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The effects of cut-off grade and block sizes on the net present value for an iron ore deposit.

Moore Theresa Malisa

A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 2019

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Masters of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

(Signature of candidate)

26th day of June 2019

Abstract

Optimisation of the Net Present Value (NPV) needs to consider cut-off grade as well as the block model size. This study considered the impact of these on the optimisation of the NPV. The orebody could be mined sub-optimally due to the misunderstanding of the relationship between cut-off grade and block model size. The research was based on an iron ore deposit mined through open-pit mining method in South Africa.

The main objectives of the study were: to understand the importance of cut-off grade; to determine the effect of block model sizes on the average grade; to determine the effects of the block sizes and cut-off grades on the NPV, and to determine which block sizes and cut-off grade maximise the NPV. It was found that there were different cut-off grades at different levels of the exploitation of the iron ore deposit. These differences can lead to the deposit not being mined optimally. Therefore, it was important to understand the importance of cut-off grades, hence the need to investigate the effects of cut-off grades. The effect of block sizes on the NPV was included because there was insufficient research on the topic.

From the literature review, the cut-off grade was defined as the boundary that separates material that is discarded from the material that is taken further for treatment. The cut-off grade determines whether the material will be considered as waste or ore. If the cut-off grade is too high, more material will be discarded as waste while a lower cut-off grade increases the entire mining capacity. The lower the cut-off grade, the higher the Mineral Reserve. It was shown from the literature that the determination of the cut-off grade is determined by factors such as the price of the commodity, production costs, grade distribution, environmental factors and other factors.

The literature review highlighted that a block model is a representation of orebody characteristics, whereby a single cube will have sizes (x, y and z). The

single cube will be allocated with grades, volumes, rock types, densities and many more attributes assigned to it depending on what information is required. The block model dimensions should represent the minimum block that could be selectively mined, that is, the smallest selective mining unit. The block model sizes are selected at the initial stages of creating the block model. The block size is also dependent on the sample spacing. The block size should be one-half or one-fourth of the sample spacing. When the selective mining unit is selected it should take into account the excavator that will be used to load the material. The selective mining unit is important since it determines the amount of dilution that will be encountered during mining. The larger the selective mining unit, the more the dilution, which decreases the grades.

The methodology that was used to analyse the effects of cut-off grade and block sizes on the NPV was through the use of grade-tonnage curves and the DCF for different block sizes and cut-off grades. NPV is the sum of the DCF's and the NPV assists in projecting the future revenues in terms of mines that are already in production. The DCF's for this report were done only for 10 years because it was enough to create data of a high level of confidence. The cut-off grades that were used were 53%,60%,63% and 64% Fe as they covered the definition of the ore for the iron ore deposit. The base block model size 6.25m x 6.25m x10m.The base block-model was re-blocked into sizes: 12.5m x 12.5m x 10m; 25m x 25m x 10m and 50m x 50m x10m. Grade-tonnage curves were created for each block model size including the base 6.25m x 6.25m x 10m block model. The obtained tonnes and an average grade above certain cut-off grade were used to create the DCF in Excel to obtain the NPV.

The results showed that an increase in the cut-off grade decreases the tonnes above the cut-off grade while increasing the average grade. The larger the block size, the lower the average grade due to increased dilution. The larger block sizes result in a lower NPV if the effects of mining selectively are not considered. However, if the effects of selective mining are considered, larger

block sizes result in an optimised NPV. Some of the conclusions were that small block sizes result in an optimised NPV only if the effects of selective mining are not considered while larger block sizes result in an optimised NPV when the effects of selective mining are considered. The 25m x 25m x 10m which is a larger block model size is not affected by selective mining and it resulted in a higher NPV when compared to the 12.5m x 12.5m x 10m,therefore,it is better to work with larger block model sizes to avoid selective mining. It was recommended that a 60% Fe cut-off grade paired with a 12.5m x 12.5m x 10m block size to be used when the effects of selective mining are not considered since it increases the tonnes above the cut-off grade, thus increasing the LOM and the NPV is optimised. A 60% Fe cut-off grade paired with a 12.5m x 12.5m x 10m block size was also recommended to be used when the effects of selective mining are considered as this optimises the NPV. A 60% Fe cut-off grade paired with a 25m x 25m x 10m block size is recommended since it does not require to be mined selectively.

Acknowledgements

I would like to thank Mr C. Birch for guiding me throughout the process of writing this research project.

I am also grateful for VBKOM for allowing me to use the company's resources which allowed me to complete this research report.

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Abbreviations

Al_2O_3	Aluminium oxide (Alumina)
BaO	Barium Oxide
CaO	Calcium Oxide
CSV	Comma-separated values
DCF	Discounted Cash Flow
DMS	Dense Medium Separation
Fe	Iron
GT	Grade-tonnage
kton	Kilo tons
KUS$	Thousands US Dollars
kg	Kilogram
K_2O	Potassium oxide
LOM	Life Of Mine
m	Metre
mm	Millimetre
MPRDA	Mineral and Petroleum Resources Development Act
Mn	Manganese
Na_2O	Sodium Oxide

NPV	Net Present Value
P	Phosphorous
P_2O_5	Phosphate
S	Sulfur
Rm	Million rands
R/t	Rand per tonne
$	Dollar
$/t	Dollar per tonne
t	tonne
%	Percent
g/t	Grams per tonne
SiO2	Silicon dioxide (Silica)
SAMVAL	South African Code for the Reporting of Mineral Asset Valuation
SAMREC	South African Mineral Resource Comimittee
SMU	Selective Mining Unit
%TCu	Percent Total Copper
%TCo	Percent Total Cobalt
VBKOM	VBKOM Consulting Engineers
Wt Avg	Weighted Average

Chapter 1: Introduction

1.1. Chapter 1 overview

The chapter defines the regional and local geology of the iron ore deposit, the purpose of the study, the background behind the need to do the research on the effects of cut-off grades and block model sizes on the net present value (NPV). The research motivation, research objectives and the problem statement are also discussed in detail.

1.2. Introduction of the project area

The project area is located in the Northern Cape,South Africa.The project area is 30km away from a town called Khathu. The project area has been in production for 10 years. The iron ore produced is transported through trains to Saldhana which is approximately 861km away from the project are. The iron ore is then exported to clients from Saldhana.

1.3. Regional geology

The iron ore deposit was deposited approximately between 2500 and 1800 million years ago. The deposit is contained within the Proterozoic sediments of the Transvaal Supergroup and Olifantshoek Group. The deposit is divided into the Bruce-King-Mokaning-McCarthy and the Southern Beeshoek Olynfontein. Although the deposit is divided into two areas, the two areas have identical geological settings (African Rainbow Minerals, 2017). In the Carboniferous period, the Dwyka Glacial Event eroded some of the sequences. The Southern Beeshoek Olynfontein deposit was the most affected by the erosion compared to the Bruce-King-Mokaning-McCarthy deposit. The erosion resulted in the portions of the orebodies that are down dipping to be developed and well preserved while the outcrop became thin and isolated (ASSMANG, 2005).

The two areas are located on the Maremane Dome and along the unconformity between the Gamagara Formation and the underlying Manganore Iron Formation which is indicated in Figure 1.

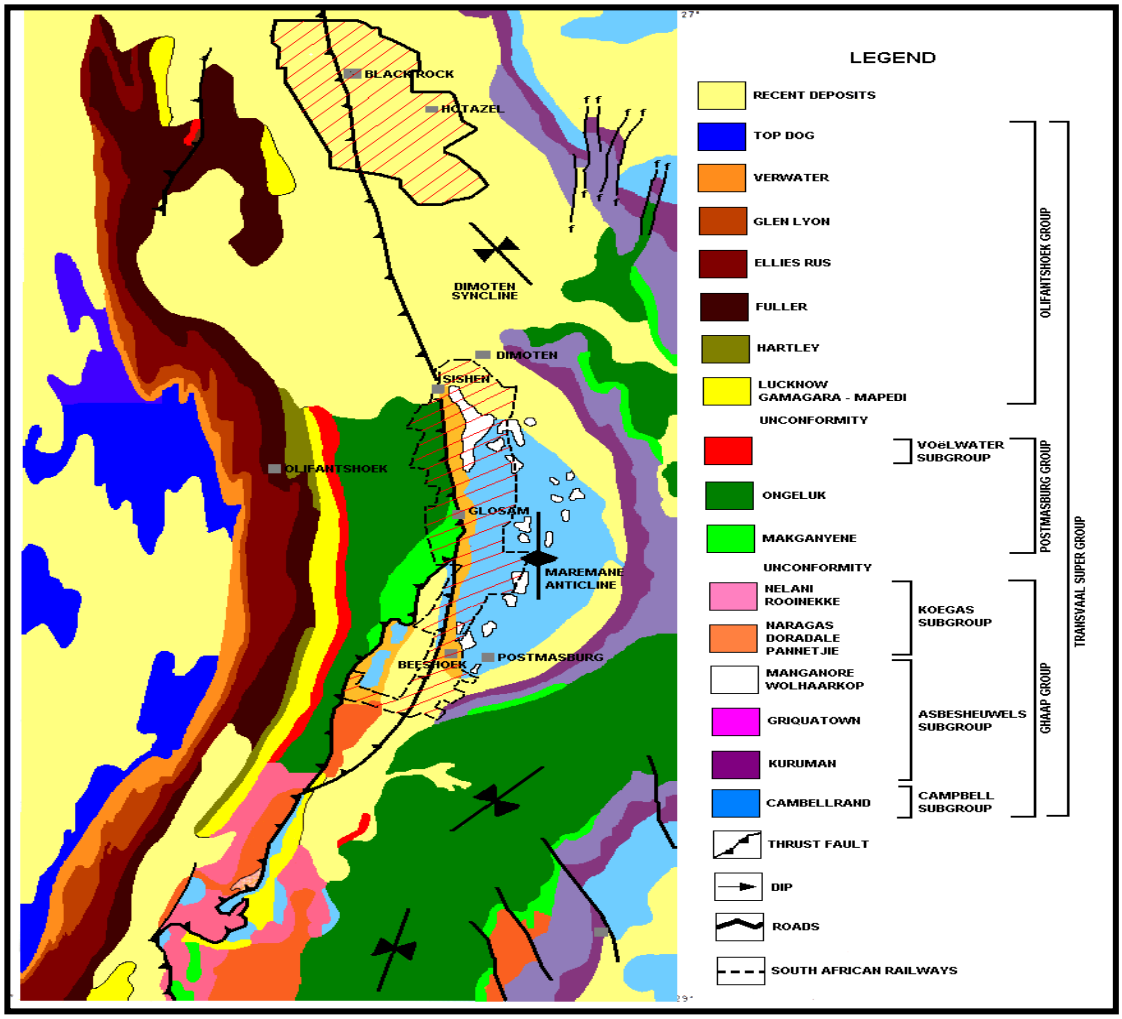


Figure 1: Regional geology of the iron ore deposit (ASSMANG, 2017)

The Manganore Iron Formation is preserved and restricted in pockets below the Gamagara Unconformity. The ore types which are present in the Manganore Iron Formation are namely the Laminated Hematite ore and the Conglomerate ore. The Laminated Hematite ore forms part of the Manganore Iron Formation while the Conglomerate ore forms part of the Doornfontein Conglomerate Member which is at the base of the Gamagara Formation. The

Doornfontein Conglomerate is best developed along the east-central perimeter of the Maramane Dome within the Manganore Iron Formation (ASSMANG, 2017) .

1.4. Local geology

The stratigraphy of the local geology of the iron deposit is illustrated in Figure 2. Figure 2 shows the composite profile of the Manganore Iron Formation and the Gamagara Formation of the iron ore deposit that is discussed in this report. The Kalahari Formation which includes clay, calcrete and sand masks some of the detailed geology (ASSMANG, 2009).

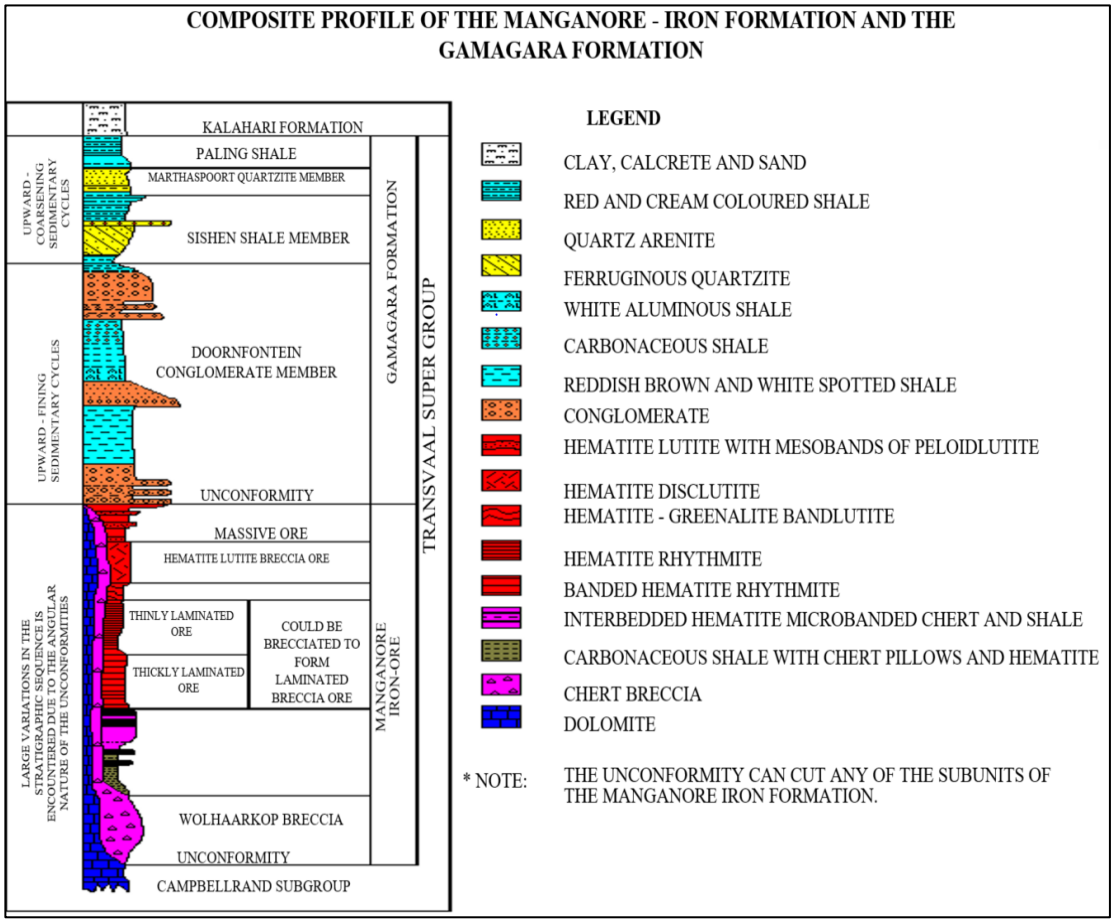


Figure 2: Composite profile of the Manganore Iron Formation (ASSMANG, 2017)

Figure 2 further shows that the Manganore Iron Formation is below the Gamagara Formation. The Gamagara Formation is well developed while the Manganore Iron Formation is preserved in pockets. The composite profile shows that the Conglomerate ore is closer to the surface since it is within the Gamagara Formation inside the Doornfontein Conglomerate Member.

1.3.1 Ore types

As mentioned in the preceding sections, there are two types of ore which are Laminated ore and conglomeratic ore, Figure 3. Laminated ore is the oldest ore type which is found in the Manganore Formation and is enriched with high-grade hematite bodies.

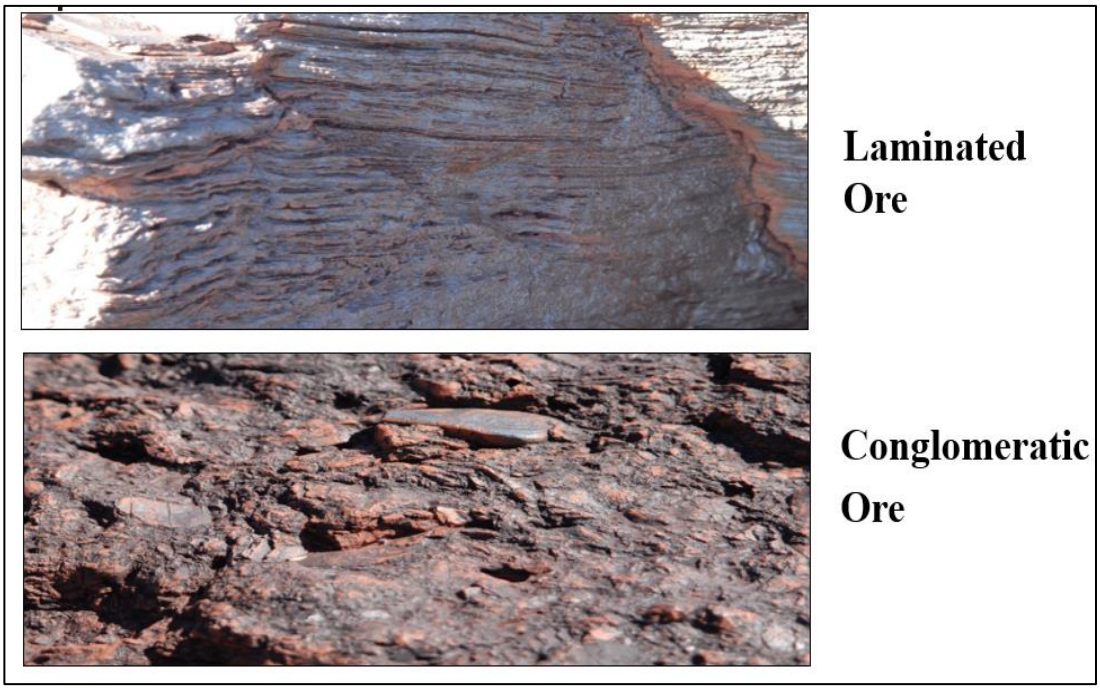


Figure 3: Ore types (ASSMANG, 2017)

The primary sedimentary bedding is being cross-cut by the boundaries of high-grade hematite, this is evidence of secondary hematisation of the iron formation. The conglomerate ore is found in the Doornfontein Conglomerate Member of the Gamagara Formation. There is inconsistent development along

strike and it is lenticular in shape. Conglomerate ore is rich in rounded to sub-rounded hematite ore granules and pebbles and it forms the largest part of the orebody (African Rainbow Minerals, 2017). The mineralogy of the two types of ore are related to the chemical components that occur within the iron ore. Table 1 indicates the mineralogy of the conglomerate and laminated ore.

Table 1: Mineralogy of the ore types (Moeti, 2017)

Ore type	**Fe**	**SiO_2**	**Al_2O_3**	**K_2O**	**P_2O_5**
Conglomerate ore	62.16	5.34	2.87	0.28	0.06
Laminated ore	66.27	2.39	0.83	0.07	0.06

Conglomerate ore contains a low Fe (Iron) as compared to the Laminated ore. The presence of K_2O (Potassium oxide) determines the presence of muscovite and illite in the ore. Conglomerate ore contains more muscovite and illite. The presence of Al_2O_3 (Aluminium oxide) determines the presence of kaolinite and muscovite in the ore. Laminated ore contains less kaolinite and muscovite (ASSMANG, 2009).

1.5. Mining method

The iron ore deposit is mined through open pit mining method. The loading and hauling is done through shovels (PC 5500 and PC 4000) which are matched with haul trucks.The haul trucks are a combination of the Komatsu 860E (280t payload) and the CAT 789 (180t payload). Selective mining is also done using a Liebherr 9200 (shovel). The ore is transported to the crusher using the haul trucks. Once the ore has been crushed,the ore is transported through conveyor belts to the crusher. The material that is mined is named ON grade,OFF grade and Waste. The ON grade is taken through washing and screening while OFF

grade is taken through washing,screening and through a Jig plant. Further details of what is ON and OFF grade ore is in the sections that follow.

1.6. Purpose of the study

Optimisation of the NPV needs to consider cut-off grade as well as the block model size. This study considers the impact of these on the optimisation process.

1.7. Research background

The research will be based on an iron ore deposit which is currently mined through open-pit mining method in South Africa. The deposit's mineable material is classified as 1=ON grade, 2=OFF grade and 3=Waste, whereby the ON and OFF grade is the ore. It was found that there are different ore definitions in terms of Fe grade (%). The cut-off grades defined in the mining block model which is used for planning purposes are different from the cut-off grades that are defined by geologists and metallurgists, that is, the ore that needs to be sent to the crusher.

Based on the block model that is currently being used; ON grade is classified as iron ore with Fe grade of greater than 63.5% and OFF grade is iron ore with Fe grade between 53% and 63.5% as illustrated in Figure 4. Waste material is defined as material below a 53% Fe grade.

