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OVERVIEW ON AN OPEN PIT MINE PLANNING OF THE PICKSTONE PEERLESS IN A VOLATILE ENVIRONMENT

TINJAUAN PERHITUNGAN PENJADWALAN PERENCANAAN TAMBANG TERBUKA PICKSTONE PEERLESS PADA LINGKUNGAN DENGAN VOLATILITAS TINGGI

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ABSTRACT

The prevailing mining climate is highly characterized by unstable consumables pricing systems, a volatile economy and skyrocketing operational costs, and exacerbated by a steady decline and intermittence in the availability of electricity. Zimbabwean mines need to extensively capitalize on the opportunity to improve productivity by emphasizing variables they can control, predominantly operational efficiency to avoid resizing of operations or facilitating downsizing by relatively insignificant factors. In this study, cycle times, rig penetration, utilization, availability and payloads were used to evaluate the mining cycles, operator costs and the information was compared against the life of mine plans with block models. Shifts were restructured to be concordant to the schedule provided by the utility company to save fuel that was being used to power metallurgical plant. Several challenges have been identified as the principal reasons behind discrepancies between the theoretical capabilities of equipment were proven to be achievable by a trial schedule which reduced the 7 days/month to less than 2 days a month. The new schedule reflects a theoretical improvement of close to 25% and significantly lower operational costs. The current mining fleet is capable of meeting the stipulated targets and even achieving more even within tough working environments characterized by harsh load shedding schedules and volatile inflation rates; however, this requires stringent monitoring and evaluation of unit process. By adopting the recommended short term production plans will avoid resizing of operations as it automatically reduces the operational costs by US $3 million annually whilst coercing both operators and management to improve their operational efficiency.

Keywords: availability, environment, mining, scheduling, volatile.

ABSTRAK

Iklim pertambangan yang ada dicirikan oleh sistem harga bahan habis pakai yang tidak stabil, ekonomi yang bergejolak, dan biaya operasional yang meroket yang diperburuk oleh penurunan yang stabil dan ketersediaan listrik yang terputus-putus. Tambang Zimbabwe perlu memanfaatkan peluang untuk meningkatkan produktivitas dengan menekankan variabel yang dapat mereka kendalikan, terutama efisiensi operasional untuk menghindari pengubahan ukuran operasi atau memfasilitasi perampingan oleh faktor yang relatif tidak signifikan. Dalam studi ini waktu siklus, penetrasi rig*, pemanfaatan, ketersediaan dan muatan digunakan untuk mengevaluasi siklus penambangan, biaya operator dan informasi tersebut dibandingkan dengan umur rencana tambang dengan model blok. Pergeseran direstrukturisasi agar sesuai dengan jadwal yang disediakan oleh perusahaan utilitas untuk menghemat bahan bakar yang digunakan untuk pembangkit listrik metalurgi. Beberapa tantangan telah diidentifikasi sebagai alasan utama di balik perbedaan antara kemampuan teoritis peralatan yang terbukti dapat dicapai dengan jadwal uji coba yang mengurangi 7 hari/bulan menjadi kurang dari 2 hari sebulan.*

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Jadwal baru mencerminkan peningkatan teoritis hampir 25% dan biaya operasional yang jauh lebih rendah. Armada penambangan saat ini mampu memenuhi target yang ditentukan dan bahkan mencapai lebih banyak dalam lingkungan kerja yang berat yang ditandai dengan jadwal pelepasan beban yang keras dan tingkat inflasi mudah berubah, namun hal ini memerlukan pemantauan dan evaluasi ketat terhadap unit proses. Dengan mengadopsi rencana produksi jangka pendek yang direkomendasikan, akan menghindari pengubahan ukuran operasi karena secara otomatis mengurangi biaya operasional sebesar US $3 juta per tahun sambil memaksa operator dan manajemen untuk meningkatkan efisiensi operasional mereka.

Kata kunci: ketersediaan, lingkungan, pertambangan, penjadwalan, volatile.

INTRODUCTION

Pickstone Peerless gold has been one of the major players in the gold mining industry of Zimbabwe since 2013 (Mining Zimbabwe, 2019). The mine suffered a series of over four closures and resuscitation of operations ever since the discovery of the deposit by Charles Rudd in the early 90s until its recent transition from underground to open-pit operations by Vast Resources. However, another threat to shut down operations looms in as the economic environment escalates on a more volatile trajectory with the sky-rocketing inflation rates and persisting unavailability of electricity (Kaseke, 2013; Mahonye and Zengeni, 2019). The mine was recently put on a three-day electricity schedule by Zimbabwe Electricity Transmission Distribution Company (ZETDC) as the parastatal continues on a downward trend towards economic meltdown (Business and Human Rights Resource Centre, 2020). The situation calls for urgent measures to recalibrate the mine planning and scheduling design techniques in order to save the mine from yet another closure. Existing mine planning and scheduling techniques were designed during the much economically viable and lucrative year of 2013 which was almost characterized by zero inflation and 100% electricity availability.

The current ZETDC load shedding schedule, for Pickstone Peerless Mine consequently resulted in an adequate electricity availability of 50% a week. This has resulted in the tumbling of productivity from over 50,000 t by January 2019 to a staggering 30,000 t of ore delivered to the plant by August 2019. Furthermore, if the situation is not addressed, shutting down of operations or downsizing may be inevitable given the current trend as the mine's diesel expenses doubled from about 300,000l/month to over 500,000l/month. However, addressing this situation is not wholly on issues of energy supply but taking heed of all production bottlenecks that contribute and aggravate the problem.

Since the launch of the ZETDC load shedding schedules the mining industry has been characterized by continuous tumbling productivity with values of net declines estimated at 10% at the end of the 2019 first quarter and the leading platinum mine in Zimbabwe (ZIMPATS) output fell by over 30% by the 1st of October 2019 (ZIMPLATS, 2019). Pickstone Peerless Mine was not spared from these trends with 50% electricity availability a week. Figure 1 exhibits how the inception of load shedding impacted the productivity of the mine.

Increased operating expenditure due to the increased unplanned diesel use whose price continues on an unpredictable upward trajectory. As the load shedding schedules continue to intensify, the mine continues to incur unbudgeted expenses on fuel to run backup generators.

In addition, the unpredictable supply of diesel in Zimbabwe ever since the start of 2019 makes it difficult and risky to depend on petroleum-generated supplies of energy hence the need for a recalibrated mine plan tailor-made to address the economic challenges faced by the mine. The existing mine plans and schedules were designed during 2013 when the economic status of Zimbabwe was lucrative and sustainable. Some bottlenecks within the planning and designing system could therefore be neglected however the current operating conditions are not ideal for that kind of planning.

