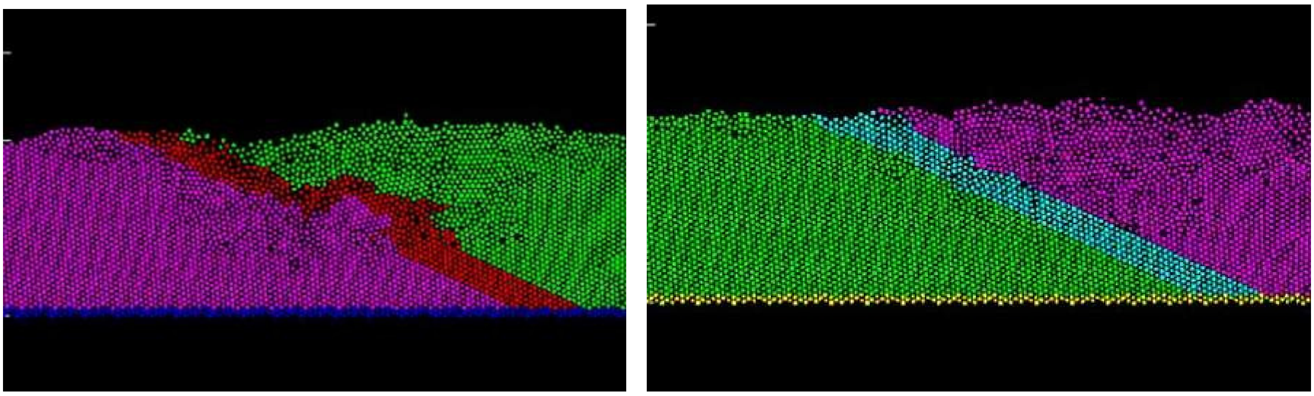

Figure 8 – Initiation Sequence Modeling, Up-Dip (Left) vs. Down Dip (Right)

The combination of pre-blast modeling, precision loading and accurate initiation sequencing has been paramount to the success of through-seam blasting in the Wollombi pit. Through the successful implementation of this blasting method, which was tailored to suit the particular pit requirements, an adjustment in mining method has been introduced, which has resulted in both optimized equipment utilization and improved production rates.

Project Results for Wollombi Pit

Since the implementation of through-seam blasting in the Wollombi pit, some dramatic improvements have been made. These improvements have helped to reduce overall costs associated with the Wollombi pit operation through improved production rates, reduced drill and blast costs and increased blast size.

Initial blasting, below the initial pre-strip level (2270RL) in the Wollombi boxcut, prior to the introduction of through-seam blasting had been conducted for approximately 3 months, during the period between August and October 2008. Excavation rate improvements, achieved after 6 months of implementation of the project are shown in Table 1.

Excavator	Variation in Dig Rate (%)
SH02	+27.1%
ES06	+17.7%
ES08	+36.7%

Table 1 – Excavator Productivity Improvements (below 2270RL)

Combined with the savings demonstrated through significant production rate improvements an increase in average blast size has helped to allow for further cost savings through a reduction in blast related machinery downtime. Prior to the implementation of the ABT project at Newlands, the average blast size in the Wollombi pit was 350 kbcm (458k cu yd). Current blasts have further improved this through the introduction of 30m (98ft) through seam blasts, which now represent volumes of up to 1.6Mbcm (2.1M cu yd) per shot, with an average of 700kbcm (910 cu yd). The utilization of 30m (98ft) through-seam blasting, allows for the opportunity to further reduce blast related downtime through larger blast volumes.

This also presented the possibility to increase loading and drilling rates, through a reduction in the amount of movement required for a similar number of drill metres and loaded explosives tonnes.

Through the optimization of blast pattern parameters, powder factors have been reduced to below budget without compromising production rates.

Due to through-seam blasting, dramatic improvements in the layout of the Wollombi pit (Figure 9 & 10) have been possible, allowing improved scheduling and a safer mining operation.