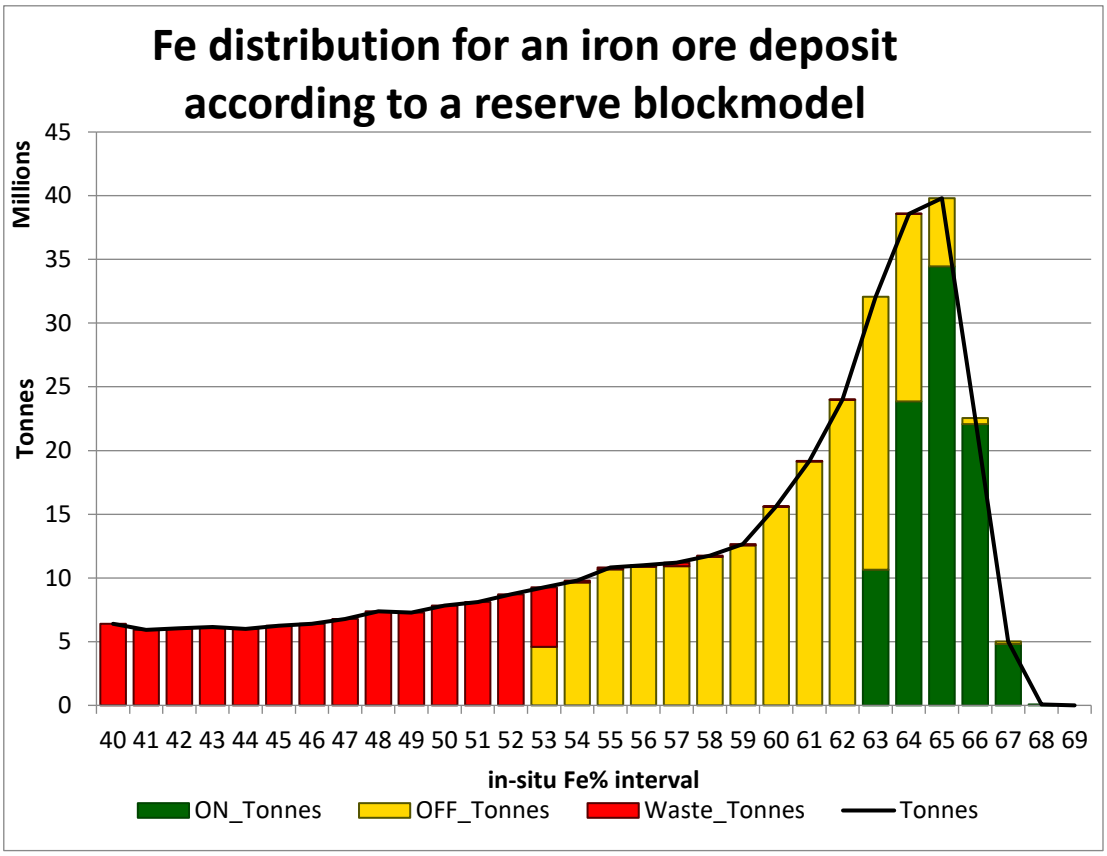


Figure 4: Frequency plot of the grade and tonnes distribution in the block model (VBKOM, 2017a)

Figure 4 which was created from Geovia Surpac CSV file shows the tonnes that are associated with different cut-off grades. From the graph, it can be seen that more material falls in the OFF grade category. The ON grade as shown is Fe of 63.5% and above. If the material does not meet the specified criteria which is indicated in Table 2, including the contaminants (SiO_2, Al_2O_3 and K_20), it is classified as waste.

However, classification of ON grade and OFF grade according to geologists and metallurgists**,** the ON grade is classified as ore with Fe grade of greater than 64.5% and can be extracted with minimum dilution. The ON grade ore does not require to be processed further processing through a jig or Dense Medium separation (DMS) plant, it only requires washing and screening to be

converted into a saleable product. The OFF grade is ore with Fe grade of between 60 and 63.5%. The OFF grade ore requires further through the jig plant in order to be converted as a saleable product (ASSMANG, 2009). Table 2 explains the ore classification in detail.

Table 2: Ore classification in terms of material taken to the crusher (Moeti, 2017)

Ore type	**Fe**	**SiO_2**	**Al_2O3**	**K_2O**
ON grade	>64.50	<6.95	< 2.95	<0.30
OFF grade	60.00-63.50	<12.69	< 5.38	<0.54

The block model that is currently being used for planning purposes and other activities at the mine is of sizes 6.25m x 6.25m x 10m. It is not clear what the effect of these sizes are on the NPV, thus the motivation for more research on this subject.

1.8. Research justification

From observations and data collected, it was seen that there is a misunderstanding of the cut-off grade in the iron ore deposit. The difference in cut-off grades leads to the assumption that there is a lack of understanding of the importance of cut-off grades and what cut-off grade to use. This misunderstanding can lead to treating ore as waste, therefore reducing the reserves and not using the ore deposit optimally and, therefore, not maximising the NPV. The effect of block model sizes on the NPV will also form an important part of the study as it is currently not clear and not enough research is available.

The motivation of this research was further obtained from experience as a planner. As a mine planner, there needs to be clarity as to what cut-off grade and block sizes are to be used as this affects the life of mine (LOM), the planning production tonnes and ultimately the NPV. Therefore, this research project is aimed at showing the importance of understanding what cut-off grade is, the effect of the different cut-off grades that are currently being used for the iron ore deposit on the reserves and the effect of block model sizes on the NPV.

1.9. Research objectives

The main objectives of this study are:

- To understand the importance of cut-off grade;
- To determine the effect of block model sizes on the average grade;
- To determine the effects of the block sizes and cut-off grades on the NPV; and
- To determine which block sizes and cut-off grade maximises the NPV.

1.10. Problem Statement

Cut-off grade and block model size have an impact on the optimisation of the NPV. The orebody is mined sub-optimally due to the misunderstanding of the relationship between cut-off grade and block model size.

1.11. Report structure

- Chapter 1:Introduction
- Chapter 2:Literature Review
- Chapter 3:Methodology
- Chapter 4:Results and analysis of results
- Chapter 5:Conclusions and recommendations
- References

Chapter 2: Literature Review

2.1. Chapter 2 overview

Chapter 2 reviews the current literature related to cut-off grades, case studies on cut-off grade optimisation, NPV, block modelling, mine selectivity and case studies on optimisation of block model size creation of block sizes.The literature review gives a brief understanding of the previous work that has been done regarding cut-off grades,block model and NPV.

2.2. What is cut-off grade

According to Lane (1988), the cut-off grade is the boundary that separates material that is discarded from the material that is taken further for treatment. Nwosu and Nkwankwoala (2012, p.1) define cut-off grade as *"the minimum grade of ore at which the value of the smelted ore will balance all cost in mining, waste removal, mineral processing and smelting and leave the corporate output with at least a minimum acceptable level of profit"*. They further indicate that cut-off grade affects the reserves. When the cut-off grade is decreased, the reserves increases due to lower grade material that can be mined and processed, therefore increasing the LOM.

Cut-off grade is the ore that can be mined without incurring any loss in profit or without getting profit (School of Mining Engineering, 2017a). According to Bascetin and Nieto (2007), cut-off grade determines whether the material will be considered as waste or ore. If the cut-off grade is low, more mineable material above the cut-off grade can be classified as ore thus increasing the entire mining capacity. They further emphasise that an open pit mine's cut-off strategy has an influence on the yearly cash flows and on the NPV. They further indicate that cut-off grade optimisation is used to maximise the NPV.

2.3. The effects of cut-off grades on reserves

Cut-off grades for ferrous metals such as iron ore are based mainly on market specification and what product the client requires. Knowing the cut-off grade and using the same cut-off grade mine-wide results in ensuring that mining below the cut-off grade does not occur. It also assists in identifying the growth potential looking at the longer term through long-term planning and assists in maximising the available reserves (School of Mining Engineering, 2017a).

According to (Birch, 2016a), the primary purpose of cut-off grades is for mine planning and to convert Mineral Resources into Mineral Reserves. The lower the cut-off grade, the greater the mineral reserve. Cut-off grades determine value and profit, the lower the cut-off grade, the larger the reserve which can be good for investors, as long as the mining of lower grades can be justified. Figure 5 indicates the effects of the cut-off grade on the reserves, as the cut-off grade increases the, most tonnages will be excluded, thus a decrease in the LOM. A lower cut-off grade can result in an increased LOM, however, it might be unprofitable due to material with low grades being included as part of the reserve. A balance must be obtained, and that balance is the optimum cut-off grade which maximises the NPV.

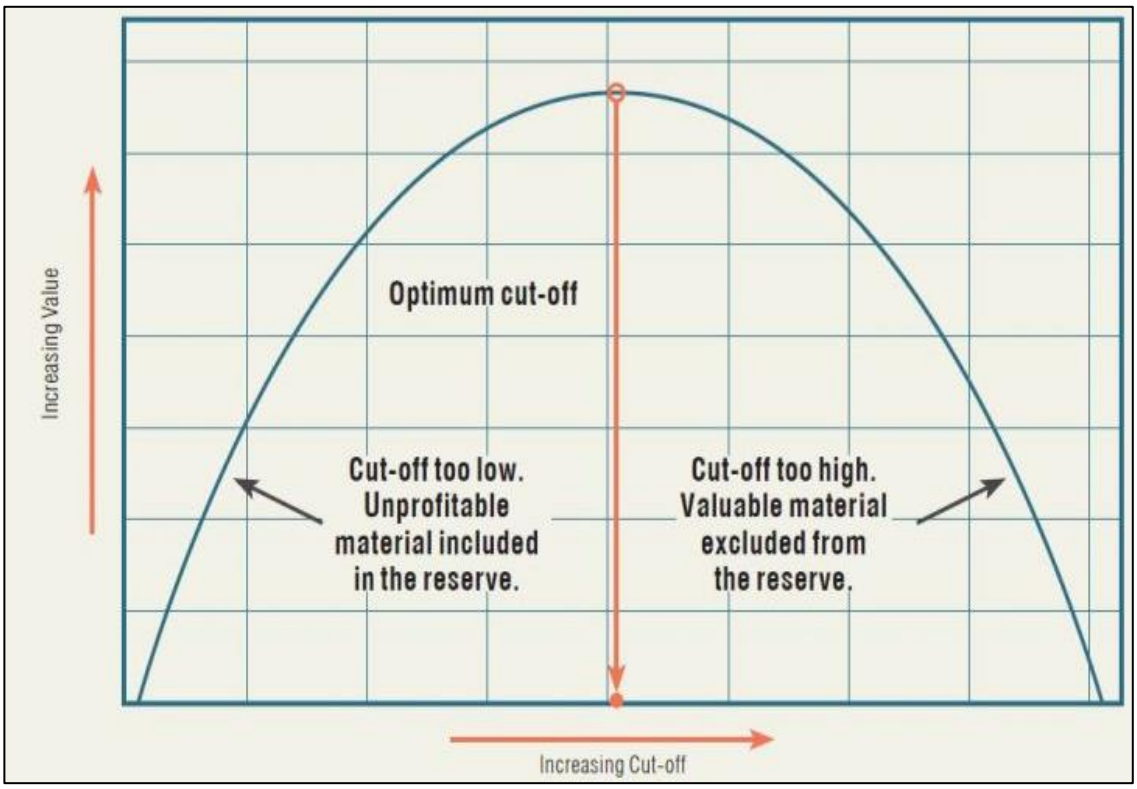


Figure 5: The effects of cut-off grade on the value (Hall, 2014).

2.4. Stakeholders in the cut-off grade setting

Cut-off grades as mentioned has an influence on the reserves and thus determines the LOM of the operations and most important the NPV. There are a number of stakeholders that are affected. Investors, the community, and employees are some of the stakeholders (Sinding and Larsen, 1995). The lenders, parent company and investors would prefer a high cut-off grade in the initial stages of the mine life in order to create revenue enough to reduce the payback period. Employees would rather prefer a low cut-off grade because a low cut-off grade means a larger reserve, therefore, jobs for a longer period of time. The Mineral and Petroleum Resources Development Act (MPRDA) states that the "*mineral and petroleum resources are the common heritage of all the people of South Africa and the state is the custodian thereof for the benefit of all South Africans*" (MPRDA, 2002,18). The state would, therefore, prefer a low-

cut-off grade that will ensure that the community around the mining project benefits for an extended period.

Figure *6* indicates more stakeholders of the cut-off grade policy.

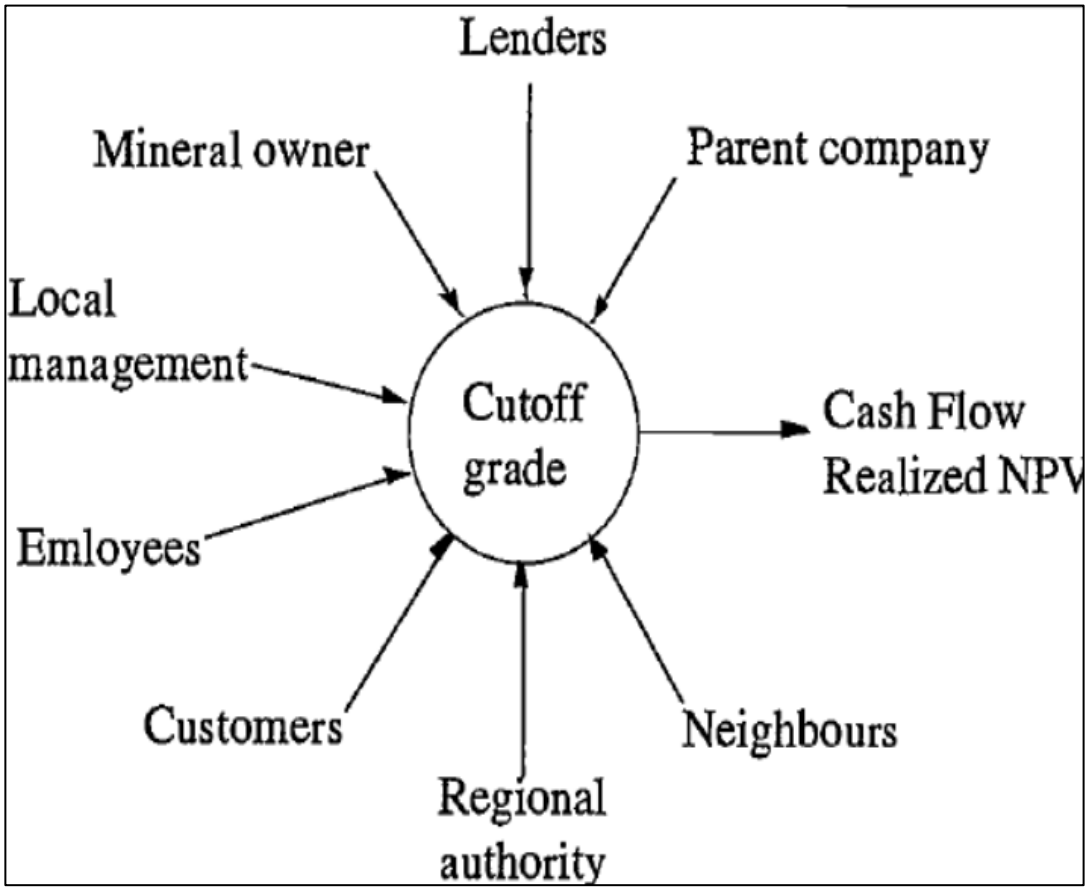


Figure 6: Stakeholders of the cut-off grade policy(Sinding and Larsen, 1995).

2.5. Types of cut-off grades

2.5.1. Geological cut-off grade

A geological cut-off grade separates the material into fractions of in-situ grades. The geological cut-off grade separates in-situ grade into grade intervals and relates them to in-situ tonnages related to those grade bins or fractions. Figure 7 shows an example of a geological cut-off grade.

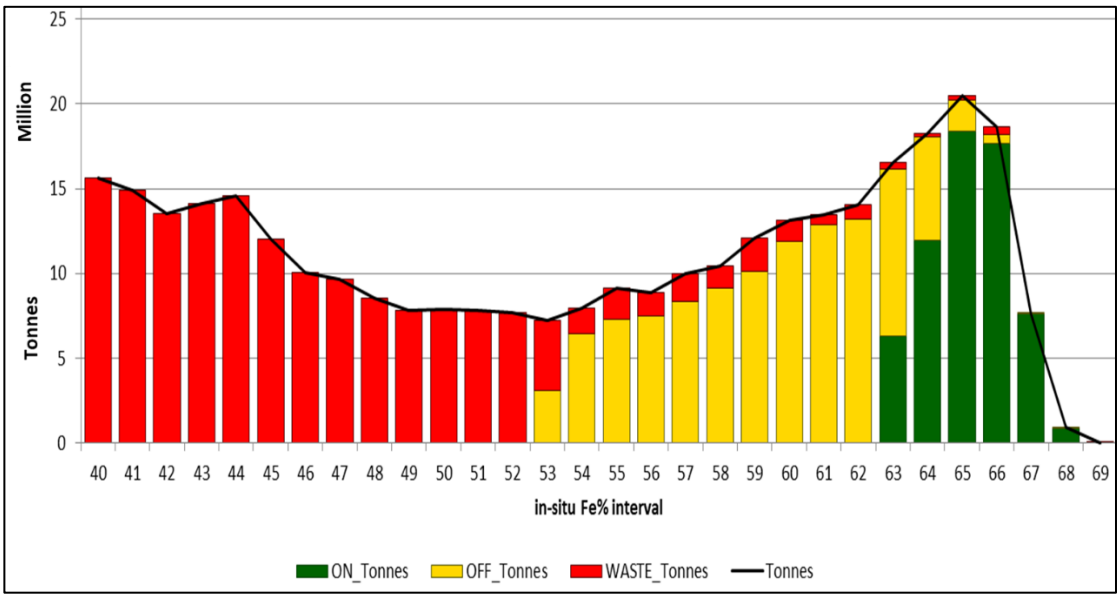


Figure 7: Example of geological cut-off grade (VBKOM, 2017a)

2.5.2. Breakeven cut-off grade

The breakeven cut-off grade is the grade where the mineralised material pays for the mining and processing costs. The breakeven cut-off grade is generally not the optimum solution since the aim for mining operations is to make a profit. For cases where the LOM is expected to be longer, a cut-off grade higher than the break-even cut-off is recommended so that the ore with higher grades can be depleted quickly and increase the revenue at the earlier years of the mine. The cut-off grade can then be reduced closer to the end of the LOM, thus increasing the LOM. In cases where there is an ore shortage, the break-even cut-off grade should be used (Border, 1993). According to Birch (2016), the break-even grade can become a cut-off grade as long as only the material above the break-even cut-off grade is mined. This will result in no dilution of the material and the costs of mining will be covered.

2.5.3. Budget cut-off grade

The budget cut-off grade is the grade required for the generation of cashflow for a certain year which is necessary to fulfil a company's objectives (Pasieka and Sotirow, 1985).

2.5.4. Planning cut-off grade

The planning cut-off grade is the minimum grade of the mineralised material, whereby the NPV is zero, that is, no economic value. Both plant and mine capacity can be determined with the aid of planning cut-off grade (Pasieka and Sotirow, 1985). It must also be able to cover the capital, operating costs and costs of marketing the product. It is usually used in the initial stages of a feasibility study (School of Mining Engineering, 2017b).

2.5.5. Minimum(marginal) cut-off

The marginal cut-off grade can be defined as the grade at which the net revenue exceeds additional processing costs and internal hurdle rate. The aim for this grade is to mine material that is sufficient to cover direct extraction costs, processing and marketing of the product. The marginal cut-off grade has a direct effect on the profitability of a mine and it must be managed within the optimum pit, the processing plant parameters and other factors such as the commodity price and production costs (School of Mining Engineering, 2017b).

2.5.6. Variable cut-off grade

Variable cut-off grade varies as the mine life increases and it varies due to the variability of the orebody. It is recommended to start with a high cut-off grade at the beginning of the mine operations in order to make money upfront. When the capital has been paid off, the cut-off grade can be lowered. The main purpose of this cut-off grade is to prioritise high-grade material in order to improve the NPV (School of Mining Engineering, 2017b).

2.5.7. Optimum cut-off grade

This is the grade which maximises the NPV, thus creating a profit (Border, 1993). The NPV can be maximised through the use of the optimum cut-off grade policy through the consideration of refining and processing constraints (Asad and Topal, 2011). It is recommended that the optimum cut-off grade is reviewed regularly as it can change with time due to factors such as the metal price and interest rates. The review should not be major as to avoid the disruption of mining operations. The application of the optimum cut-off grade should ensure that the ore that is mined at any part of the mine results in high returns. If there are areas that are costly to mine, it is recommended to increase the cut-off grade (Border, 1993). Figure 8 shows the optimum grade model. The model indicates the factors involved in the determination of an optimum cut-off grade.