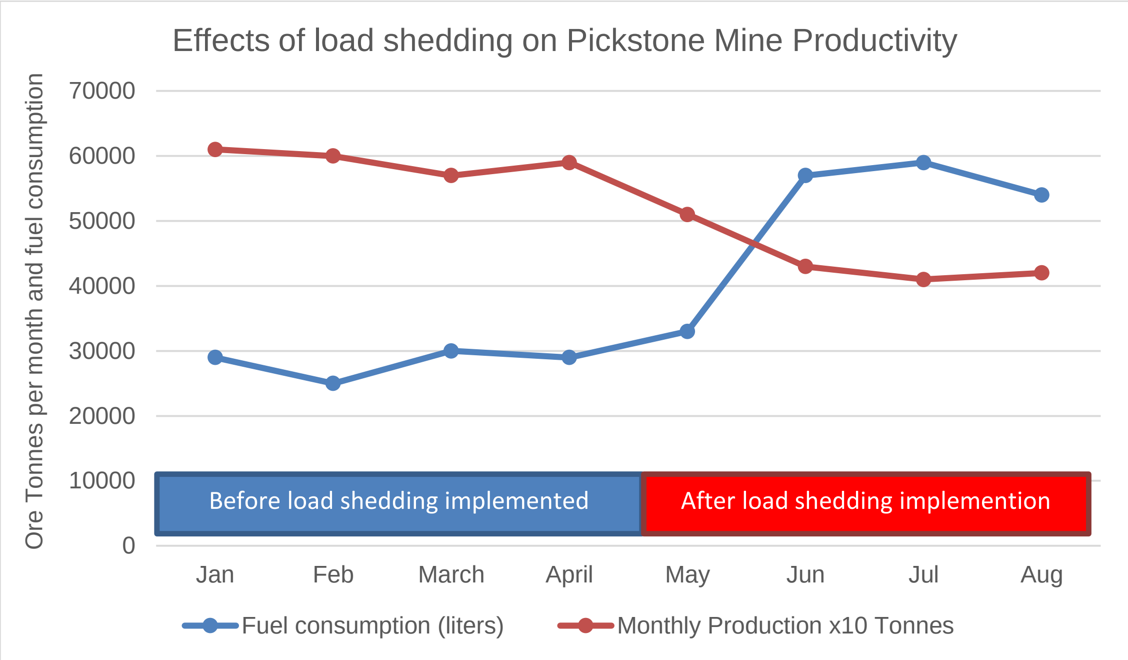

Figure 1. The impact of load shedding on gold ore production and fuel consumption by Pickstone mine

Furthermore, skyrocketing inflation rates requires proactive planning or else downsizing and shutting down of operations becomes inevitable. Fidelity pays gold in two currencies, the United States Dollar and the local Zimbabwean dollar whose value continues to tumble on a daily basis from US$1:ZW$1 at the beginning of 2019 to over US$1:ZW$150 by August 2021 (StartupBiz Zimbabwe, 2021). With this kind of inflationary statistics, a dynamic system of planning is called for.

METHODOLOGY

Fieldwork was inclusive of time and motion studies of the drill and blast operations as well as the load and haul operations. It also reviews the inadequacies of the pit design and the bottlenecks that were introduced on production considering these shortfalls. Geotechnical parameters and other factors that had a bearing on the production trends were taken into consideration. The field analysis primarily sought to obtain the upper quartile results in every mining operation. Figure 2 shows the research flow chart.

Scheduling tools employed by the mine and the plans generated thereof were assessed. These tools and mechanisms include the mine layouts, production budgets, production reports, tally sheets, production meetings, datasheets, and other tools. Evaluations were done to establish the adequacy of these tools and methods for the realization of stipulated targets.

In order to assess whether the drilling and hauling machinery was capable of achieving the stipulated production without the acquisition of new units, a number of factors were analyzed to understand if the problem was wholly a planning and scheduling inadequacy. The equipment match factors, evaluation of equipment deterioration, utilization and availability factors, operator expertise, and other factors were critically examined (Kennedy, 2009; Morad, Pourgol-Mohammad and Sattarvand, 2013; Manyele, 2017; Cheng, 2019).

Drilling and hauling data were evaluated to assess how effectively the machines were being utilized and the frequency of breakdowns (Darling, 2011). Major causes of low utilization were gathered. More so, the following breakdowns and several others were characterized in terms of their frequency and time frame a machine spends under breakdown and the ideal time requirements for repairing such machine problems (Tomlingson, 2010).

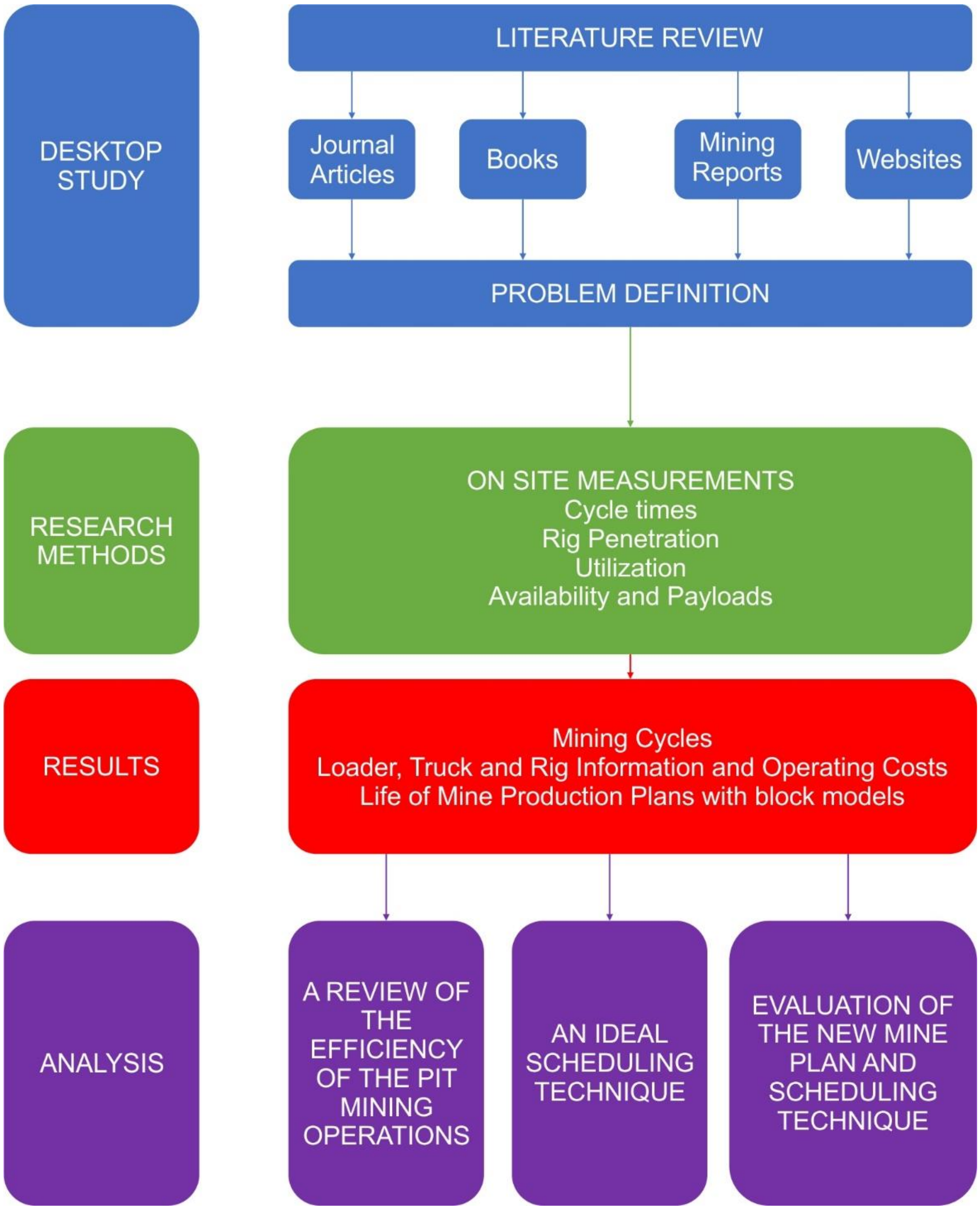

Figure 2. Flow chart of research

One of the assumed bottlenecks towards the achievement of required is inadequately designed haul roads. In order to ascertain this hypothesis, sections of the roads were taken randomly and measured in terms of width and the gradation thereof was obtained from the Caterpillar Electronic Displays within the trucks. Measurements were taken right from the pit to the material destination and the results analyzed.