Figure 9 – Wollombi Pit Panoramic Photo December 2008

Figure 10 – Wollombi Pit Panoramic Photo August 2009

Project Implementation in Suttor Creek Pit

Previous drill and blast designs utilized in the Suttor Creek pit were analysed and adjustments were implemented to improve the drill and blast process, with the aim to reduce the overall mining costs of the pit. Specifically, a reduction in unit drill and blast costs, an increase in cast, and a reduction in coal loss was sought, whilst maintaining or improving dragline production rates.

The initial steps were to make adjustments to pattern parameters, to reduce overall powder factors whilst maintaining cast percentages. Current blast practices were modeled, along with a variety of potential improvements (Figure 11). Based on results of the modeling, particular bulk explosive products were selected and a new pattern design was implemented. Overall powder factors were able to be reduced, without significantly effecting cast percentages.

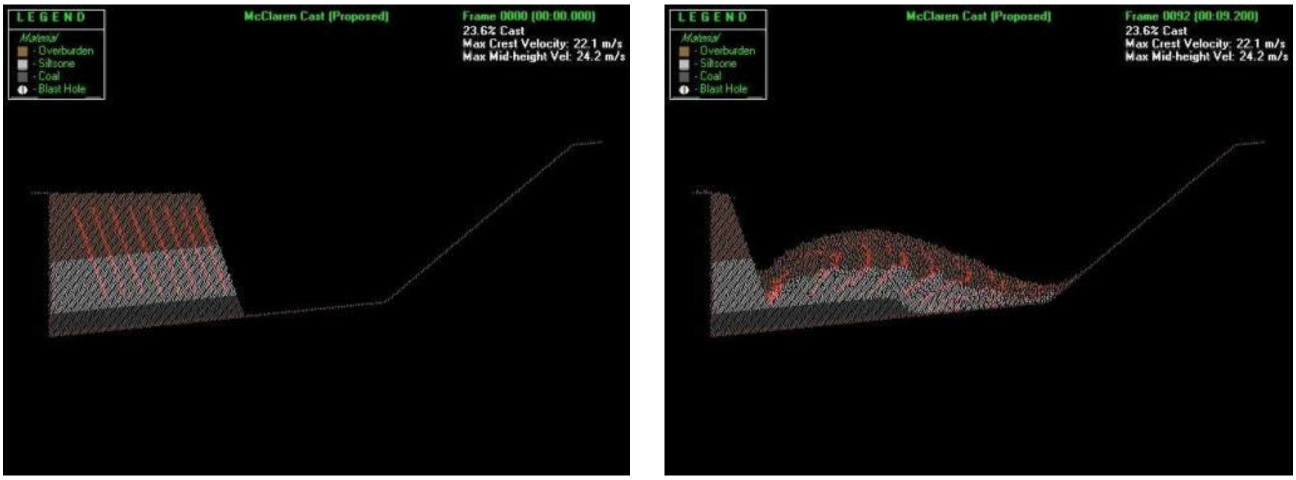

Figure 11 – Suttor Creek Cast Blast Modeling

The next step was to introduce electronic detonators and baby-decking techniques aimed to reduce coal losses that are commonly associated with cast blasting. Electronic detonators allowed for the utilization of advanced initiation sequences, which allowed for further pattern expansion whilst maintaining results. Through the introduction of electronic detonators, a significant increase in front row relief time was possible, due to the ability to use increased delays between blast rows. Through the implementation of significantly longer delay times between rows, electronics have allowed for the utilization of burden reliefs up to 60% greater than those available using standard non-electric timing, which has assisted the ability to maintain cast percentages whilst decreasing powder factors.

Project Results for Suttor Creek Pit

Powder factors in Suttor Creek Pit have been reduced to well below previous, whilst dragline productivity rates have improved. Table 2 shows a summary of the reduction in powder factor and improvements in dragline dig rates achieved.