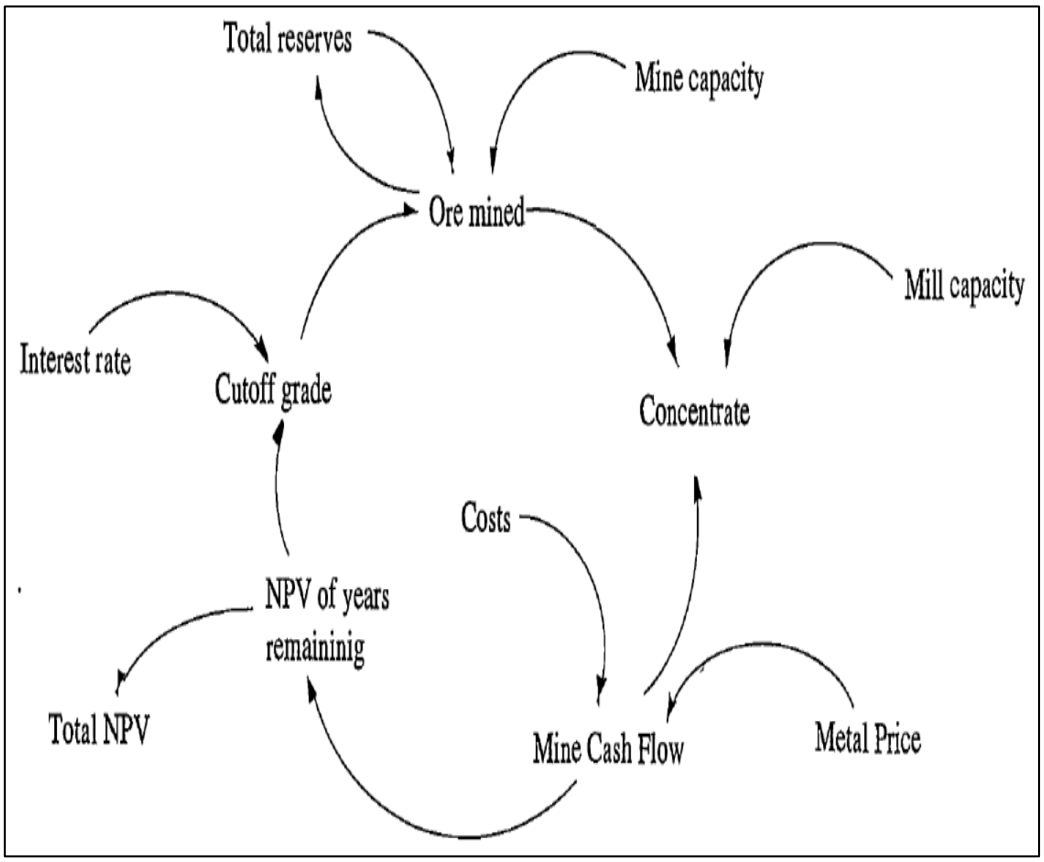


Figure 8: Optimum cut-off grade model (Sinding and Larsen, 1995)

2.5.8. Application of the different cut-off grades

With the aid of Figure 9, the explanation of how the different grades are applied is shown. The cut-off grades used for operational and strategic planning are also shown respectively in Figure 9 (was re-done in order for the diagram to be of better quality). Break-even and marginal cut-off grades are applied in short term planning whereas planning and geological cut-off grades are used for long term planning. It is important to understand that the delineation of ore to waste is applied during operational activities which depend mainly on objectives which are short range as depicted. Strategic planning addresses the whole project life and value as well as long-range objectives. It then becomes vital to understand where the project is on its cycle for the application of the relevant cut-off grade (Pasieka and Sotirow, 1985) .

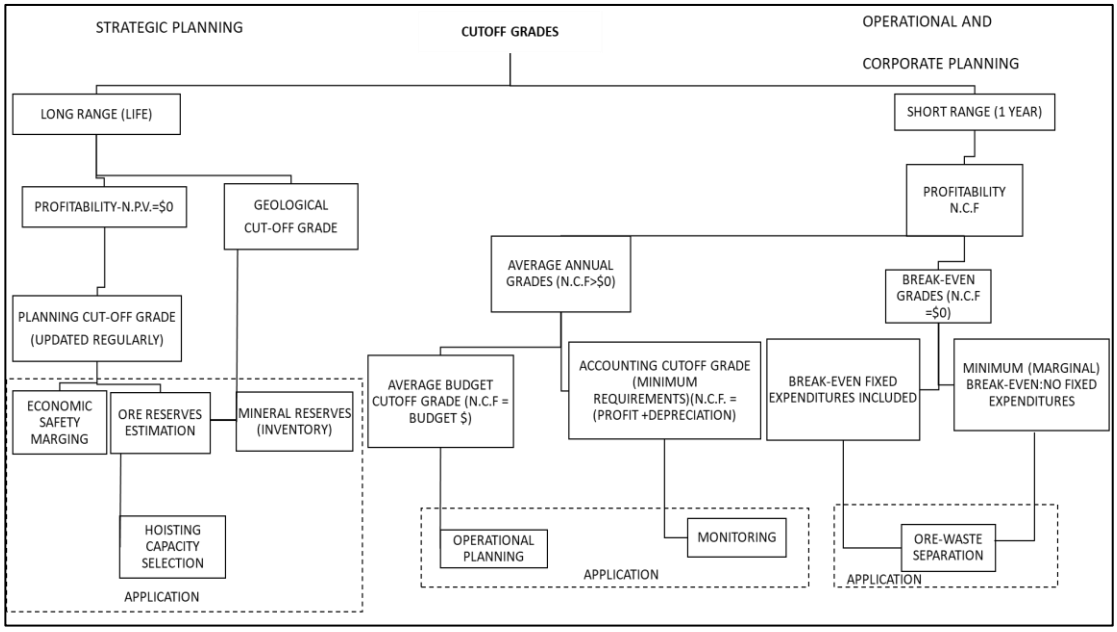


Figure 9: Purpose of the different cut-off grades (Pasieka and Sotirow, 1985)

2.6. Grade-Tonnage curves

Grade-tonnage curves show the tonnages and the average grade at different cut-off grades. A grade-tonnage curve is used to determine the tonnes above

a certain cut-off grade and the resultant average grade of all the blocks above cut-off grade (Birch, 2016). Figure 10 is an example of the grade-tonnage curve.

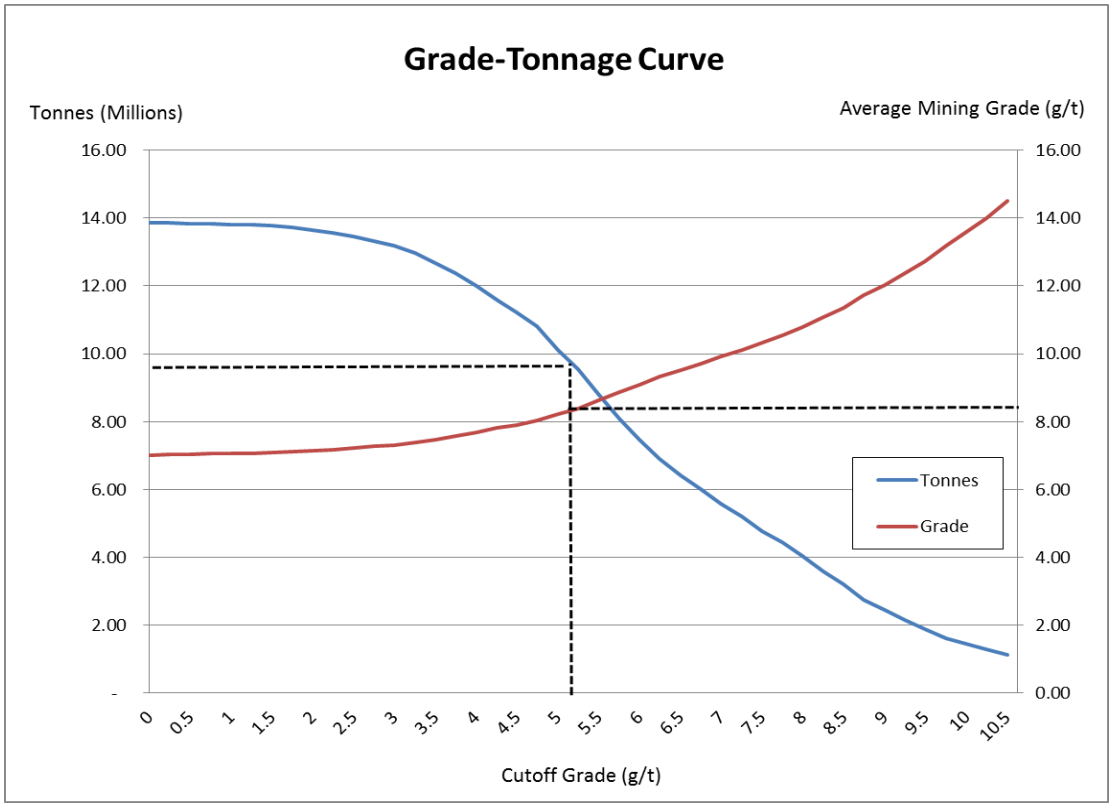


Figure 10: An example of a grade-tonnage curve (Birch, 2016)

Figure *10* shows that for a cut-off grade of 5.25 g/t, the tonnes above the cut-off grade will be 9.5 million tonnes at an average grade of 8.4g/t (Birch, 2016).

2.7. Cut-off grade policy and optimisation

A cut-off grade policy must be available in the mine operations. The cut-off grade policy informs mine planners as to which material is considered ore which is required to be for further processing and what is waste that should be sent to the waste dumps (Martinez et al, 2011). According to Border (1993), the cut-off grade policy should be included in an annual review of the cut-off grade during the Ore Reserves annual review. Bascetin and Nieto (2007)

indicate the cut-off grade policy determines the economic value of a mining operation. Everyone involved in the operations should be able to distinguish between waste and ore. The determination of the cut-off grade is determined by certain factors. Factors such as the price of the commodity, production costs, grade distribution and environmental factors as well as factors shown in in Figure 11. The cut-off grade determines the cash flow, which leads to the requirement of cut-off grade optimisation.

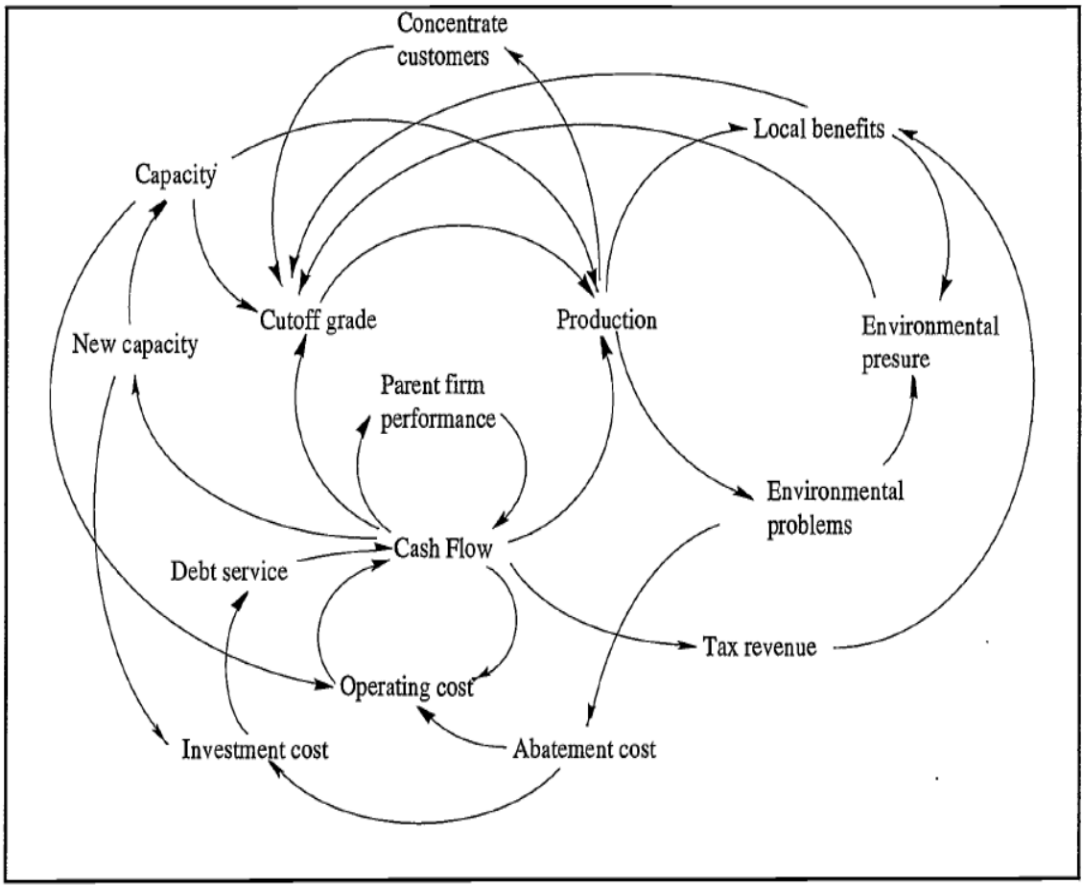


Figure 11: Factors affecting the cut-off grade (Sinding and Larsen, 1995)

According to Martinez et al (2011,p1)*, "cut-off grade optimisation is the process used to determine the operating mining strategy (long-term production scheduling) that will maximise the total profit value (normally referred as the net present value (NPV)) of a mine operation".* The production capacity and the processing capacity act as a constraint to the dynamic cut-off grade policy.

Bascetin and Nieto (2007) also agree that the cut-off grade optimisation maximises the NPV based on constraints such as the mine production, milling and the market. They further indicate that optimisation of the cut-off grade is regarded as the most important and difficult problems faced in a mining operation.

Cut-off grade optimisation in order to maximise the NPV of a mining operation is the most common criteria used and it is already well established in the mining industry. Cut-off grade has a direct effect on the cash flow, the higher the cut-off grade, the higher the revenue due to high grades per tonne of ore. To do a proper cut-off grade optimisation, the production costs, processing costs, mining method sequence, grade distribution of the deposit and the material types should be known.

2.8. Net Present Value (NPV)

The discounted cash flow (DCF) and NPV which is the sum of the discounted cash flows are recognised by the South African Code for the Reporting of Mineral Asset Valuation (SAMVAL Code) as methods of valuation for mines already in production and for exploration projects (Birch, 2016). The DCF takes into account the time-value of money by discounting future cash flows by an increasing rate (Whittle and Whittle, 2007). The NPV assists in projecting future revenues in terms of mines that are already in production. The production rate is directly linked to the maximisation of the NPV. Mining operations should aim at getting the production rate that maximises the NPV. To obtain an optimum production rate that maximises the NPV, several scenarios should be performed whereby the NPV is calculated at different production rates. Each production rate scenario should be associated with selectivity, pit geometry, fixed costs, capital costs, variable costs and the infrastructure required.

There needs to be information and estimations with high confidence in terms of costs, recoveries, expected tonnes and grades in order to do a discounted

cash flow which can be reliable. A discount rate is the mine's cost of capital which is used in the cash inflows and outflows. Whittle and Whittle (2007) define the discount rate as the average cost of capital for an organisation adjusted looking at the risks. It can be based on the current financial conditions (real) or it can be based on inflation and escalation (nominal). According to Smith et al. (2006), it is good practice to use the real discount rate because the assumptions made during the initial stages of the investment evaluation are done on real terms and the risks that are in nominal terms (inflation) are avoided when the real discount rate is applied to real cashflows. South African mining projects discount rates that are appropriate are between 9% and 12%. This is due to the 8% to 9% minimum acceptable rate of return in real terms, 1% to 2% project risk rate in real terms and the zero risk rate for projects funded from local sources. The 9% and 12% is equivalent to a 14.5% and 17.6% nominal weighted cost of capital at a 5% annual inflation rate (Smith et al, 2006). A high discount rate indicates that emphasis should be on reducing capital costs (Darling, 2011).

A positive NPV indicates that the project or operation is viable. After 20 years there are minimal changes in the NPV because of discounting (Birch, 2016). The cut-off grade has a direct effect on the NPV. If the material of high grade is mined in earlier years of mine life, the NPV will be maximised, this is the theory of time value of money.

2.9. Case studies on cut-off grades

2.9.1. Operation 1: Ruashi Mine (Copper-Cobalt deposit)

Mugwagwa (2017) carried out research on the *"Cut-off Grade Optimisation for a Bimetallic Deposit: A Case Study of the Ruashi Mine Copper-Cobalt Deposit"*. Although it is a Copper-Cobalt Deposit, the information is still relevant for an

iron ore deposit. The objective of the research was to recommend a cut-off grade policy that optimises NPV for Ruashi Mine.

To solve the cut-off grade issue, Mugwagwa (2017) started by calculating the break-even cut-off grade. This is the grade whereby the production costs are equal to the revenue. The aim of the calculation was to show the effects of running an operation on break-even cut-off grade. A grade-tonnage curve was then created with the calculated cut-off grade to get the tonnes and an average grade above the cut-off grade, see Figure 12. LOM cash flows were created based on the break-even cut-off grade whereby the profit and NPV were obtained, see Table 3.

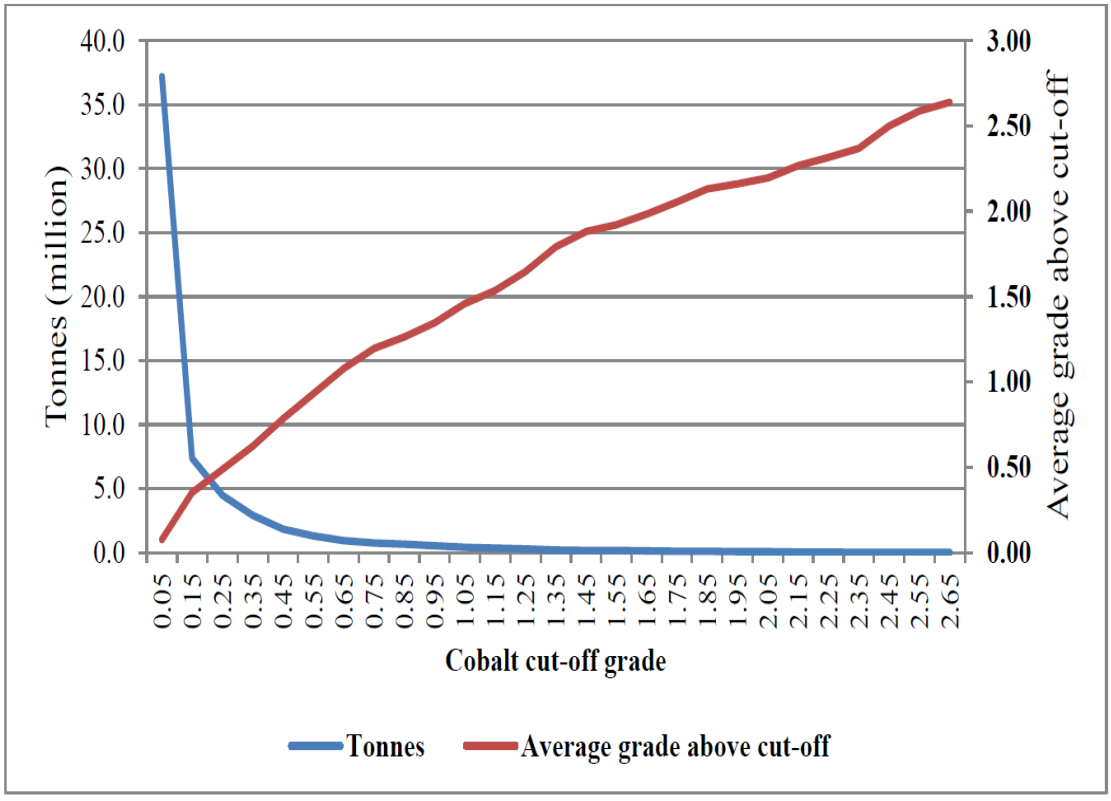


Figure 12: Grade-tonnage curve for the Ruashi mine (Mugwagwa, 2017)

Table 3: Life of Mine schedule based on the break-even cut-off grade (Mugwagwa, 2017)

Year	Mined Tonnes	Processing	COG	Average Grades		Cu Cathode	Co in Conc	Profit	NPV
	(Mtonnes)	(Tonnes)	%TCu	%TCu	%TCo	(Tonnes)	(Tonnes)	($m)	($m)
1	10.74	1.2	2.00	3.75	0.26	38,274	2,059	79.33	70.31
2	10.74	1.2	2.00	3.75	0.26	38,274	2,059	79.33	62.32
3	10.74	1.2	2.00	3.75	0.26	38,274	2,059	79.33	55.23
4	2.41	0.3	2.00	3.75	0.26	8,597	462	17.82	10.99
Total	**34.62**	**3.87**		**3.75**	**0.26**	**123,419**	**6,638**	**255.82**	**198.85**

From the calculated cut-off grades, LOM cash flows were created and the NPV was obtained and then compared to one another to see which cut-off grade gives the best NPV. Grade-tonnage curves were also created and analysed. Mugwagwa continued with other methods of calculating the cut-off grades. The methods include NPV scheduler pit optimisation and optimisation based on recoverable value (SimSched DBS). These methods will not be discussed in detail as the aim of this research is not to optimise the cut-off grade. From the study, it was concluded that the NPV from the calculated break-even cut-off grade was the lowest. The method of using the SimSched DBS resulted in an optimised cut-off grade policy and there was room to improve the NPV at Ruashi mine.