In addition, operational inefficiencies were considered as a component of inadequate planning and scheduling hence could possibly delay the mining process (Dagdelen, 2001). The benchmark was either modelled or obtained from the equipment specifications. The delay aspect was then converted into the production potential that was not realized as a result of the delay. Major delays that were analyzed were inclusive of idling, queuing, tipping, loading, bench preparation, migrating to the new working areas, delayed information dissemination and other factors.

The penetration rate was computed using Equation 1.

$$PR=\left[RF\text{-}28\log_{10}UCS\right]\times\frac{W}{D}\times\frac{RPM}{17.6}\;\ldots\ldots\ldots\ldots\ldots\;(1)$$

Where PR is the Penetration Rate, RF is the Rock Factor, UCS is the rock Uniaxial Compressive Strength, W is the pulldown weight, D is the bit diameter and RPM is the rate of rotation. Table 1 shows how the RF is deduced from the UCS.

The load and haul fleet sizing and equipment selection was computed based on the information derived from time and motion studies carried during field work.

Table 1. Rock description based on UCS and RF classification

Rock	UCS (MPa)	RF
Extremely weak	<7	323.5
Very soft	7-34	224
Soft	34-69	158
Moderate	69-103	123
Hard	103-207	104
Very Hard	>207	84.5

The number of trucks was calculated using Equation 2 (Lowrie, 2009).

$$\text{Number of trucks}=\frac{\text{Truck Cycle Time}}{\text{Average Excavator Cycle Time}}\;.(2)$$

$$\text{No of Exc Req}=\frac{\text{Monthly Production Target}}{\text{Actual Production}\times\text{Actual Production Time}}\;\ldots\ldots\ldots\ldots\;(3)$$

$$\text{Match No.}=\frac{\text{Truck Cycle Time}}{\text{Average Excavator Cycle Time}}\;\ldots\ldots\ldots\;(4)$$

$$\text{Match factor}=\frac{\text{No. of trucks}}{\text{Match Number}}\;\ldots\ldots\ldots\ldots\;(5)$$

$$\text{Efficiency}=\frac{\text{Match factor}}{100}\;\ldots\ldots\ldots\ldots\;(6)$$

$$\text{No. of trucks Req}=\frac{\text{Monthly Production Target}}{\frac{\text{Trock Capacity}}{hr}\times\text{eff time}}\;\ldots\ldots(7)$$

$$\text{Number of Drill Rigs}=\frac{\text{Drilling Target Per Month}}{\text{Penetration Rate }(\frac{m}{hr})R\times 22\text{days}\times 24\text{Hrs}\times\text{Utilization}\times\text{Availability}}\;\ldots\ldots\ldots\ldots\;(8)$$

$$\text{Drilling Target Per Month}=\frac{\text{Material Volume}}{\text{burden}\times\text{spacing}}\;\ldots.(9)$$

The correlation of shift hours (HS) and shift efficiency hours (E_S) was computed using Equation 10;

$$E_S=S_4\times S_3\times S_2\times S_1\times H_s\;\ldots\ldots\ldots\ldots\;(10)$$

Where S_1 is Shift mechanical availability, S_2 is Shift utilization, S_3 is Working efficiency and S_4 is job efficiency.

The minimum width of curves is computed by

$$W=3.5\times w_t\;\ldots\ldots\ldots\ldots\;(11)$$

The minimum width of corners is computed by

$$W=4\times w_t\;\ldots\ldots\ldots\ldots\;(12)$$

For one-way straight haul access ramps and roads, the minimum width is given by;

$$W=2\times w_t\;\ldots\ldots\ldots\ldots\;(13)$$

For one-way curved haul access ramps and roads, the minimum width is given by;

$$W=2.5\times w_t\;\ldots\ldots\ldots\ldots\;(14)$$

RESULTS

Recalibrated Mine Plan

As highlighted in Table 2, a shift restructuring from the 7 days working calendar to 5 days per week taking heed of the decision by ZETDC to supply the mine with electricity four days a week was proposed. This was expected to yield positive results since the mine was now experiencing unplanned shutdowns due to exhaustion of diesel which was conventionally meant for the mining fleet but was now being used to power the metallurgical operations. However, this change would mean higher production target per unit time thus necessitating the need to rule out all inefficiencies and produce a dependable schedule.

Consultations and Field Observations

The study implored for bottlenecks and inefficiencies towards the realization of production targets given the new plan, the following plan and design challenges were highlighted to be the major drawbacks; narrow haulage access, improper fleet matching ratios, inadequate scheduling techniques and inadequate time dedication to drilling operations and disharmony of the schedule on inter-departmental operations.

Table 2. Recalibrated mine plan working hours

	Working days/week	Working days/month	Working days/yr	Hours/Shift	Production BCMs/Shift
New Plan	5	22	264	10.5	6100
Old Plan	7	30	348	10.5	4450

Load and Haul fleet capacity

The fleet was composed of 3 Caterpillar (CAT) Excavators of the CAT 374 model, 6 CAT 740B trucks and 6 CAT 773E trucks. The fleet was expected to meet an average production target of 210 000 BCMs (Bank Cubic Meters) inclusive of both waste and ore. A time and motion result was done to measure the capability of this fleet over 22 days a long month.

Based on the following information which was incorporated into monthly target = 210 000 BCMs, total shift hours = 10.5 hrs, truck availability = 0.80, excavator availability = 0.85, truck's utilisation = 0.86, excavator utilisation = 0.9 m, around 12 trucks and 3 excavators are required.

Truck and Shovel Loading Rates

Figure 2 exhibits a trend for the average loading rates of three excavators over a period of one month. A linear average was generated to estimate the potential capacity of the shovels given near ideal loading condition, although the rate instantaneously fell below 150 BCMs/hr. The trend shows that under certain circumstances, the rate was as high as 230 BCMs/hr, hence the average fell around 200 BCMs/hr. using the linear average graph to estimate the possible production per hour, it can be deduced that the fleet is capable of producing 9 639 BCMs/day (200 BCMs/hr x 0.85 x 0.9 x 21 hrs/day) where 0.85 and 0.9 are the excavator availability and utilization factors. Thus a monthly target of 210 000 BSMs (586 000 t) would be achievable in a maximum of 24 days a month.

Load and Haul Upper Quartile Cycle Times

Figure 3 shows the upper quartile results for the truck and shovel recorded over a period of six months in order to standardize the ideal cycle time duration. All the load and haul destinations were taken into account from the ROM pad to the waste dumps and from two operational pits. The ideal cycles are seen to fall within the range of 12.5 to 16.5 minutes. The highest time durations emanated from trips hauling ore to the ROM pad.