	Variance (%)
Powder Factor	-35%
DL01 Avg. Dig Rate	+2.5%
DL03 Avg. Dig Rate	+4.9%

Table 2 – Suttor Creek Powder Factor and Dragline Productivity Improvements

Whilst powder factors have decreased since implementation of the project, through the increase in burden relief available through the implementation of electronic detonators, cast percentages have been maintained (Figure 12). The implementation of the significant increases in relief available through the use of electronic detonators has also helped to improve wall conditions through the ability to enhance the relief provided to the back row of blastholes in the production pattern (Figure 12)

Figure 12 – Cast & Highwall Results in Suttor Creek Pit

Further focus is required on tailoring the muck pile shape in Suttor Creek pit, to suit the design dragline dig methods, and provide further efficiency improvements. Future projects also aim to improve wall conditions through the reduction of crest rounding and improvement of presplit results in holes containing significant amounts of water. Projects also aim to further define coal seam location in comparison with geological models, to allow for a further reduction in the possibility of both coal damage and hard digging on top of the coal seam.

Issues & Complications

Throughout the introduction of the service at Newlands, a number of issues have been encountered that have been, and continue to be addressed to ensure optimum blast outcomes. Four issues that all designers should account for when conducting through-seam blasting are as follows:

1. Different overburden and interburden rock strengths: At Newlands, some difficulty has arisen when blasting through-seam around the 'P seam' coal, which is the second seam from the bottom of the 4 seams that are mined in the Wollombi Pit. Whilst the material below the P seam is quite soft and can often almost be removed as free dig, the P seam overburden (between the P and GU seams) is much harder. As a result, it is often difficult to select appropriate blast parameters that will produce optimum results in both material types.

2. Depth of through-seam blasting: As a result of the significant strength of the P seam overburden, the depth of the through-seam blasting needs to be continually assessed prior to design. Initially, a series of 30m (98ft) deep through seam blasts were conducted (normally 15m (49ft) deep), which although resulting in quite good fragmentation, produced some tight digging towards the lower levels of the blast as a result of the reduced relief and hence limited movement available, associated with the increased depth. As a result, it is imperative that through-seam depth is designed to suit particular geology.

3. Actual location of coal seam roof and floor: The significant variation between the actual coal seam location (as determined by gamma logging) and the geological coal model has also resulted in some inconsistencies. On occasions this has resulted in explosive decks being placed within the coal seam and hence the possibility of some damage to the coal seam. As a result, it is ensured that every blast is gamma logged prior to loading to ensure that the actual location of the coal seam is taken into account when the placement of explosive decks is designed and the importance of the precise loading requirements are taken into account by the blast crews.

4. Stemming requirements: The large amount of stemming required, to prevent damage to the coal seam can have a significant impact on loading. As crushed aggregate is used to provide optimum protection to the coal seam and utilization of explosive energy, a large amount of this material is required to be available and easily accessible from the blast area. A stemming truck is utilised for the placement of stemming decks within the hole, however time can be lost as a result of large turn-around distances to the stemming stockpile. This can create loading delays and hence result in the delay of the firing of blasts if not accounted for in the drill and blast schedule.

Conclusion

The partnership formed between Xstrata Newlands and Orica Mining Services has provided a new system for drill and blast management in the production process. This tailored service has resulted in the introduction of through-seam blasting in the Wollombi pit and optimised cast blasting in the Suttor Creek pit to produce significant benefits for the overall mining operation and the ability to win more coal.

Improvements such as;

- Increased excavator production rates (from 18% to 36%)
- Increased blast sizes, up to twice the previous average volume
- Optimised blast design parameters, reducing overall drill and blast costs
- Tailored product selection to suit varying geology
- Accurate loading and design to minimize coal loss/damage and
- Thorough drill and blast management

Have resulted in considerable cost savings and allowed for an improvement in the entire mining process. The focus on drill and blast management, afforded by the resources available due to the introduction of the service, has allowed each and every drill and blast design to be tailored for the required mining outcome.

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