2.9.2. Operation 2: Cementacija open pit copper mine in Serbia

Krzanovic et al (2015) mention that cut-off grade is one of the important parameters that affect the economic efficiency of a mine in their study *of "Maximizing the net present value by applying an optimal cut-off grade for long-term planning of the copper open pits"*. The maximising of the NPV was shown through a case study for the Cementacija surface copper mine in Serbia.

Cut-off grade is a key component in planning and design, production and an investment decisions foundation. They further emphasise that determining the cut-off grade with the aim of maximising the NPV is the most used and acceptable method and it has been used for the last four decades. During the earlier years of the mine life, high NPV can be achieved in order to pay for the initial investment, but this depends on the grade distribution. "*The objective function of the cut-off grade optimisation model is to maximize the NPV of the operation subject to mining, processing and refining. For capacity constraints on mentioned processes this may be represented mathematically as follows":*

$$MaxNPV = \sum_{n=1}^{N} \frac{P_n}{(1+\delta)^n}$$

$$Qm_n \leq M \forall n$$

$$Qc_n \leq C \forall n$$

$$Qr_n \leq R \forall n$$

where: n = period (year) indicator,
N = total life of operation (years),
P = profit ($/year),
δ = discount rate (%),
M = mining capacity (tons/year),
C = processing or milling capacity (tons/year),
R = refining capacity (tons /year),
Qm = quantity of material mined (tons/year),
Qc = quantity of ore processed (tons/year),,
Qr = quantity of concentrate refined (tons /year).

Figure 13: Equations providing a reference to the study (Kržanović et al, 2015, p 51)

From the mathematical function shown in Figure 13, economical parameters (i.e., Life of Mine, discount rate, mining capacity, milling capacity etc.) are

required to calculate the NPV annually. The following steps used to maximise the NPV were:

1. Geostatistical modelling: A block model using the Gemcom Gems software was created to determine the grade of each block model. Figure 14 shows the 15m x 15m x 15m size block model that was created. The ore in the block model was classified into ore with copper oxide grade that is greater than 10 per cent and ore with copper oxide grade that is less or equal to 10 per cent (Kržanović et al, 2015, p 51).

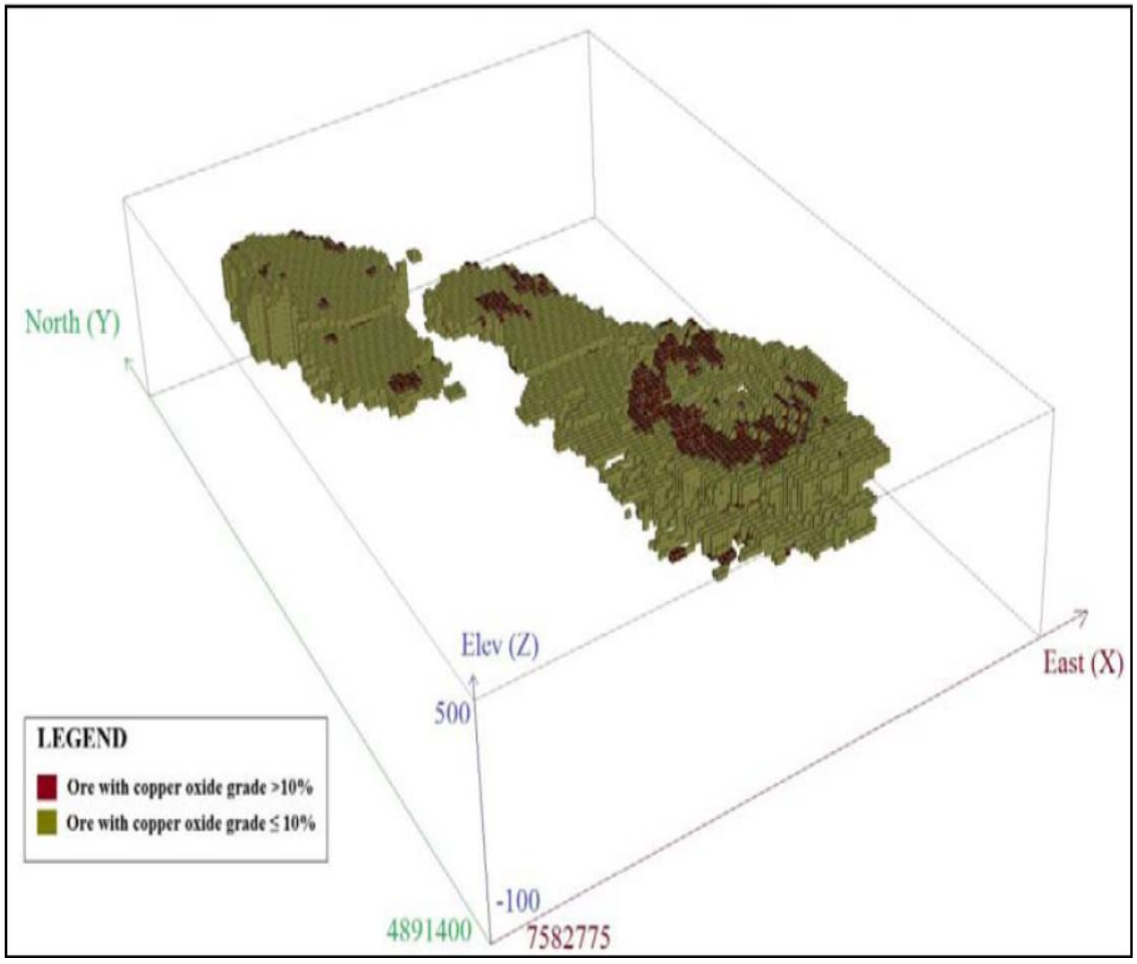


Figure 14: Block model created by Gemcom Gems software for Cementacija (Kržanović et al, 2015)

A grade-tonnage curve was created from the block model to get the grade distribution, see Figure 15.

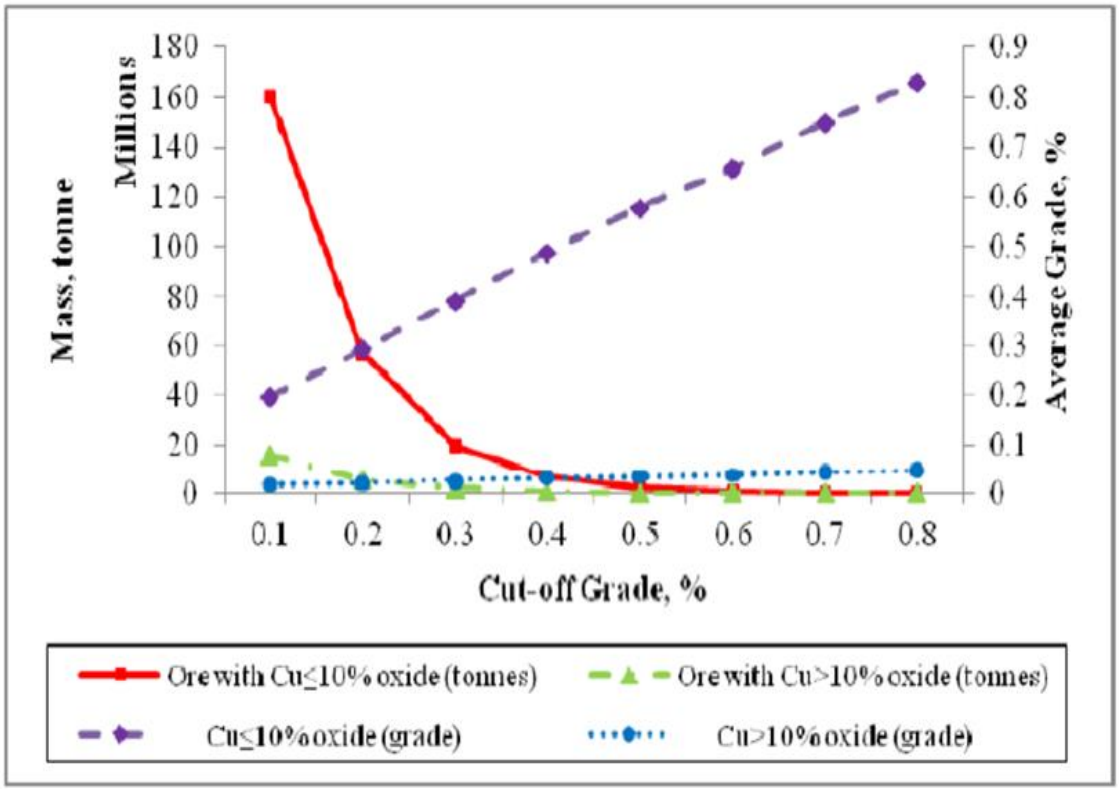


Figure 15: Grade-tonnage curve for Cementacija deposit (Kržanović et al, 2015)

2. Long-term planning and optimisation of an open pit: Whittle software was used to obtain pit optimisation (i.e. final optimum pit limit) and for NPV analysis. The whittle optimisation was done for two scenarios. Scenario A was with copper oxide grade that is greater than 10 per cent and Scenario B with copper oxide grade of less and equal to 10 per cent. Table 4 shows the economic parameters that were used for the pit optimisation and the NPV analysis(Kržanović et al, 2015, p 51).

Table 4: Economic parameters used for the open pit optimisation(Kržanović et al, 2015)

Parameter	Unit	Scenario A	Scenario B
Mining capacity	t/god	15,000,000	15,000,000
Processing or milling capacity	t/god	5,500,000	5,500,000
Copper selling price	$/t	5,000	5,000
Gold selling price	$/kg	35,000	35,000
Silver selling price	$/kg	500	500
Mining cost	$/t	1,5	1,5
Processing or milling cost	$/t	6,0	6,0
Copper refining cost	$/t	450	450
Gold refining cost	$/kg	150	150
Silver refining cost	$/kg	15	15
Copper recovery (processing and refining)	%	0,529	0,784
Gold recovery (processing and refining)	%	0,504	0,504
Silver recovery (processing and refining)	%	0,396	0,396
Discount rate	%	10	10

3. Cut-off grade optimisation: The mathematical function parameters shown in Figure 13 were then used in Whittle in order to obtain cut-off grades that maximise the NPV. Asad et al (2016) also agree that economic parameters such as the metal selling price, costs (mining, processing, fixed) and the discount rate are important in cut-off grade optimisation. Scenario C was obtained as a result of the cut-off grade optimisation. Scenario C is for copper with copper oxide grade of less or equal to 10 per cent. LOM discounted cash flows were obtained for scenario A, B and C, see Table 5. Scenario C was for an optimised cut-off grade. (Kržanović et al, 2015)

Table 5: Cashflow results for Scenario A, B and C (Krzanovic et al, 2015)

Period [year]	SCENARIO A		SCENARIO B		SCENARIO C	
	Copper to process [%]	Open pit cashflow [$ disc]	Copper to process [%]	Open pit cashflow [$ disc]	Copper to process [%]	Open pit cashflow [$ disc]
1	0.278	-6,857,551	0.243	-13,302,615	0.243	-13,302,615
2	0.372	20,912,870	0.321	17,844,472	0.346	19,553,816
3	0.300	11,640,120	0.332	22,861,295	0.350	24,663,926
4	0.314	13,708,915	0.274	14,421,012	0.279	13,712,179
5	0.311	15,488,022	0.265	11,499,553	0.304	15,650,136
6	0.279	11,387,060	0.286	14,386,357	0.314	18,406,110
7	0.244	6,880,224	0.303	15,752,074	0.296	16,335,742
8	0.237	5,047,815	0.273	9,727,949	0.256	11,683,298
9	0.253	6,828,434	0.245	6,860,688	0.237	8,154,479
10	0.262	6,560,273	0.225	4,877,313	0.229	5,770,656
11	0.241	6,339,081	0.219	4,866,233	0.241	6,017,591
12	0.261	4,764,820	0.234	5,038,979	0.250	7,390,766
13			0.248	6,328,040	0.237	6,592,143
14			0.231	5,335,653	0.226	416,720
15			0.274	1,647,656		
Total	0.280	102,700,083	0.265	128,144,659	0.307	141,044,947

The results indicate that scenario C resulted in a high NPV. It was concluded that cut-off grade optimisation should be adopted in the long-term planning process for Cementacija.

2.10. Block modelling

A block model is a representation of orebody characteristics, see Figure 16. A single cube will have sizes (x, y and z) and be allocated with grades, volumes, rock types, densities and many more attributes assigned to it depending on what information is required (Darling, 2011). Block models are created because they describe the orebody in a 3D representation, they allow for resource estimations, they are used for mine designs, geotechnical analysis, planning processes and many other purposes. To create a 3D block model, borehole data is usually the first information that is required which is obtained through

exploration drilling (School of Mining Engineering, 2018b). The block model should be large enough to cover the drilling database (Bele, 2018). The block model size is selected when the block model is initially created (Darling, 2011). The block model dimensions should represent the minimum block that could be selectively mined (Birch, 2018).

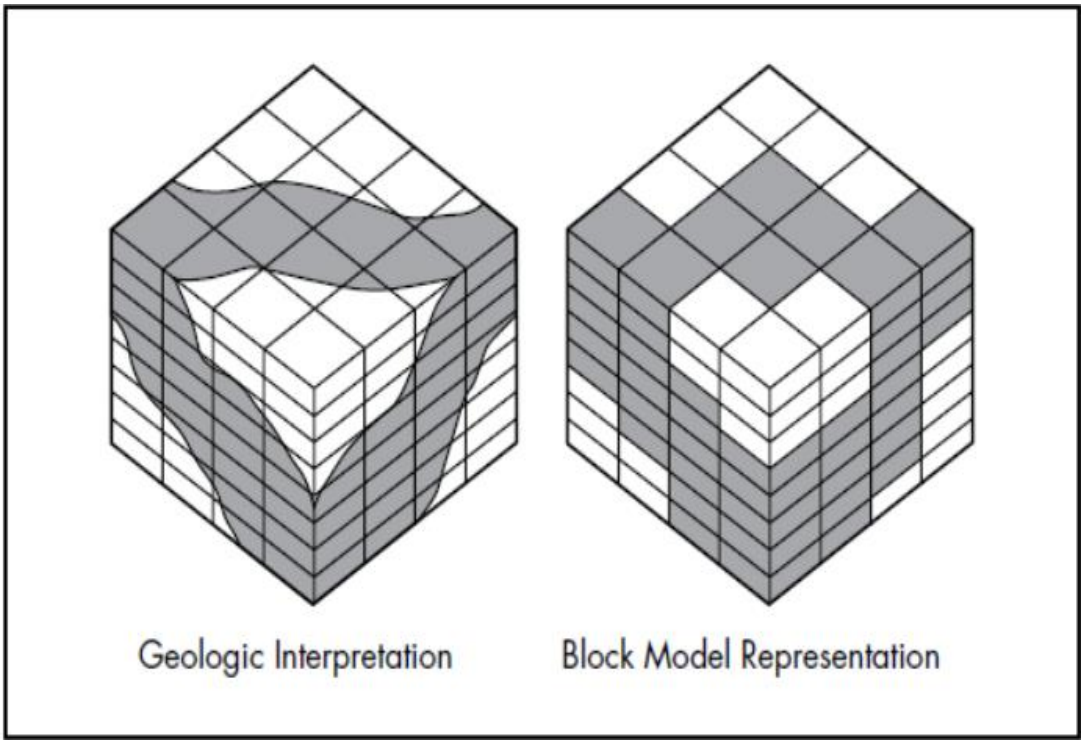


Figure 16: Geological feature represented as a block model (Darling, 2011)

Darling (2011) indicates that there are rules that are used to determine the block model size. The rules are as follows:

- The block model size should consider disk storage and the amount of time to process and compute results;
- The drill hole spacing should be taken into account because the block size should be one-half to one-fourth of the spacing. There would not be a need to modify smaller block models sizes;

- The block size determination should be as a result of the mining method as well as the geology. The bench height in open-pit mining is normally the same as the block height; and
- Depending on the geology, the same block model can be of different sizes because most of the software allows it.

The orebody characteristics, the size of the orebody and the type of ore are some of the factors that should be considered when choosing block sizes (Bele, 2018). WSP (2015) mention that the factors that determine the block size are computing time, the smallest mining unit, the block size should be one-half of the sample spacing, the block size is not necessary to be smaller than the sample interval of the data and that small block sizes do not necessarily increase the accuracy. When the block size is created, the individual block grades are estimated using methods such as kriging (Chanderman, 2015).

2.11. Mining selectivity

Couble et al. (2006) define mining selectivity as the process of separating ore from the waste. Open pit mining has been mostly considered bulk mining with less selectivity. However, there are technological advances that are making selective mining feasible by reducing the selective mining unit. Selective mining unit (SMU) is the smallest volume of material that an excavator can mine with less dilution. Selective mining purpose is to reduce dilution, reduce ore loss and create a constant feed to the plant. A common SMU size is 2.5m, however, a 1m size is also possible depending on the SMU of an excavator and the geometry of the orebody. The bigger the excavator, the larger the SMU which will result in an increased dilution and ore loss (Darling, 2011).

Mine designs and production schedules are created based on a block model. Decisions on the grades, rock density, selectivity and dilutions are based on the block model, therefore, it is an important part of determining the economic value of mining operations. Block model size is an important parameter as this

affects the decision of whether selective mining can be achieved and also the dilution. Dilution and selectivity have a direct impact on mining costs (Couble et al., 2006).

Couble et al (2006) further indicate that there are four effects that affect mining selectivity that can result in the degradation of operational results.

- Support effect: The support effect is about the amount of information in the block model. The block model has more volume detail than that of the drill hole cores. The grade distribution and selectivity index are based on the volume. The support effect, in this case, is the block model which represents the Mineral Resource/Reserve. The amount of ore above the cut-off grade is based on the support effect. Selectivity is based on the high grades, meaning that high grades are given priority;
- Information effect: The information effect is when high-grade ore is underestimated and then sent to the dump and low-grade ore overestimated and then sent to the processing plant during grade control due to lack of information;
- Geometrical constraints: In the open pit environment, the geometrical constraints include the bench angle, berm width and overall slope angle. The geometrical constraints are one of the South African Mineral Resource Comimittee (SAMREC) Codes modifying factors that are used to convert from resource to reserves. There are cases where high graded ore blocks are not mined due to high costs of reaching that block, thus, the block is not free for selection; and
- Dilution: Dilution is the waste that is not separated from the ore and is subsequently sent to for further processing. Dilution decreases the grade and increases the tonnage. The amount of dilution depends on the type of equipment used to move the material, the blast designs and ore/waste contact.

Selectivity also affects the grade-tonnage curves. A grade-tonnage curve produced from a block model will be affected by the block size and grade parameters that are chosen, that is, selectivity depends on the block size. Grade-tonnage curves created from mining blocks may have different selectivity and shape. This means that they can be different grade-tonnage curves at different levels of selectivity for the same orebody. Selectivity results in less dilution and improved grade (Darling, 2011).

2.12. Theoretical exercise on block model sizes

Geological block models and mining block models are key elements in the mine planning process as they form the basis of grade-tonnage curves and financial models. Data spacing guides the dimensions of blocks. Block models are created at certain sizes which are guided by mainly the mining method and how much selective mining can be done to reduce the dilution (Birch, 2018).

According to Birch (2018), in narrow tabular gold mines, grade-tonnage curves are created based on the geological block models and then further taken to the financial models. *"The blocks are however smaller than the smallest block that can be selectively mined*" (Birch, 2018, p1). The effect of the sizes of the block models is not clear.

Birch (2018) completed a study focusing on the effect of different block model sizes on the financial model. In his study, Figure 18 which shows the Leapfrog Software and Figure 17 which shows EXCEL were used to create different block model sizes and then grade-tonnage curves were created using an assumed break-even cut-off grade of 10g/t at different block model sizes using a hypothetical orebody. The grade-tonnage curves were then used to determine the average grade and the tonnages above the cut-off grade.