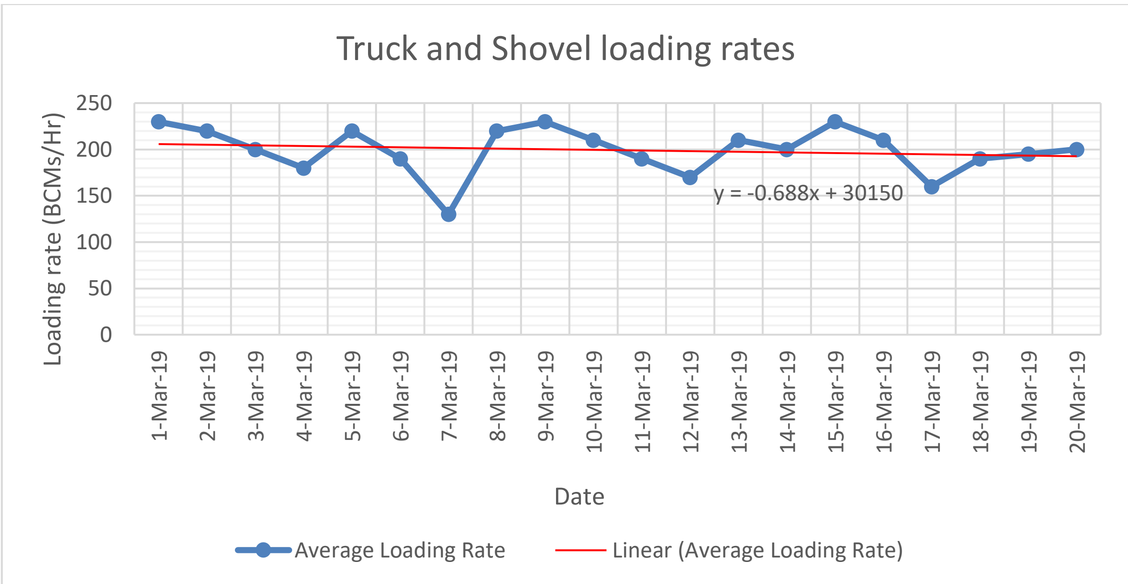

Figure 3. Truck and shovel loading rate

Figure 4 is a comparison of the major load and haul cycle activities ideal and actual time. It is clear that all the measured parameters with the exception of tipping are taking far much longer than the ideal duration. Hence the overall effect is that the cycle time has an excess of over 3 minutes on top of the ideal duration of each cycle.

Figure 5 shows the loading haul cycle actual breakdowns for queuing, tipping, return trip, loading and return trip against the mine potential.

Correlation of Load and Haul Delays and Production

Figure 6 shows the impact of the delays and bottlenecks on production within the Load and Haul system. The delay durations were converted into lost tonnage that could have been realized. The mine ideal was determined by benchmarking equipment specifications, guided by the upper quartile data distribution of field data hence the potential became standardized based on the best cycle results over a period of six months. The major delays are identified to be bench preparation, fuelling, idling and shift change. A potential of over 75,000 t (27,000 BCMs) is lost to bench preparation and this amounts to an excess of 3 days which could have been avoided. Cumulatively, a potential of over 200,000 t (72,000 BCMs) per month is not realized due to production delays consequently necessitating the need for an extra 8 days to meet the target.

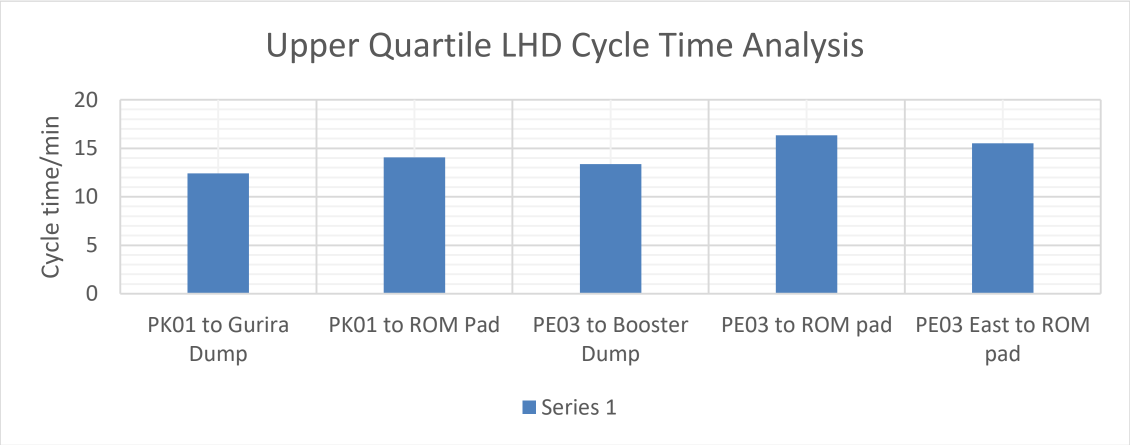

Figure 4. Assessment of upper quartile truck cycle time with regards to proposed mine plan

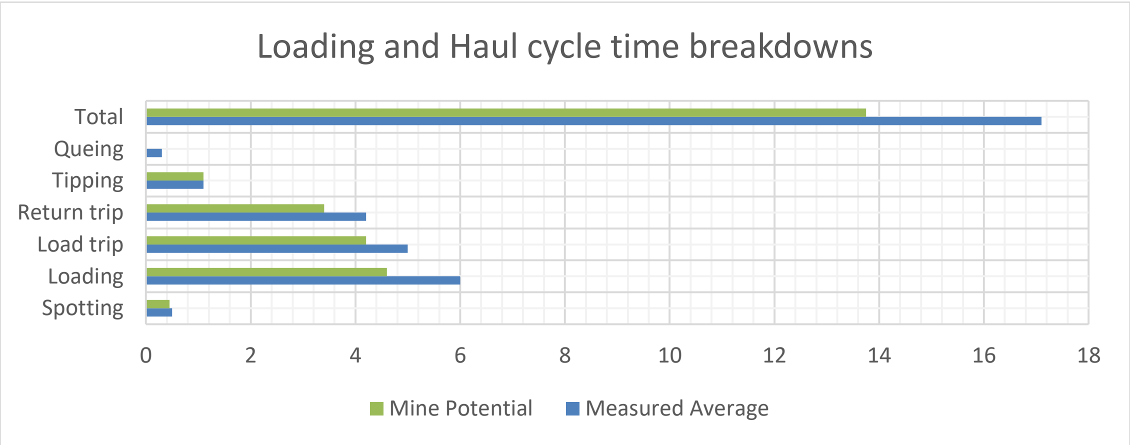

Figure 5. Load and haul actual and mine potential cycle time breakdown

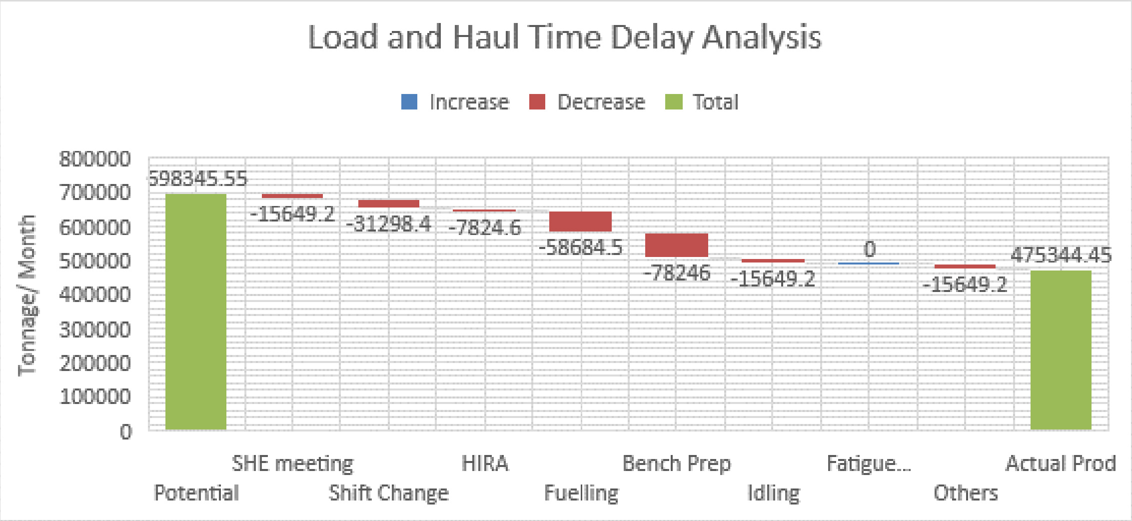

Figure 6: Assessment of CAT 374 excavator compatibility with proposed mine plan

Load and Haul Fleet Matching Ratios

Based on Figure 7, the optimum equipment combination included the use of four trucks per 374 CAT Excavator with efficiency and match factor of 95.2% and 0.952 respectively. The efficiency and match factor are based on the premise that there are 4 trucks with a truck cycle time of 14 minutes and an average loading time of 3 minutes 30 seconds. However, as noted the match factor is below 1 indicating that other factors besides equipment matching ratios needed to be optimized to achieve an efficiency that is closer to 100%. Inadequate haul access and grades are major drivers towards failure to meet a 100% efficiency. However, with a cycle time of 14 minutes on four trucks the excavator is capable of 16 trips ultimately making an hourly production of 200 BCMs possible (16 trips/hr x 13 BCMs/truck=208 BCMs/hr) and (16 trips/hr x 18 BCMs/hr =288 BCMs/hr) for CAT 740 B and 773 trucks respectively.

Figure 8 shows the extent to which production delays affected the monthly drilling coverage by analyzing the potential meters that could have been realized had the delay been idealized or avoided. Ideal measurements were derived from the drill rigs specifications and standardized by the upper quartile results. Major delays identified are clearance for blasting, bench preparation, bench allocation and addressing toes. The drilling process is taking twice as much potential mining time due to the effect of delays.

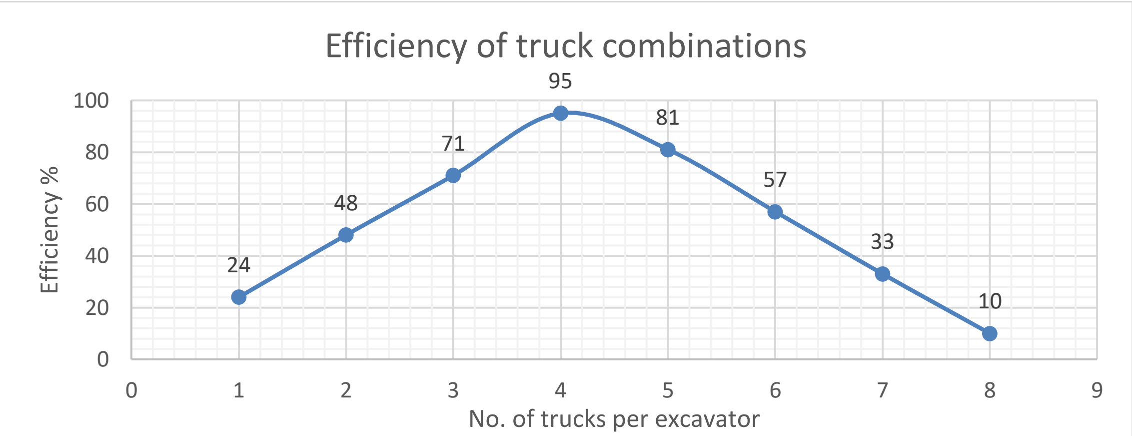

Figure 7. Excavator, trucks combination efficiency analysis based on match factors

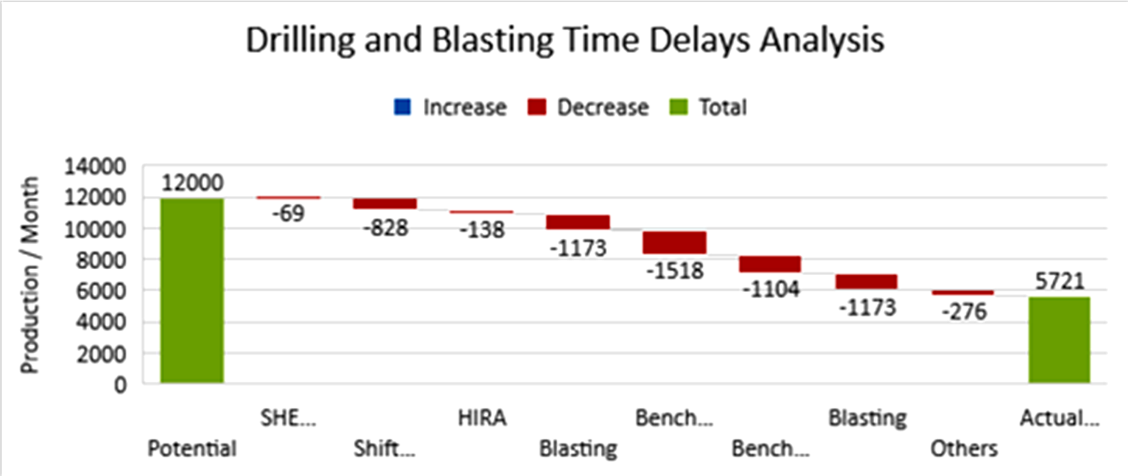

Figure 8. Drill and blast cycle delays analysis

Empirical Modelling of Penetration Rate

The penetration rate for the DI550 Sandvic Rig was modelled to fall just above 40m/hr using the local geology of Pickstone Peerless with a UCS value of 157 MPs and an RF of 104. The rig specifications are inclusive of a pull down of 32 KN and drill rotation of 80 rpm obtained from the manufacturer's specifications. Based on the specified parameters the Penetration Rate is 42 m/hr.

Figure 8 shows the extent to which production delays affected the monthly drilling coverage by analyzing the potential meters that could have been realized had the delay been idealised or avoided. Ideal measurements were derived from drill rig specifications and standardized by the upper quartile field results. Major delays identified are clearance for blasting, bench preparation, bench allocation and addressing toes. The drilling processes are taking twice as much time the potential of the mine due to effects of the delays.

Figure 9 shows how the drilling rate averages within a range of 15 and 20 m/hr over a period of 3 weeks that the continuous data collection was done. This corresponds to the values from previous production reports for the mine. The average predicted by the linear trend is estimated to be 17 m/hr.

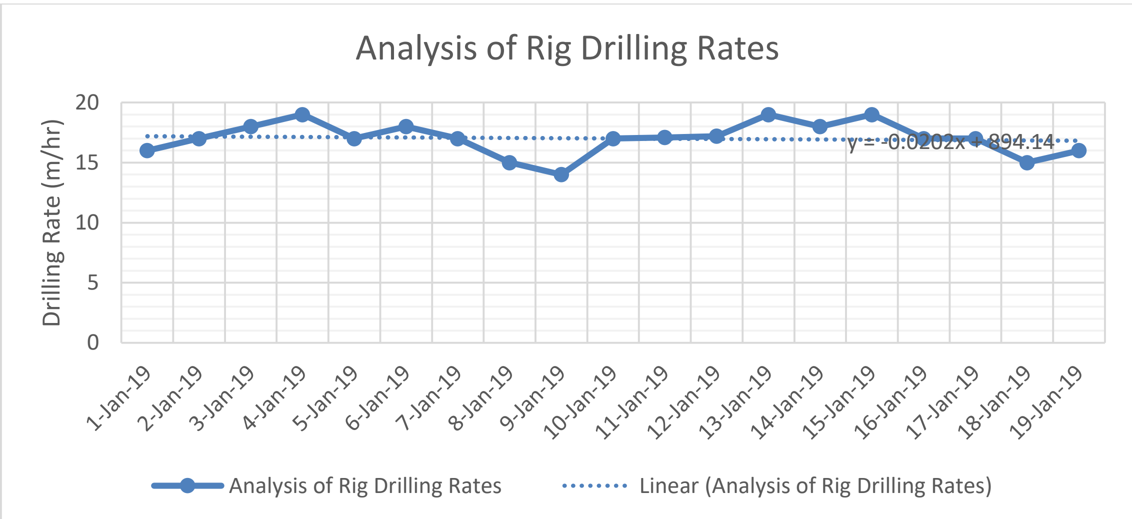

Figure 9. Drilling rate average for the three Pickstone rigs

The average 17 m/hr as shown by the average trendline in the figure is applied in this computation as the upper quartile. Though the penetration rate of 42.6 m/hr is almost double the field value for drilling rate, 17 m/hr is used to obtain the number of rigs required since it accounted for delays in flushing, adding or removing rods, greasing and tracking from hole to hole. The number of rigs required is therefore approximately 1.7 hence 2 rigs are ideal.