	1	2	3	4	5	6	7	8	9	10
1	1.51	23.69	9.11	5.85	10.42	8.44	12.94	12.98	8.92	17.97
2	9.55	8.56	8.68	5.52	11.39	7.09	13.19	10.76	3.31	13.09
3	13.05	2.73	4.59	6.49	9.02	4.65	5.87	4.71	16.51	4.00
4	3.93	2.40	12.69	4.27	7.28	2.79	5.17	9.04	5.46	2.02
5	7.55	6.75	2.55	2.49	3.21	5.53	3.77	10.24	7.29	7.04
6	5.56	9.11	10.99	20.78	3.60	1.84	1.62	5.27	7.97	21.17
7	5.44	1.84	4.59	12.06	3.77	5.88	4.30	6.22	3.91	14.04
8	7.14	19.63	10.11	24.33	4.42	3.81	10.19	3.33	3.85	13.30
9	6.77	4.12	6.35	4.70	7.38	5.60	5.93	12.94	26.19	9.18
10	9.04	2.85	2.39	5.26	5.19	2.83	12.75	7.02	6.17	7.33

Figure 17: EXCEL Grade Model (8g/t) 10mx10m Grid (Birch, 2018)

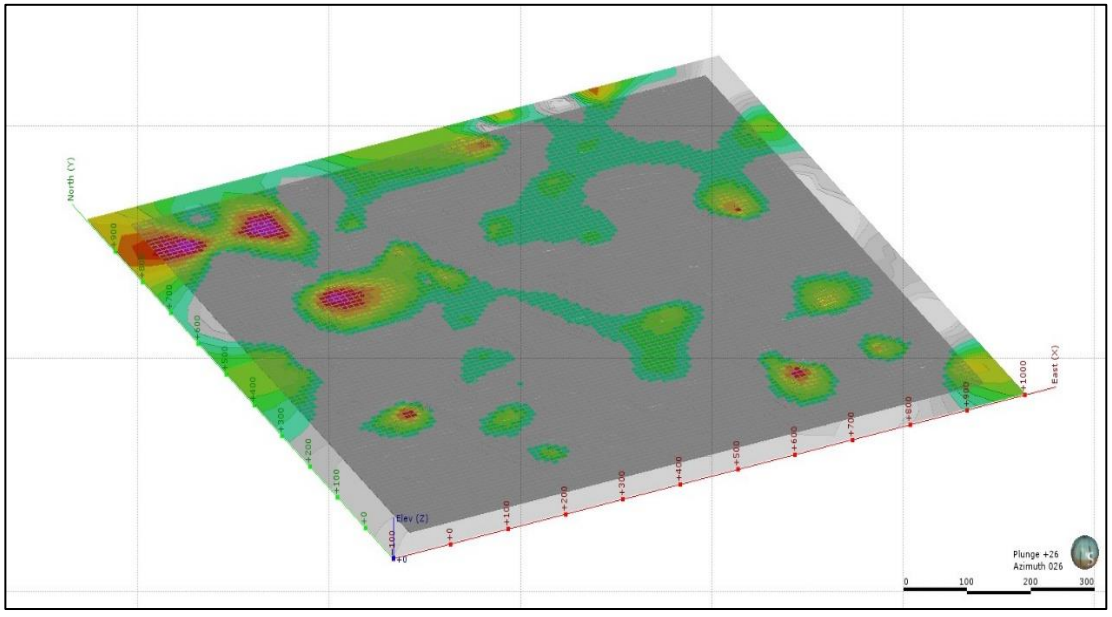


Figure 18: Leapfrog 8g/t Grade Model 10mx10m Grid (Birch, 2018)

Figure 17 and Figure 18 show a 10m x 10m Grid EXCEL and Leapfrog Grade Model that was used in the study, from the hypothetical orebody, different block model size options and grade-tonnage curves, financial models were created to analyse how much of an effect do block model sizes have on the NPV and how similar must the block model sizes be when compared to the smallest SMU (Birch, 2018).

The results obtained showed that the average grade and tonnages above cut-off grade are high at 14.88 g/t and 735 000 tonnes for a 10m x 10m block size, see Figure 19. The 20m x 20m block sizes resulted in an average grade of 11.78g/t and 571 000 tonnes, see Figure 20 (Birch, 2018).

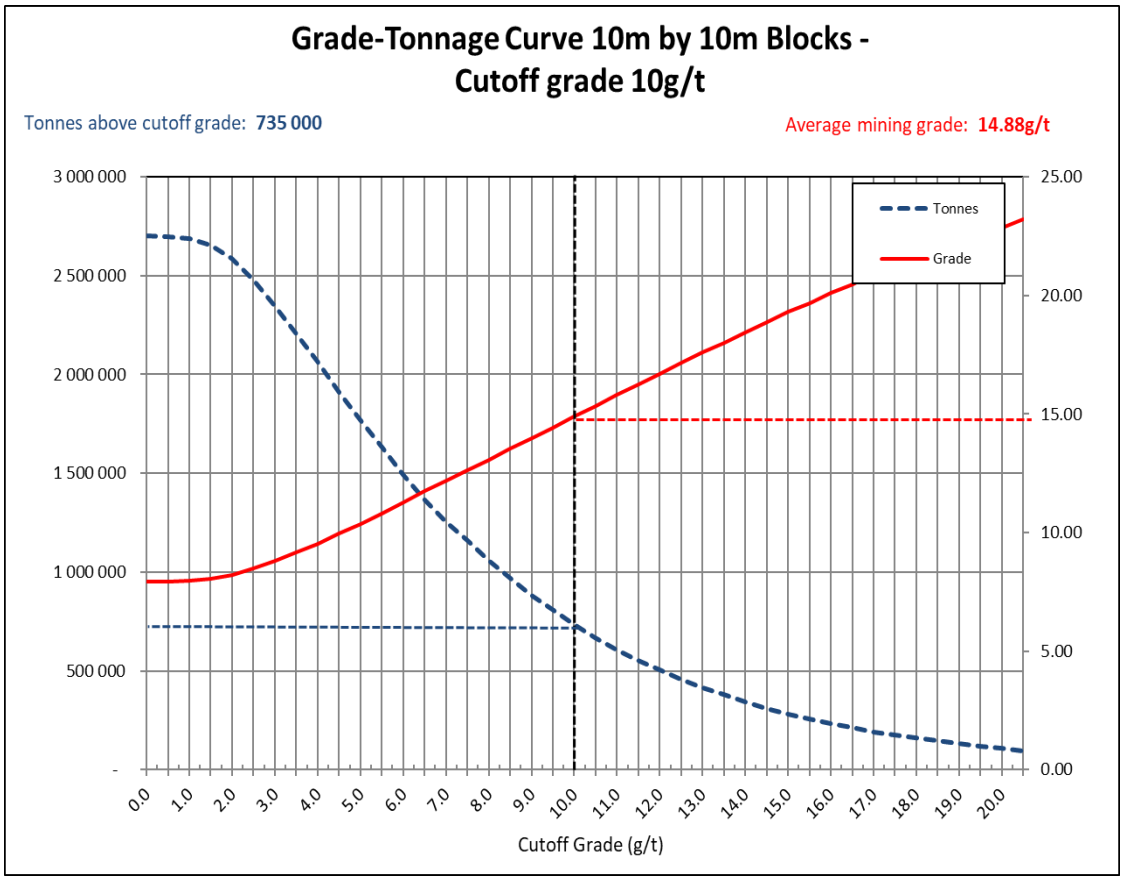


Figure 19: The 10m x 10m grade-tonnage curve (Birch, 2018)

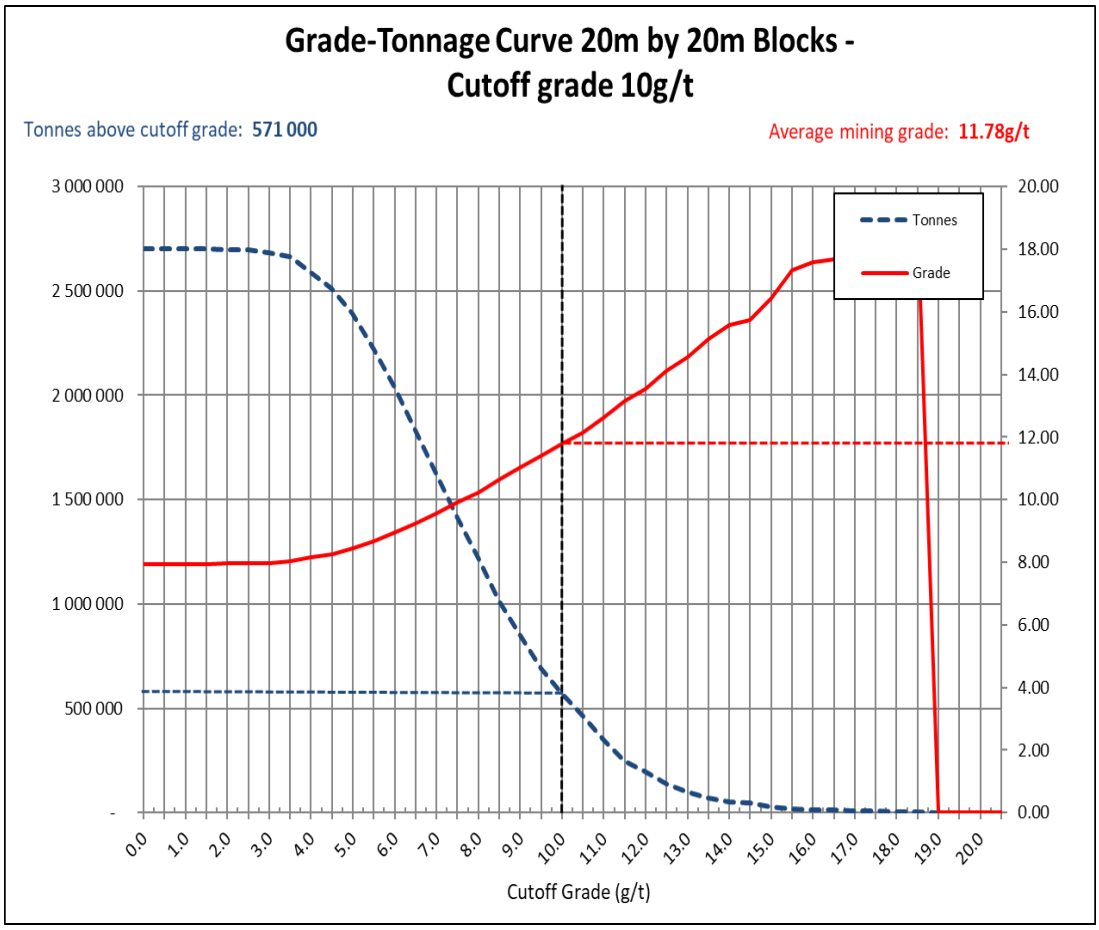


Figure 20: The 20m x 20m grade-tonnage curve (Birch, 2018)

Birch (2018) further did an analysis of profit and the NPV on the different block sizes with a scenario not considering the cost of selective mining and another scenario considering the cost of selective mining. The results showed that the smaller block sizes result in high profit and NPV, see Figure 21 when the cost of selectivity is not considered.

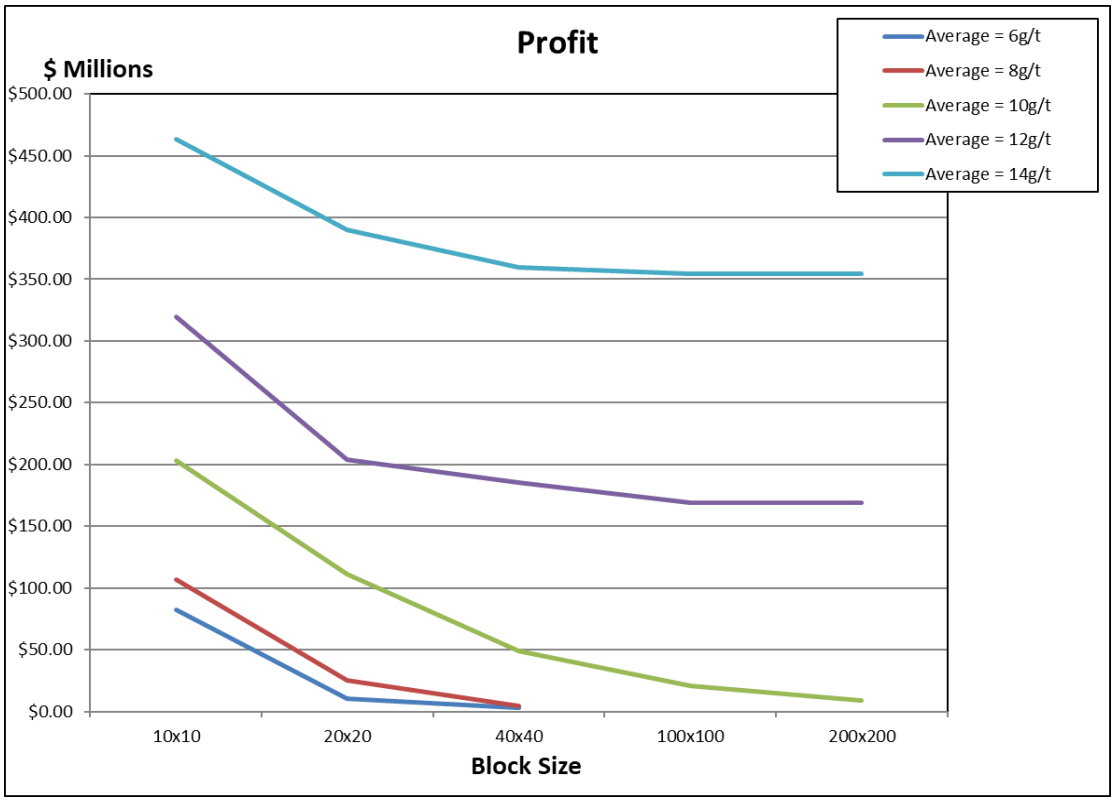


Figure 21: Profit of different block sizes not considering the cost of selective mining (Birch, 2018)

Selectivity was then taken into consideration by reducing the mining rate. In this case, the larger block sizes resulted in a higher profit and NPV, see Figure 22. This shows that it is not economical to mine small block sizes due to the cost of selectivity.

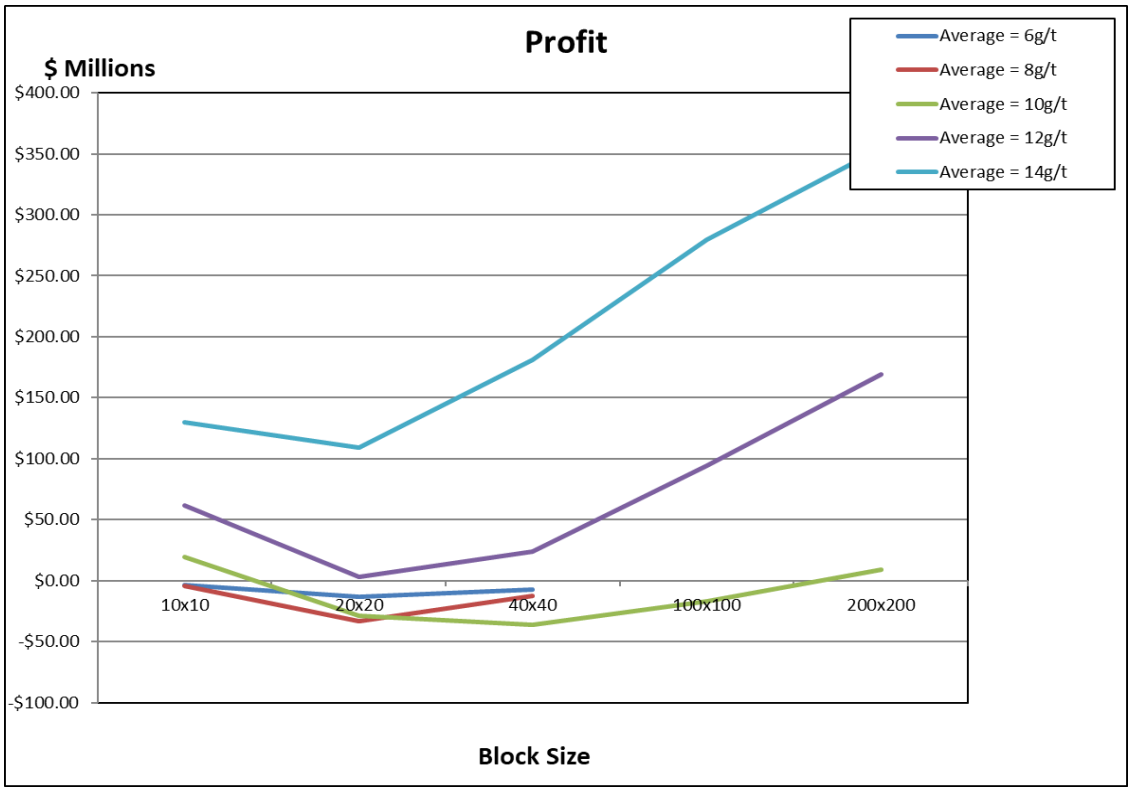


Figure 22: Profit of different block sizes considering the cost of selective mining (Birch, 2018).

A key finding for this study was the aspects of the average grade of the orebody. When the average grade is higher than the cut-off grade, then larger block sizes are optimum. When the average grade is below the cut-off grade, then small blocks give an optimum profit and NPV. The study concluded that mining small block model sizes are optimum if the cost of selective mining is not taken into account. If selective mining costs are taken into account, larger block model sizes are optimum(Birch, 2018) .

2.13. Block size selection and the impact of block sizes in mine planning

Couble et al (2006) performed an analysis of the impact of block selection on open-pit design and mine planning on a copper orebody. The first results were based on a block model that was used to create the ultimate pit before the start

of the production scheduling process. The results did not include the cost that can be incurred from mining a certain block size, that is, the cost of selective mining was not taken into account.

Selectivity curves were used to describe the relationship between tonnage and cut-off grade and the relationship between metal and tonnage. The selectivity curves where created based on three different SMU's. The base block size was 2.5m x 2.5m x 2m. This was then re-blocked into 5m x 5m x 4m and 10m x10m x 8m block model sizes.Table 6 shows the different block sizes that were used for the study.

Table 6: Selective Mining units analysed (Couble et al, 2006)

Block size (m)	Multiplying factor			Objective
	Easting	Northing	Elevation	
2.5 x 2.5 x 2	1	1	1	Reference case
5 x 5 x 4	2	2	2	Estimating the impact of block size along three directions
10 x 10 x 8	4	4	4	Estimating the impact of block size along three directions

From the analysis, it was found that re-blocking from a 2.5m x 2.5m x 2m block model to 5m x 5m x 4m block model results in a greater reduction in selectivity, that is, there is a loss of metal content. The re-blocking from 5m x 5m x 4m to 10m x 10m x 8m, however, resulted in almost no loss of metal content. Figure 23 further proves the results of the re-blocking.

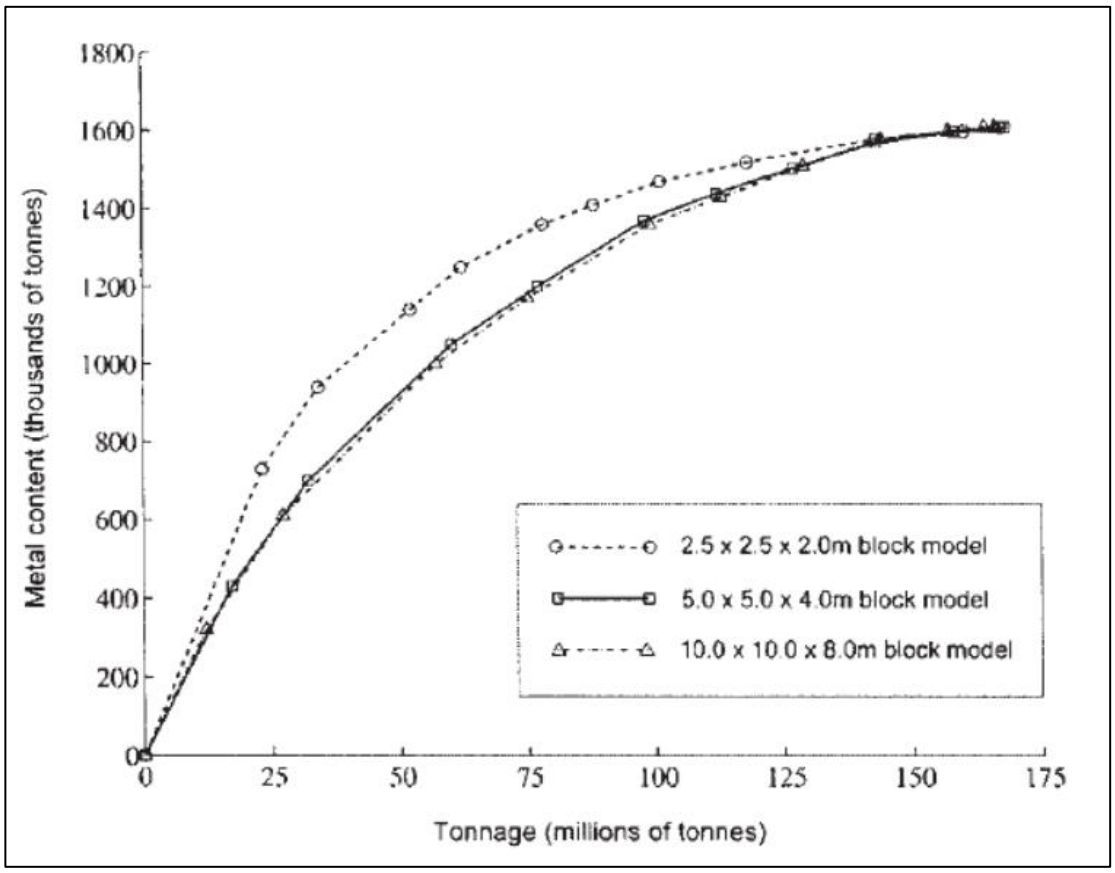


Figure 23: Selectivity curves (metal vs tonnage) based on the different block sizes (Couble et al, 2006)

Couble et al (2006) discovered that as the block model sizes increases, the tonnages increase with a decrease in the average grade. The NPV decreases with an increase in the block model sizes.

The second results were done based on the production schedule. These results also did not consider the cost of selective mining. The production sequence was aimed at optimising the NPV based on the production and economic parameters. For the production schedule, a marginal cut-off grade was used. Discounted cash flows were then created using the SMU sizes of 5m x 5m x 4m and 10m x 10m x 8m to obtain the NPV. Table 7 shows the NPV and the tonnages obtained over a period of 9 years.

Table 7: Comparison of metal content and NPV for two different block model size options (5 x 5 x 4m and 10 x 10 x 8m) (Couble et al, 2006)

Period	SMU size: 5.0 x 5.0 x 4.0 m				SMU size: 10.0 x 10.0 x 8.0 m			
	Metal [kton]		NPV [kUS$]		Metal [kton]		NPV [kUS$]	
	Incremental	Cumulated	Incremental	Cumulated	Incremental	Cumulated	Incremental	Cumulated
1	68	68	39 810	39 810	59	59	30 851	30 851
2	177	245	108 414	148 224	168	227	102 489	133 340
3	165	410	76 964	225 188	167	395	84 340	217 680
4	144	554	48 567	273 755	131	526	37 324	255 004
5	148	702	36 716	310 471	137	663	30 578	285 582
6	139	840	33 009	343 480	135	798	29 200	314 782
7	143	983	38 164	381 644	134	932	32 633	347 415
8	125	1 108	33 849	415 493	130	1 062	33 868	381 283
9	51	1 159	16 678	432 171	63	1 125	19 612	400 895
Total	1 159	1 159	432 171	432 171	1 125	1 125	400 895	400 895

From Table 7 it was found that the metal content and the NPV increases with time until period 6 and after period 6, there was not a significant change. This is because the high-grade ore was given priority, that is, high-grade ore is mined out first. The metal content and the NPV is high in the 5m x 5m x 4m block model than in the 10m x 10m x 8m block model.

Couble et al (2006) further did more analysis that included the cost incurred due to mining a certain block size, meaning that the cost of selective mining was taken into account, mainly the cost of equipment required to extract ore using the different SMU's (5m x 5m x 4m and 10m x 10m x 8m). It was found that the block model size of 5m x 5m x 4m was 14% more expensive to mine than the 10m x 10m x 8m. Therefore, it was concluded that the 10m x 10m x 8 m were more profitable to mine when considering the costs of selective mining.

Chapter 3: Methodology

3.1. Chapter 3 overview

Chapter 3 describes how the block model was created. The re-blocking to different block model sizes and the creation of the grade-tonnage curves and DCF.

3.2. Creation of the block model

A reserve block model of an iron ore deposit was used for this research report. The iron ore deposit was suitable for this study due to its defind block model attributes and the information that was required to do the study was fairly easily accessable.

The initial stages of creating the geological block model are through percussion drilling. The percussion drilling is used to pilot holes through the waste until the iron ore is intersected. A 200m x 200m grid is used in the next stage which is diamond drilling. The 200m x 200m grid is not sufficient to provide detailed geological information, therefore, in-fill drilling of 100m x 100m grid is done. To increase the confidence of the information, the grid is further decreased to 50m x 50m and 25m x 25m depending on the complexity of the orebody. For this iron ore deposit, a 50m x 50m grid was used. The core samples are then sampled for Iron (Fe),Potassium oxide(K_2O),Sodium oxide (Na_2O),Silica (SiO_2), Alumina (Al_2O_3), Phosphorous (P), Sulfur (S), Calcium oxide (CaO), Mangnesium oxide (MgO), Manganese (Mn) and Barium oxide (BaO) using a 0.5m spacing. The borehole data is then exported to Datamine Fusion (African Rainbow Minerals, 2017).

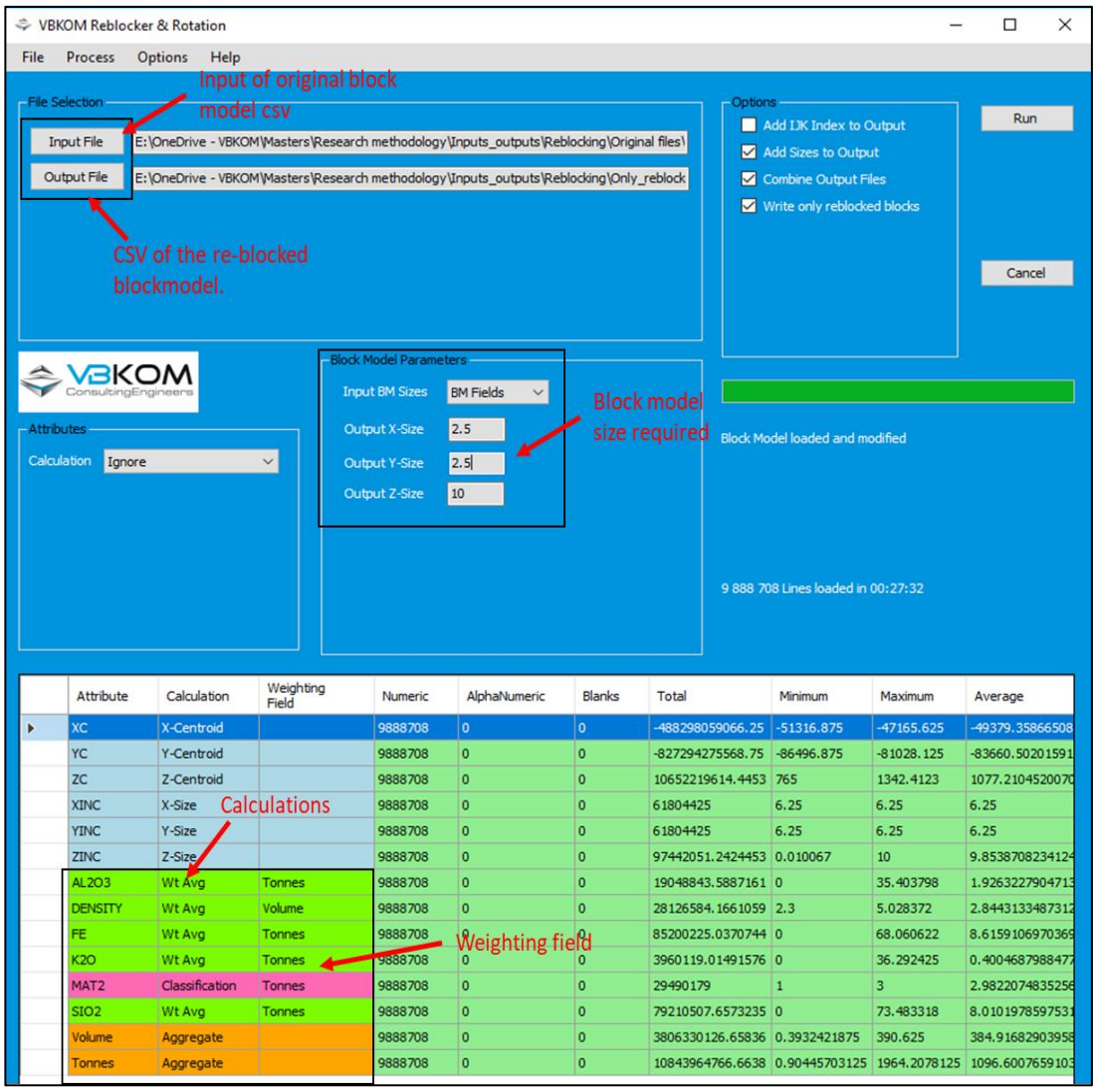
Datamine's Strat3D is further used to create the 3D representation of the stratigraphy using the borehole data. The modelling of the stratigraphy is done

from the surface geology to the stratigraphic unit below the lowest mineralised zone. Solid wireframes are created for cut-off grades above 53% Fe. The lower-grade samples are modelled separately and they are interpreted as internal waste. The waste model and the ore model are then combined to create a geological model. Estimation of grades for individual block sizes of 25m x 25m x 10m is done through ordinary kriging interpolation. The geological model is then re-blocked to 6.25m x 6.25m x 10m for further use (African Rainbow Minerals, 2017). The iron 50m x 50m grid spacing is sufficient to justify the estimation of individual grades of block sizes of 25m x 25m x 10m since it is one-half of the borehole spacing.

3.3. Re-blocking

The Datamine block model was used in Geovia Surpac in order to export the comma-separated values (CSV) in order to allow for re-blocking. The re-blocking process was done using the base block model of size 6.25m x 6.25m x10m. The base block model was re-blocked into different sizes to analyse the effects of the change in the block sizes specifically on the tonnes, average grade and ultimately the effect on the NPV.

The base block-model was re-blocked into sizes: 12.5m x 12.5m x 10m; 25m x 25m x 10m and 50m x 50m x10m.The re-blocking was done through a re-blocking tool that was created by VBKOM. The tool is able to up-block and also down-block the block model sizes. Figure 24 below shows the interface of the “VBKOM Reblocker”.



Attribute	Calculation	Weighting Field	Numeric	AlphaNumeric	Blanks	Total	Minimum	Maximum	Average
XC	X-Centroid		9888708	0	0	-488298059066.25	-51316.875	-47165.625	-49379.35866508
YC	Y-Centroid		9888708	0	0	-827294275568.75	-86496.875	-81028.125	-83660.50201591
ZC	Z-Centroid		9888708	0	0	10652219614.4453	765	1342.4123	1077.2104520070
XINC	X-Size		9888708	0	0	61804425	6.25	6.25	6.25
YINC	Y-Size		9888708	0	0	61804425	6.25	6.25	6.25
ZINC	Z-Size		9888708	0	0	97442051.2424453	0.010067	10	9.8538708234124
AL2O3	Wt Avg	Tonnes	9888708	0	0	19048843.5887161	0	35.403798	1.9263227904713
DENSITY	Wt Avg	Volume	9888708	0	0	28126584.1661059	2.3	5.028372	2.8443133487312
FE	Wt Avg	Tonnes	9888708	0	0	85200225.0370744	0	68.060622	8.6159106970369
K2O	Wt Avg	Tonnes	9888708	0	0	3960119.01491576	0	36.292425	0.4004687988477
MAT2	Classification	Tonnes	9888708	0	0	29490179	1	3	2.9822074835256
SIO2	Wt Avg	Tonnes	9888708	0	0	79210507.6573235	0	73.483318	8.0101978597531
Volume	Aggregate		9888708	0	0	3806330126.65836	0.3932421875	390.625	384.91682903958
Tonnes	Aggregate		9888708	0	0	10843964766.6638	0.90445703125	1964.2078125	1096.6007659103

Figure 24: VBKOMs reblocking tool (VBKOM, 2017b)

The re-blocker uses calculations and weighting fields in order to re-block the block model. The calculations used to re-block were the Weighted average (Wt Avg), classification and aggregate. The Wt Avg is used for grades and density. The aggregate was used for the calculation of the volume and tonnes. The classification was used to separate the ON, OFF and waste per block. If in a block there is ON grade and OFF grade, and the OFF grade has more tonnes than the ON grade, that specific block will be classified as OFF grade. The tool allows the user to input the block model sizes that the user wants to re-block to. The output of the re-blocker is a CSV of the re-blocked block model.

The re-blocked CSV's were imported to Geovia Surpac to create re-blocked block models. Figure 25 shows one of the re-blocked block models.

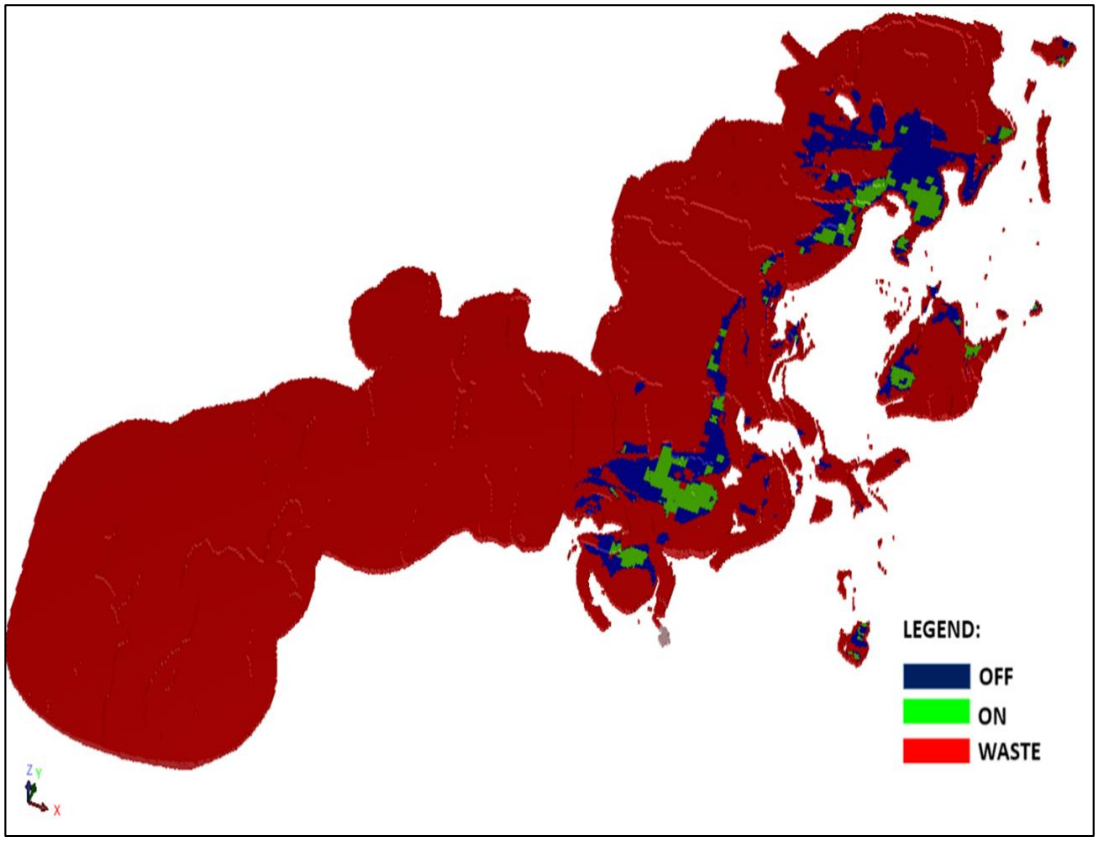


Figure 25: Reblocked block model constrained within the optimised pit and below end 2017 survey

The re-blocked block models were constrained within the optimised LOM pit and December 2017 survey because the cash flow was based on the inputs of the end of 2017 and the beginning of 2018. The constrained re-blocked block models were then exported to CSV in order to create grade-tonnage curves.

3.4. Grade-tonnage curves and DCF

The grade-tonnage curves were created with a "VBKOM graph tool" created by VBKOM. Grade-tonnage curves were created for each block model size including the base 6.25m x 6.25m x 10m block model. The grade-tonnage

curves were used to calculate the tonnes and average grades above the cut-off grade. Cut-off grades that were used for the scenarios were 53%, 60%,63% and 64% because they covered all the grades that are classified as for whether ON grade and OFF grade in the deposit as discussed in the research background (section 1.7). These grades where also chosen because the 53% Fe falls within the geological cut-off grade as mentioned in section 2.5. The 53% Fe grade is defined in the geological block model as the insitu cut-off grade for OFF grade ore. The 60%,63% where chosen because they fall within the optimum cut-off grade as mentioned in section 2.5. The 60% is the cut-off grade for the OFF grade according to the metallurgists and geologists which will produce the optimum value. These grades were also chosen as they would be able to give information that would be able to be compared. The need to calculate the cut-off grade was eliminated. The cut-off grades were applied in all the block model sizes.

3.5. Creation of the DCF and selective mining assumptions

The obtained tonnes and the average grade above cut-off grade were used to create the DCF in excel to obtain the NPV. The DCF was done for 10 years (2018 to 2027) because the 10 years was sufficient to produce results that can be comparable and analysed in detail. The DCF sheets were created by using examples from notes from the School of Mining Engineering (2017a).The production tonnes used where from An existing 10year production schedule that was done at the end of 2017.

The DCF was done using the input parameters that follow which are also shown in Table 8 :

- Tonnes produced which are composed of ON and OFF grade ore. The tonnes for each year where taken from an existing 10 year schedule that was done in XPAC.

- The recovery for ON and OFF grade ore were obtained from the mine where the deposit has been mined.The recoveries had been used in the mine's operations.
- Product produced is the ore that is sent to the client after it has gone through processing. The product can be lumpy or fine which is described by the size of the ore. Lumpy is ore with size of between -32mm to +6mm. Fine is ore of size between -6mm to +0.2mm. There is a percentage of lumpy and fine that must be produced from the mined ore. The percentage that was used in the DCF was obtained from the mine where the iron ore deposit is mined.
- The market inputs that were used included the exchange rate,the lumpy price and fines price. These inputs were taken from the mine where the deposit is mined.
- The costs were the actual costs that were used for the pit optimisation process at the mine and were assumed to also be applicable for the DCF.It was assumed that there was no CAPEX since the operation is already in production and the DCF was only done for 10 years.
- The royalties were considered for an unrefined mineral since iron ore is not refined. The royalty rate for an unrefined mineral should not exceed 7% and this was taken into account.The tax rate used was 28% which is the standard tax rate used throughout the mining industry.The discount rate that was used was assumed to be 10% and this was the assumption also for the financial calculations that were done at the mine.

Table 8: Parameters that were used to create the DCF

Block model size and cut-off grade	Year Project year	2018 1
Tonnes produced		
ON grade ore	Mt	
OFF grade ore	Mt	
Total ore tonnes	Mt	
Average grade	%	
Recovery		
ON grade ore	%	
OFF grade ore	%	
Product produced		
Lumpy	%	
Fines	%	
ON grade ore	Mt	
OFF grade ore	Mt	
Total product produced	Mt	
Total lumpy produced	Mt	
Total fines produced	Mt	
Market inputs		
Exchange rate	$/t	
Lumpy price	R/t	
Fines price	R/t	
Revenue		
Lumpy	Rm	
Fines	Rm	
Gross sales revenue	Rm	
Costs		
Total fixed costs	Rm	
Unit variable costs:		
Mining costs	R/t	
Total Mining costs	Rm	
Plant costs:		
ON grade ore	R/t	
OFF grade ore	R/t	
ON grade ore	Rm	
OFF grade ore	Rm	
Total plant costs	Rm	
Total costs	Rm	
Net sales revenue (Operating profit) before CAPEX	Rm	
Capital Expenditure (CAPEX)		
Unredeemed CAPEX		
Royalties and taxes		
Royalty (x)		
Royalty rate (0.5+x/9)	%	
Royalty rate must not exceed 7% for unrefined	%	
Royalty to be paid (rate xtotal revenue)	Rm	
Taxable income (Net sales revenue - Royalty)	Rm	
Tax rate	%	
Tax	Rm	
Cashflow (operating profit -royalty to be paid-taxable income)	Rm	
Discount rate	%	10%
Discount factor		
PV @ discount rate	Rm	
NPV @ discount rate	Rm	-

The DCF's were created for two scenarios. Scenario 1 was DCF's not considering the effects of selective mining and scenario 2 was DCF's considering the effects of selective mining. The difference between scenario 1 and scenario 2 was that scenario 2 had a reduced production per year. This was due to the smaller excavator that was required in order to achieve selective mining.

The assumptions was that selective mining will be throughout the 10 years. The operation that this report was based on had started a process of selective mining in conjunction with the normal mining rates. The production rates for a normal shovel was 28 000t/day. The production rate for a selective mining excavator decreased to 15 000 t/day, which is approximately 46% less than the normal production rate. Another assumption was that the production rate was reduced by 46% on the 6.25m x 6.25m x10m and on the 12.5m x 12.5m x 10m, the production rate was reduced by 23% which is half of the 46%. The 25m x 25m x 10m and the 50m x 50m x10m production rates remained the same as the block model size are large and therefore there would not be a requirement to mine selectively.

The reduced production per year was the only change between the two scenarios. The effect of selective mining on the average grade was not considered. The costs assumptions on both scenarios stayed the same. These assumptions were made due to the lack of information on the effects of selective mining on other parameters that make up the DCF's for this iron ore deposit.The selective mining was expected to upgrade OFF grade ore to ON grade ore. In this report, the upgrading of OFF to ON grade ore was not considered as there was no substantial information on selective mining on the operation to have been included in the report.

Chapter 4: Results and analysis of results

4.1. Chapter 4 overview

Chapter 4 explains the input parameters that were used to create the block models and cashflow. It shows the re-blocked block model results, grade-tonnage curves, comparison of cut-off grades, NPV and NPV when considering the costs of selective mining.

4.2. Input parameters

Input parameters are the base values that are used to generate the results that are discussed further in the following sections. The input parameters were obtained from an existing iron ore operation and other values were through the assumptions of the author of this research report.

4.3. Block modelling input parameters

Table 9 explain the input parameters used in the decision of what block model sizes to use in order to get meaningful results.