Haul Access Adequacy

Figure 10 shows the various sections of the haul roads that were measured within and outside the main pit. The results are summarised in Figure 11 and 12 and show a shortfall in width for one way access close to two meters and for two way accesses a deviation of almost 3.5 m between the measured and the ideal values.

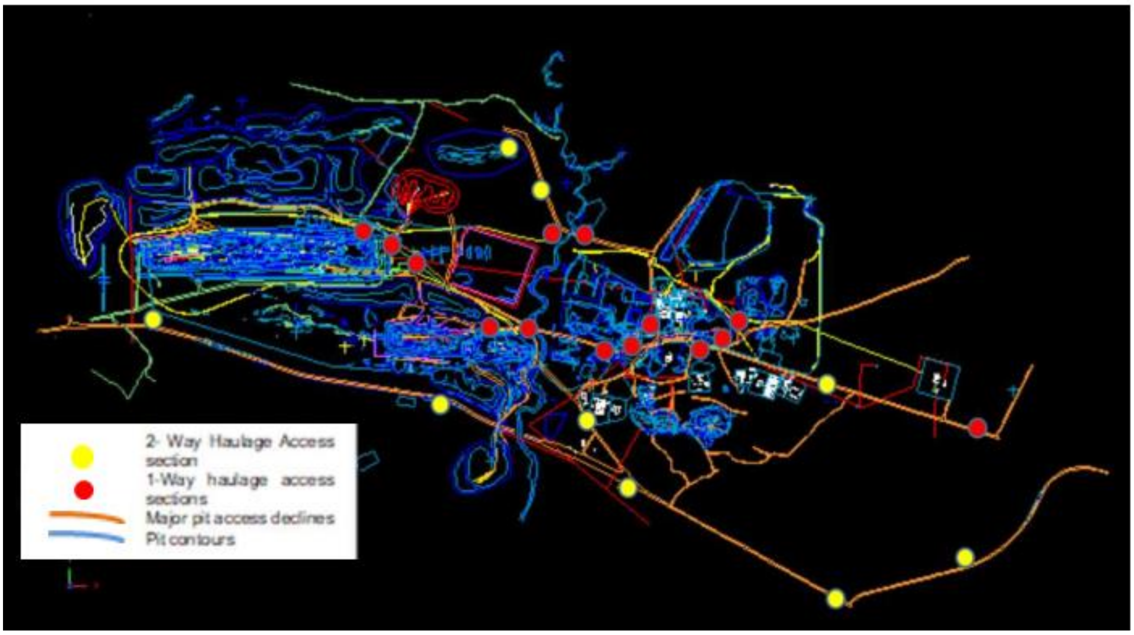

Figure 10. Haulage access sections analysed for adherence to width design standards

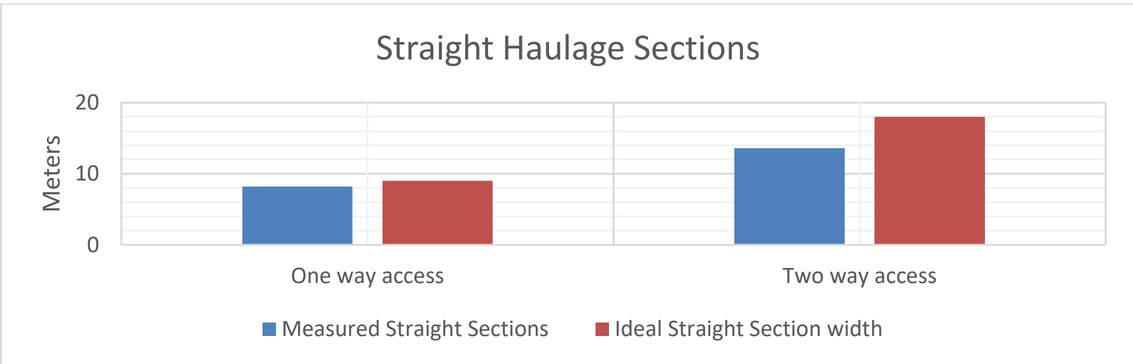

Figure 11. Width analysis for straight haul sections

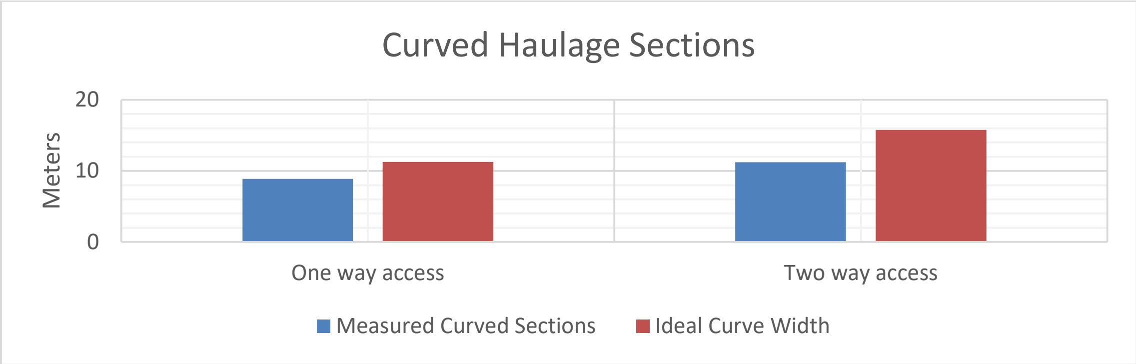

Figure 12. Width analysis for curved haul sections

Most one-way designs are temporary production accesses while two-way accesses include main haulages and ramps. The overall observation from the above design shows that the accesses are not ideal for rigid CAT 777E trucks whose specifications are used in the analyses. The primary haul designs from the mine plan are in congruency with this design however do not account for the incorporation of a Berm or Wind row.

Figure 14 is a production schedule generated from Surpac Gemcom. The schedule shows how the production of 211 168 BCMs was planned for 22 working days of May 2019 as a trial. A total of 14 days was dedicated to drilling close to 6,500 m leaving the rigs idle for the remaining 7 days due to the existence of almost 70,000 BCM bench which was rippable without blasting 22.5 days were required for the load and haul fleet to move both ore and waste. The working calendar entirely excluded working on Sundays and partially working on Mondays and Saturdays. Tuesdays, Wednesdays, Fridays and Saturdays were the four days a week the mine was not cut from power by ZETDC hence the new calendar yielded close to 75% electricity availability during working hours.

Figure 15 shows the results gathered during a trial from 1st to the 31st of May 2019. A large deviation from the planned target was recorded during the first five days of the month (close to 7,000 BSMs deficit) and this was deficit gradually decreased until the 20th where it ballooned to over 8,000 BCMs by the 26th. Overall results indicate that the actual production was in short but close to 10,000 BCMs (27,000 t). Low production rates were noted during the first week, from the 20th to the 25th, and during the last five days of the month. Common challenges that were peculiar to these periods were ore mining which had longer haulage distances and involved selective mining, ore sampling delays, interdepartmental misunderstandings between geology, planning and the production teams fuelled by conflicts of interest, delays at the ROM pad and bench clean-ups during the last days characterized by extensive scavenging of material.