Table 9: Block sizes with multiplying and dividing factors

Block size	Multiplying factor			Objective
	X	Y	Z	
6.25m x 6.25m x 10m	1	1	1	Base case
12.5m x 12.5m x 10m	2	2	1	Impact of block size along two directions
25m x 25m x 10m	4	4	1	
50m x 50m x 10m	8	8	1	

The impact of the block size was done only along the two directions (x and y) in order to avoid changing the elevation (z) since it was based on the bench height whereby 10m bench height is practical as it was proven through geotechnical study and it is currently the bench height that is being used on the

existing iron ore operation. The multiplying factors used are multiples of two for the two directions.The multiples of two was an assumption made since it will include block models of varying sizes in order to get concrete results. The base block model was multiplied by 2 in the x and y direction to result in the 12.5m x 12.5m x 10m. To get the 25m x 25m x 10m block model size,it was multiplied by 4 in the x and y direction. T

4.4. Cash flow inputs

The input parameters are from an existing operation of an iron ore mine and are values that were used in 2017 and 2018 10 year plans and resource to reserve conversion reports. The cut-off grades used are 53%; 60%; 63% and 64% in order to cover all the ON and OFF grade definitions that were mentioned in the background section. Table 10 shows the input parameters that were used to create the DCF.

Table 10: Input parameters for DCF (ASSMANG, 2018)

Inputs	**Parameters**
Tonnes available(t)	Tonnes above cut-off grade
Annual production (t)	Based on an existing 10 year plan at 53% cut-off grade and also on the selected cut-off grades
Average grade (%)	Average grade above cut-off grade
Recovery (ON grade) (%)	87
Recovery (OFF grade)(%)	72
Lumpy (tonnes produced) (%)	53
Fines (tonnes produced)(%)	47
Exchange rate ($/t)	14

Lumpy price (R/t)	762
Fines price (R/t)	605
Fixed costs (Rm)	524
Discount rate (%)	10
Tax rate (%)	28
Mining (variable cost)(R/t)	30.93
Variable Plant costs	
ON grade ore (R/t)	45
OFF grade ore (R/t)	67

The main thing to note in Table 10 is that the ON and OFF grade ore variable plant costs are different. This means that the ON and OFF grade ore are treated in a different manner in the plant. The ON grade ore is taken through washing and screening then it can be taken to the load-out station while the OFF grade has to go through washing, screening and to the jig plant for further treatment. Therefore, the OFF grade is more expensive to treat than ON grade ore. The annual production for the operation that was in this report was from a 10-year schedule that was done end of 2017 through scheduling software XPAC. The schedule was based on the 53% cut-off grade. However, the 60%,63% and 64% cut-off grades used the same production schedule and in the areas where the tonnes were not enough after applying the higher cut-off grade, it was adjusted in the annual production. Capital expenditure was not included in the cash flow because the assumption was that there is no unredeemed CAPEX since it is an existing operation. The results of the production schedule at 53 % Fe cut-off grade are shown in Figure 26 below.

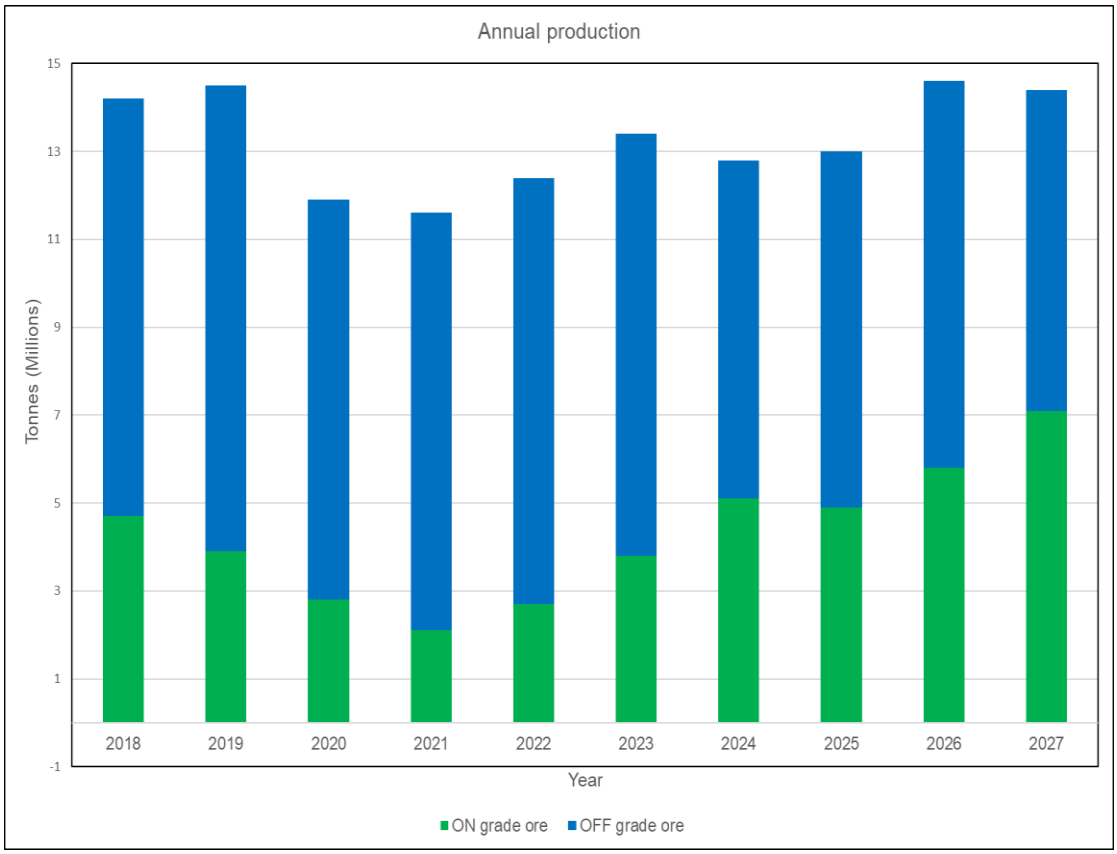


Figure 26: Annual production for the base block model at 53% cut-off grade (VBKOM, 2017c)

4.5. Re-blocked block models results

Block models of varying block model sizes where created using Geovia Surpac. Graphs were created in Excel to identify how much tonnes fall under a specific Fe% grade. Figure 27 and Figure 28 show the block models and the graphs generated from the different block model sizes.

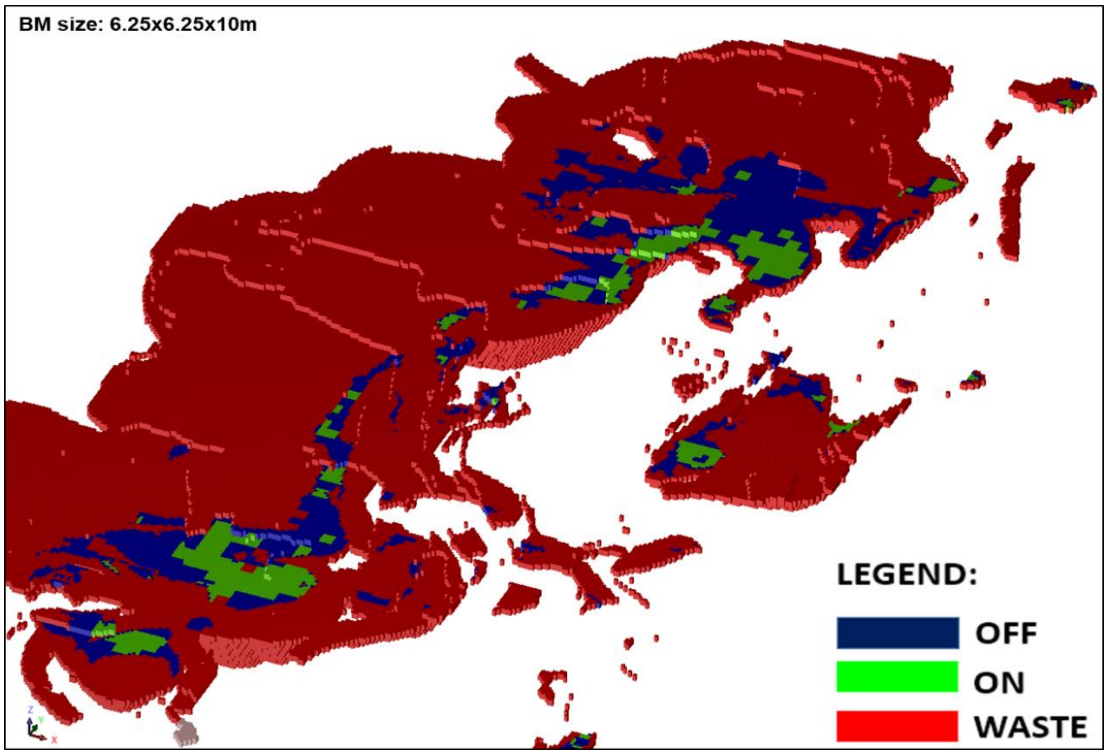


Figure 27: Block model for 6.25m x 6.25m x 10m

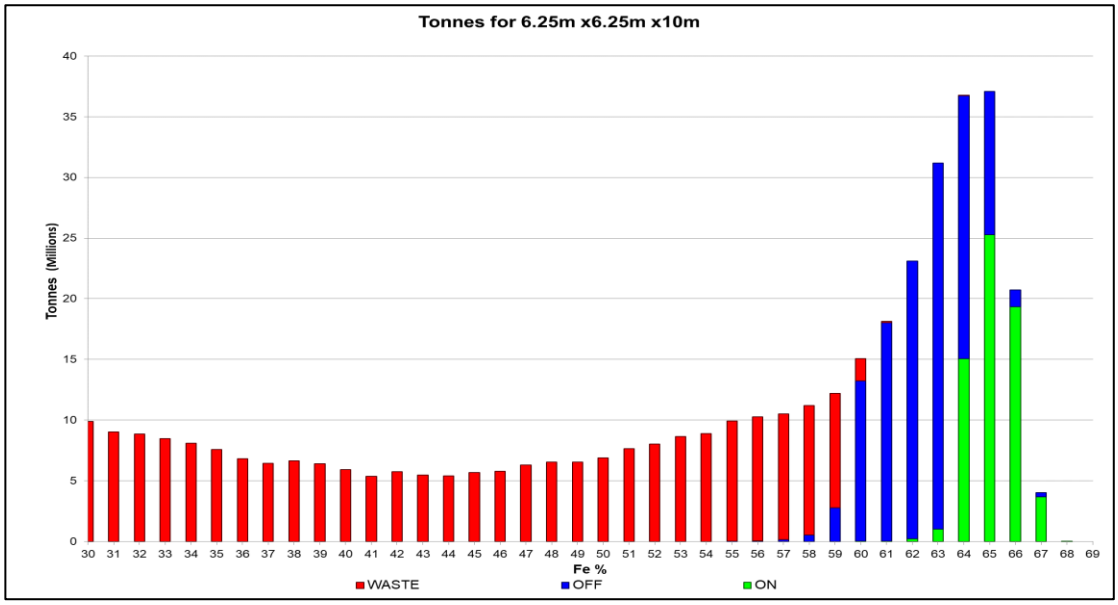


Figure 28: Tonnes for 6.25m x6.25m x10m

Figure 27 indicates the base block model of size 6.25m x 6.25m x 10m. The block model's material is classified as ON grade; OFF grade and Waste. Figure 28 is a chart which separates the ON grade; OFF grade and Waste material according to the Fe% grade and the tonnes that are available in a specific Fe %. Figure 28 indicates that there is no ore material with Fe% from 53% to 56%. It further indicates that there are approximately more than 30 million tonnes of OFF grade with a Fe grade of 63% and ON grade ore of approximately 25 million tonnes at 65% Fe.

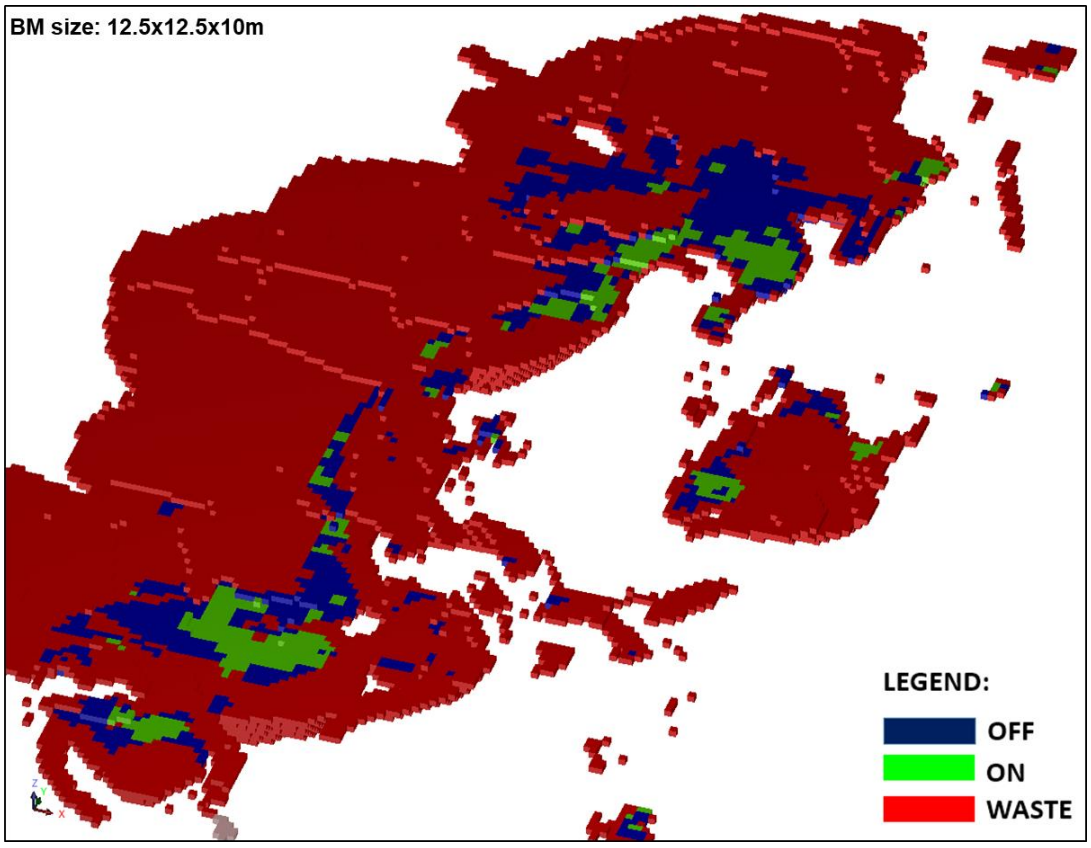


Figure 29: Block model for 12.5m x12.5m x10m

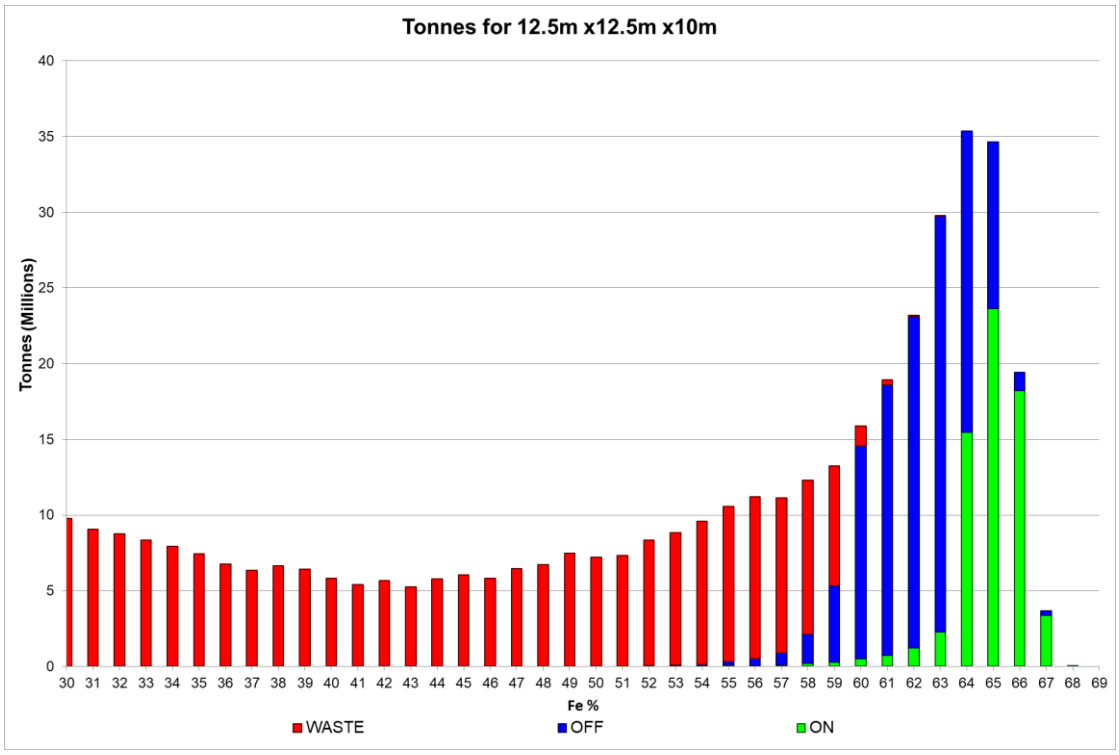


Figure 30: Tonnes for 12.5m x 12.5mx 10m

Figure 29 and Figure 30 indicates that re-blocking the base block model of size 6.25m x 6.25m x 10m to block model size of 12.5m x 12.5m x10m results in the reduction of OFF grade and ON grade ore. It can be seen that after re-blocking, from 53% Fe to 56% Fe, there is OFF grade material that is starting to show, meaning that there was an increase in dilution, therefore a downgrade of the OFF grade Fe%. Figure 30 indicates that there are less than 30 million tonnes of OFF grade with a Fe grade of 63% as compared to the base block model. The ON grade ore of fewer than 25 million tonnes at 65% Fe, which is less than the base block model. When comparing Figure 28 and Figure 30, it can be seen that there is less OFF grade material at 58 % Fe in Figure 28. However, in Figure 30, there is an increase in OFF grade material of 58 % Fe. This further proves that there is an increase in dilution with an increase in block model size.

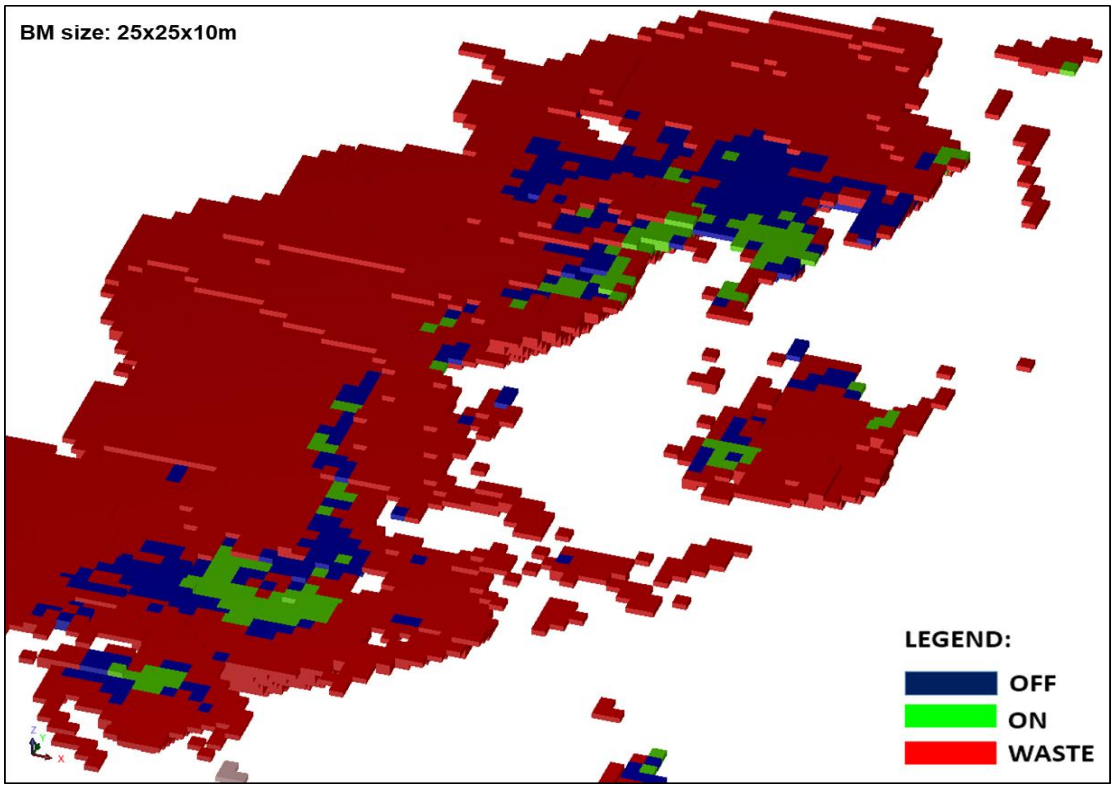


Figure 31: Block model for 25m x 25m x10m

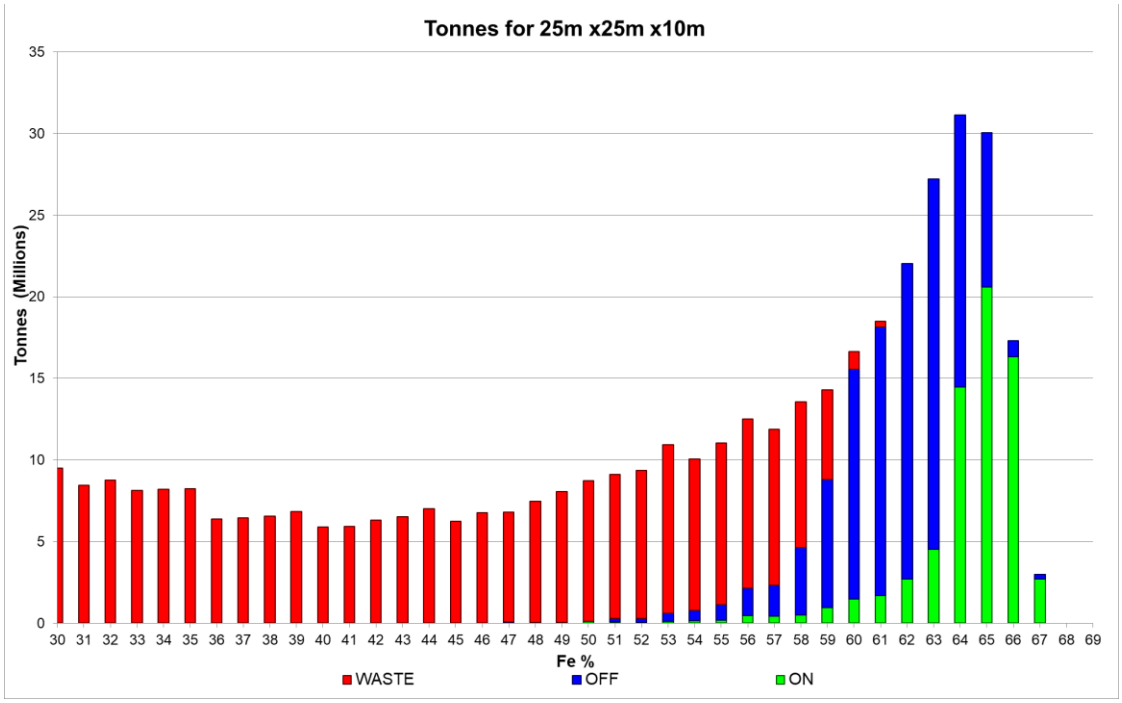


Figure 32: Tonnes for 25m x 25m x10m

The difference in the block model size from the base block model size can be seen clearly graphically when comparing Figure 27 and Figure 31. Figure 27 and Figure 31 explain the difference further through values. In Figure 27, there is no OFF grade ore with Fe of 53%, however, Figure 31, some of the OFF grade has moved to the 53% Fe interval. The ON grade at 65% Fe further decreases, the same as the OFF grade at 63% which further decreases below 30 million tonnes.