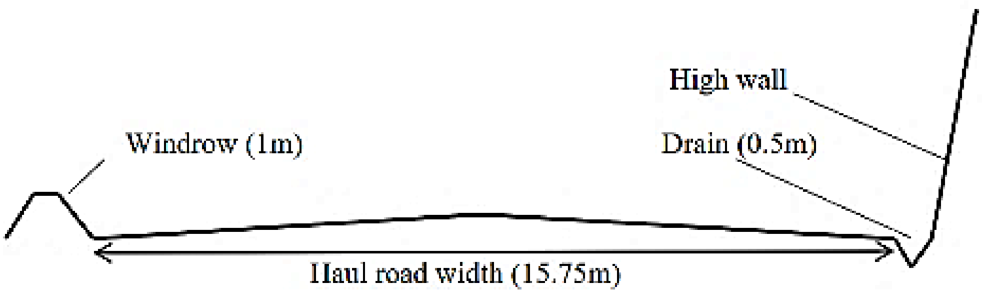

Figure 13. Straight two way haul road sections design cross profile requirements

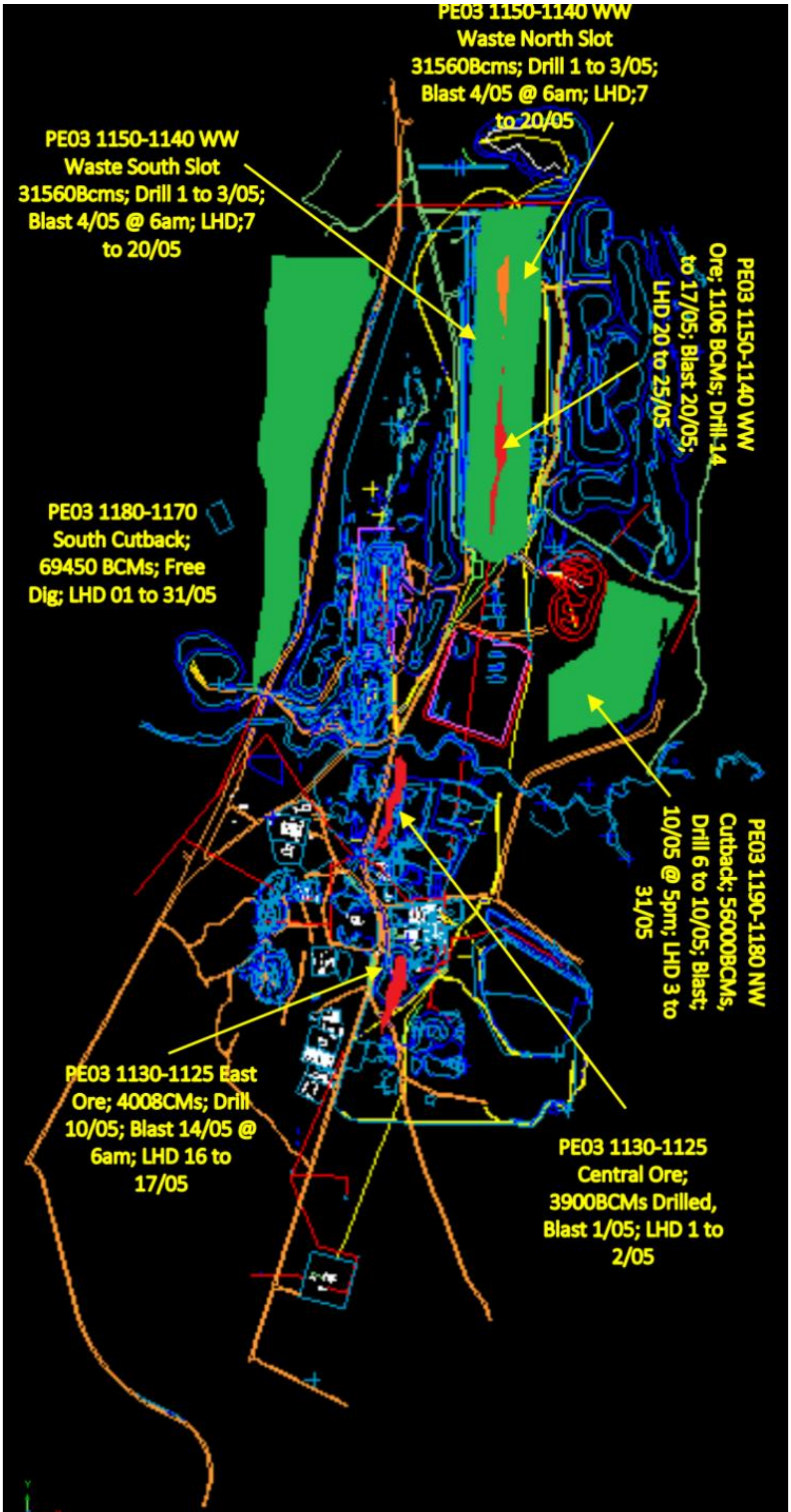

Figure 14. Surpac based monthly production scheduling techniques

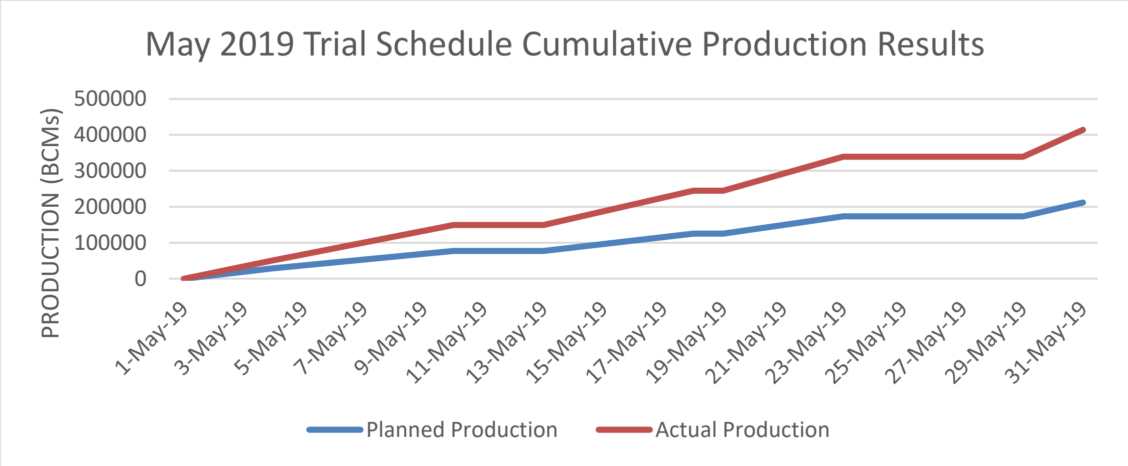

Figure 15. Trial schedule production results for May 2019

Cost Benefit Analysis

A potential reduction in mining operational expenses by US$1.42/BCM can be realised considering a major decrease in mining fuel expenditure of 90 cents per unit volume moved. Labour expenses were also found to fall by 33 cents per BCM considering the changes in the working calendar. Assuming failure to meet targets within the stipulated 23 days working calendar on a certain month by the metallurgical department, then the diesel expenses at the plant may be the same for the old and new schedule thus the resultant margin between the two schedules will be US$1.26/BCM. This remains a substantial amount annually factoring in the gross yearly production of 2.5 million BCMs thus the new schedule may lower operational expenses by close to US$3 million (2.5 Million BCMs x US$1.42/BCM).

DISCUSSION

It is critical to ensure efficient utilization of resources especially in nations facing power shortages. A restructure of the shifts concordant to the electricity schedule provided by the utility company saves fuel conventionally used for the mining fleet which was now used to power the metallurgical plant.

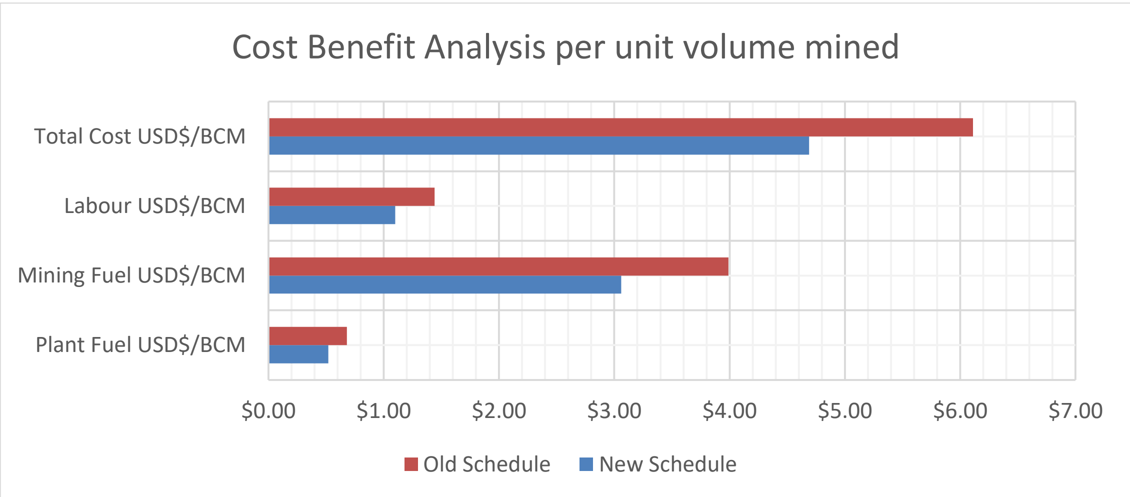

Figure 16. Cost benefit analysis of the old and proposed scheduling techniques

Several challenges have been identified as the principal reasons behind discrepancies between the production targets and actual production and these include narrow haulage accesses, improper fleet matching ratios and inadequate scheduling techniques, inadequate time dedication to drilling operations and disharmony of schedules on interdepartmental operations. Results from this study reinforce the notion that a holistic evaluation is necessary prior to the acquisition of new machinery as it is evident that the current fleet is capable of meeting production targets.

The initial short-term scheduling was developed for CAT 745C and 730C together with one CAT 374D excavator and two 333E excavators which however were removed from site one after the other for various reasons in replacement with 740B and 773E trucks coupled with three 374D excavators. The latter however possess a higher production capacity which required a review of the short-term plans. Figure 15 shows the drill rigs possess the potential of improving their productivity by a factor higher than 1.5 while delays in the LHD operations necessitated the need of over 7 days/month to meet the stipulated targets even though this could be avoided. These theoretical capabilities were proven to be achievable by a trial schedule which reduced the 7 days/month to less than 2 days a month.

Several relevant key performance indicators for the evaluation and identification of productivity improvement opportunities were assessed inclusive of loading conditions, cycle and loading time, time utilization and deviations from schedule. The resultant production improvement opportunity can be seen in Figure 16, which a reflects a theoretical improvement of close to 25% and significantly lower operational costs.

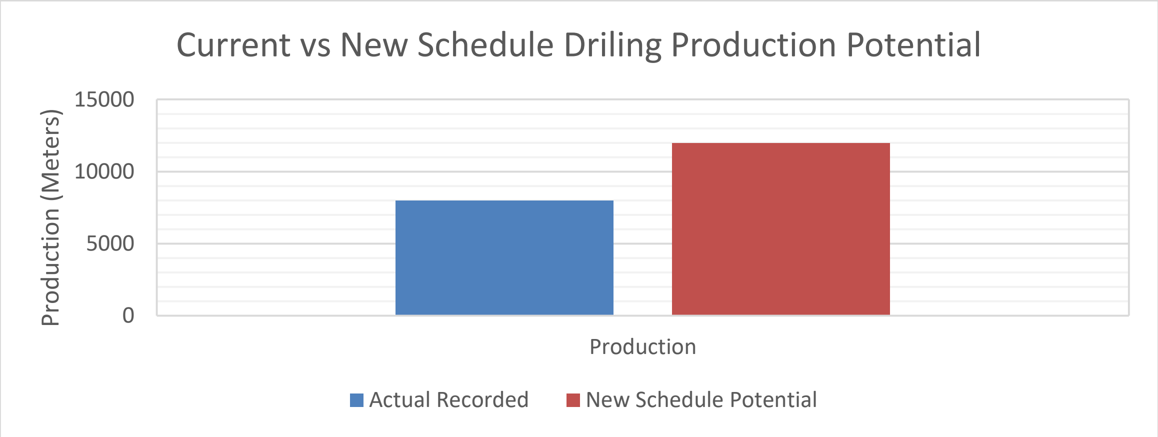

Figure 17. Drill and blast cycle productivity analysis and comparison of the two schedules

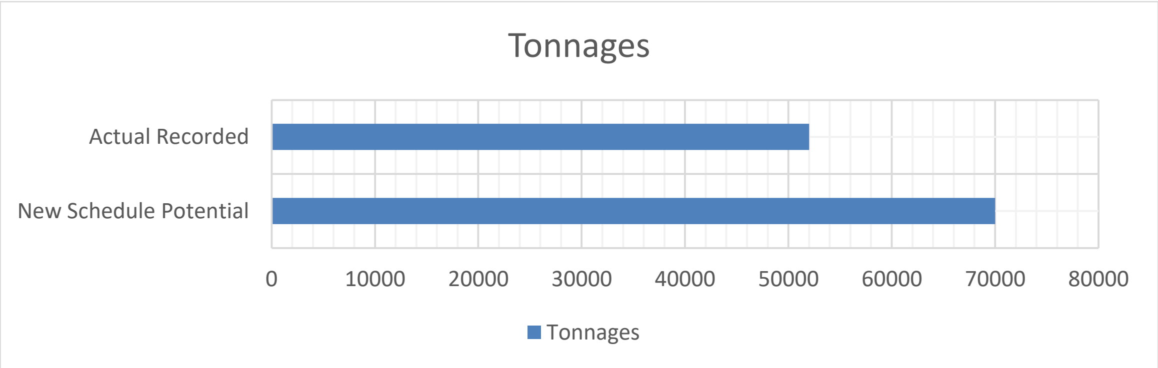

Figure 18. Load and haul cycle productivity analysis and comparison of the two schedules

CONCLUSIONS

It is evident from this research that the current mining fleet is capable of meeting the stipulated targets and even achieving more even within tough working environments characterized by harsh load shedding schedules and volatile inflation rates however this requires stringent monitoring and evaluation of unit processes with the mining cycle to reduce the delays characterizing the old practices as depicted by Figure 16 indicating drill rigs potential of improvement by a factor higher than 1.5 and delays in LHD operations that necessitated the need of over 7 extra working days per month. The old scheduling technique assumes incapability of the fleet and tries to counter production malpractices by lengthening the monthly production calendar. More so, adopting the recommended short term production plans will avoid resizing of operations as it automatically reduces the operational costs by US$3 million annually whilst coercing both operators and the as management to improve their operational efficiency.

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