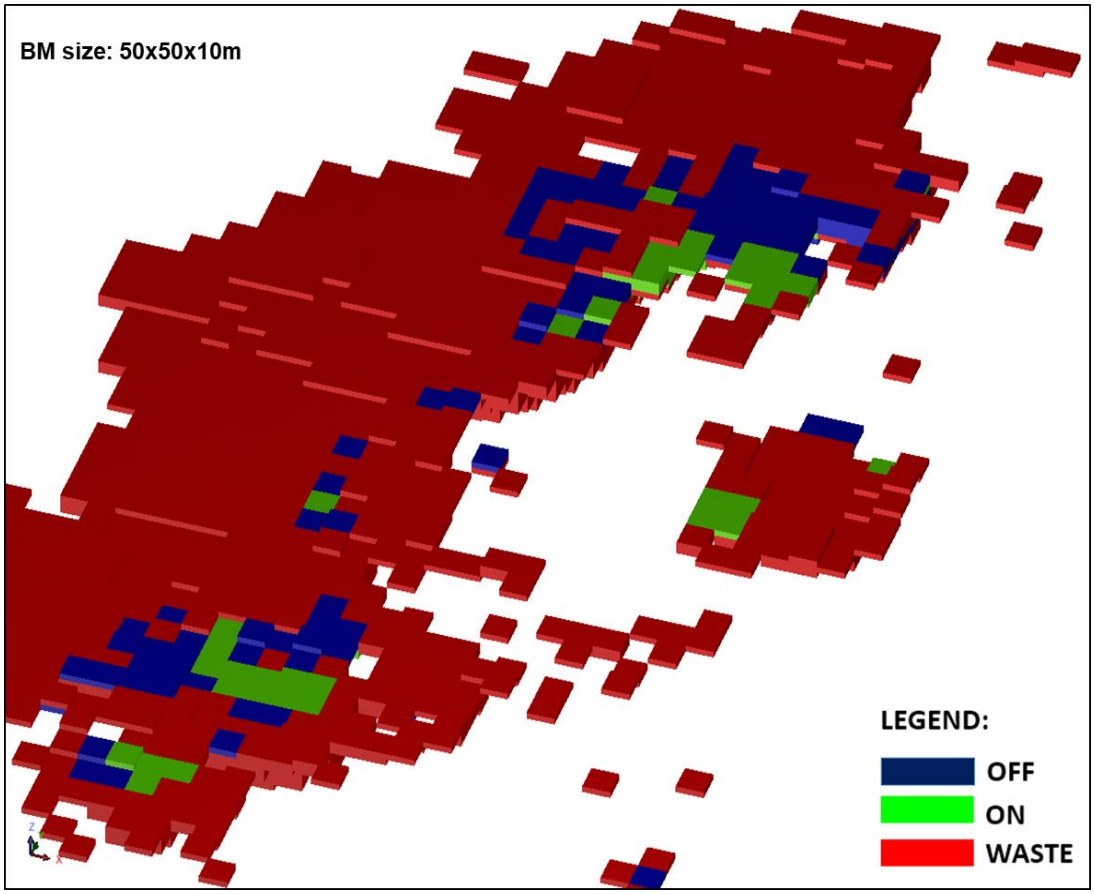


Figure 33: Block model for 50m x 50m x 10m



Figure 34: Tonnes for 50m x 50m x 10m

A further increase of the block model size of the base block model to a 50m x 50m x 10m results in ore being converted to waste. When comparing Figure 27 and Figure 33, it can be seen that areas that had ore in the base block model have been converted to waste. The OFF grade with Fe of 63% is less than 20 million tonnes and the ON grade at 65% is approximately 15 million tonnes. While the ore with Fe of 58% has increased from approximately zero to approximately 10 million tonnes.

When comparing all the graphs and the block model, it can be clearly seen that the smaller block model size results in better grades and an increase in the ore tonnes due to less dilution. The larger block model sizes result in lower grades and more material in the waste interval due to an increased dilution.

Small block sizes of 6.25m x 6.25m x 10m show a high resolution when viewed visually, however, the individual grades of the blocks may not be accurate as the small block sizes are effectively obtained by splitting the original geological

model of 25m x 25m x 10m into smaller units. This shows that smaller block sizes, cannot be supported by the original geological block model since the borehole spacing used for the creation of the block model was 50m x 50m. From literature, it was found that the block size should be one half or one-fourth of the sample spacing.

4.6. Grade-tonnage curves

Grade-tonnage curves where created for the different block model sizes in order to evaluate the number of tonnes above a certain cut-off grade and also the average grade above that cut-off grade. The cut-off grades of 53%,60%,63% and 64% Fe have been used to evaluate the tonnes and average grades mentioned in the previous sections. Figure 35 shows the grade-tonnage curve for the 6.25m x 6.25m x10m base block model at the varying cut-off grades.

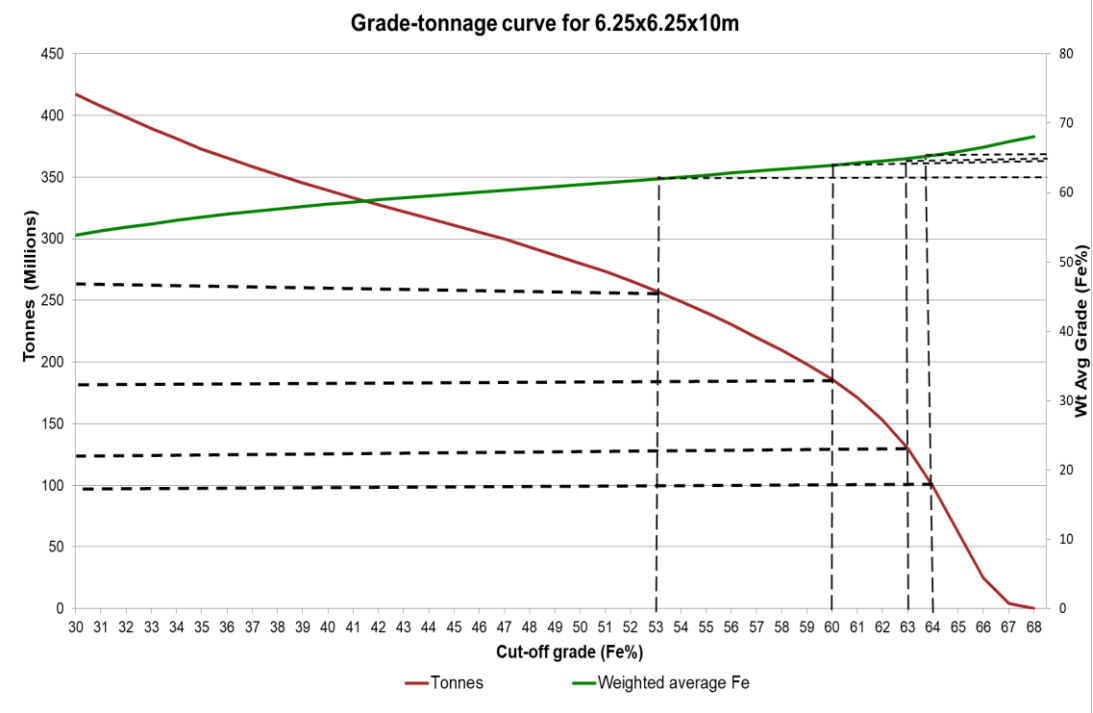


Figure 35: Grade-tonnage curve for 6.25m x 6.25m x10m

A 53% cut-off grade results in the tonnes above a cut-off grade of 257 million

tonnes with an average grade of 61.94%. When the cut-off grade is increased to 60%, the tonnes above 60% decrease to 186 million tonnes while the average grade increases to 63.94%. A cut-off grade of 63% results in a further decrease in the tonnes. The tonnes decreases to 129 million tonnes while the average grade increases to 64.94%. The tonnes decrease further to 98 million tonnes with an average grade of 65.39%.

Figure 36 shows the grade-tonnage curve for the 12.5m x 12.5m x10m block model.

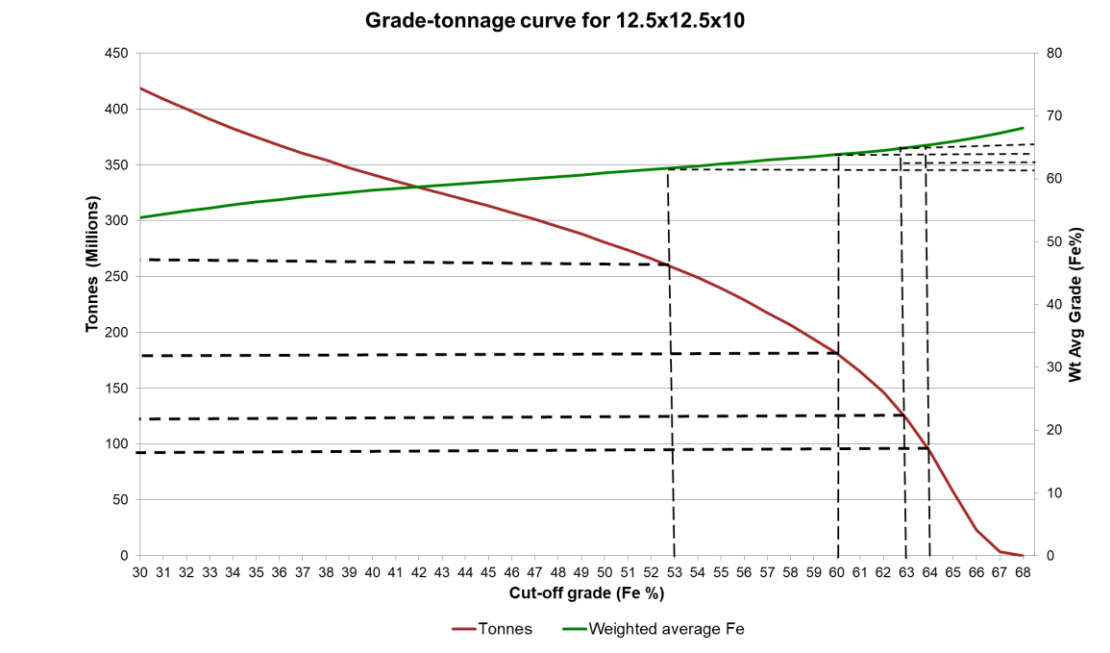


Figure 36: Grade tonnage curve for 12.5m x12.5m x10m

A 53% cog results in the tonnes above a cut-off grade of 257 million tonnes with an average grade of 61.74%. When the cut-off grade is increased to 60%, the tonnes above 60% decrease to 180 million tonnes while the average grade increases to 63.87%. A cut-off grade of 63% results in a further reduction of the tonnes. The tonnes decreases to 122 million tonnes while the average grade increases to 64.93%. The tonnes decrease further to 93 million tonnes with an

average grade of 65.34%. From these results, it can be concluded that a higher cut-off grade results in fewer tonnes and a higher average grade.

When comparing the results of the grade-tonnage curves from the 6.25m x 6.25m x10m and 12.5m x12.5m x 10m block models, it was shown that there is no difference in the tonnes above 53% Fe cut-off grade. The difference in the tonnes is significant in the 60%;63% and 64% cut-off grade. The grade-tonnage curves for the 25m x 25m x10m and 50m x 50m x10m are in Appendix 1. A further difference in tonnes and average grades is summarised in the sections that follow.

4.7. Comparison of all cut-off grades

4.7.1. Average grade

Figure 37 shows the combination of results of the block model sizes that have been mentioned in the sections prior. Figure 37 shows that the average grade at 53% cut-off grade decreases as the block model size increases.

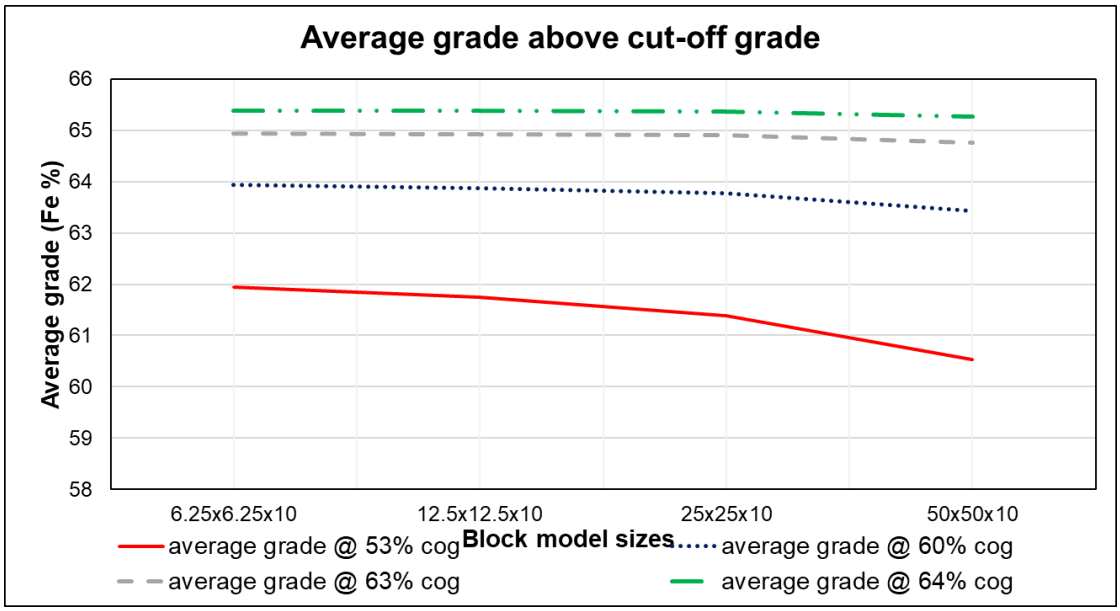


Figure 37: Average grade at varying cut-off grades for varying block model sizes

There is not a significant difference in the average grade between the 6.25m x 6.25m x10m and the 12.5m x12.5m x10m block model as the average grade changes from 61.93 % to 61.75%. This further proves that the 6.25m x 6.25m x 10m block size was increased to 12.5m x 12.5m x 10m through re-blocking into bigger units and the smaller block sizes do not show the true reflection of the individual grades. The major difference in the average grade is the transition from the base block model to 50m x 50m x10m. The base block model results in an average grade of 61.74% while the 50m x 50m x10m block model results in an average grade of 60.54% at a cut-off grade of 53%. The 25m x 25m x10m results in an average grade of 61.39% which is not a significant difference when compared to the base block model. The average grades also decrease with an increase in the block model for the cut-off grades of 60%;63% and 64%. These results prove that the larger the block model size, the lower the average grade at a certain cut-off grade and when increasing the cut-off grade, the average grade also increases.

4.7.2. Tonnes above a cut-off grade

Figure 38 shows the tonnes above varying cut-off grades and varying block model sizes. Figure 38 shows that the tonnes above the cut-off grade of 53%;60%; 63% and 64% decreases as the block model size increases. However, there is no difference in the tonnes above cut-off grade between the 6.25m x 6.25m x10m and the 12.5m x12.5m x10m block model as the tonnes remain at 257 million tonnes in both sizes for a cut-off grade of 53%.

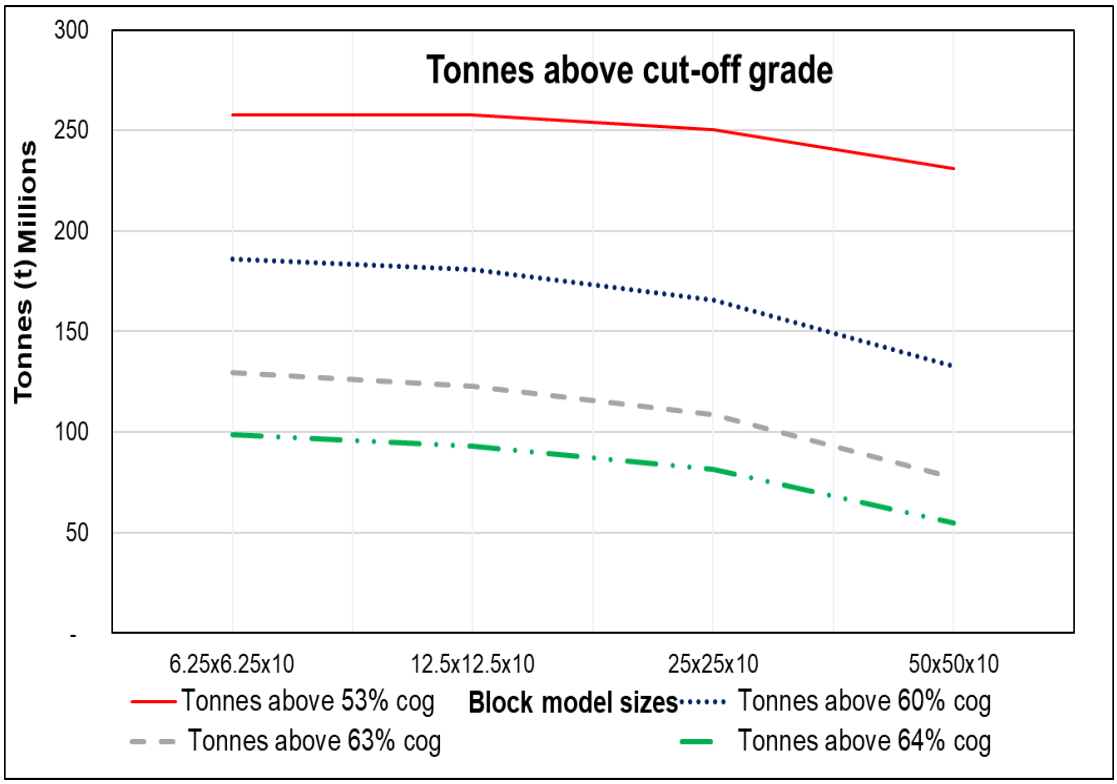


Figure 38: Tonnes above varying cut-off grades and varying block model sizes

The average grades and tonnages above cut-off grades do not vary for the smaller block sizes of 6.25m x 6.25m x 10m and 12.5m x 12.5m x 10m because the original composite block model was effectively just split into small sizes without considering the true grades of the individual block sizes. As the block model size is increased to 25m x 25 x 10 and 50m x 50m x10m, the tonnes decreases from 250 million tonnes to 231 million tonnes respectively, this is a significant change for a 53% cut-off grade. The effect of the block model size on the tonnes can be further highlighted by comparing the tonnes from the base block model size with the tonnes obtained from the 50m x 50m x 10m, whereby the tonnes decrease from 257 million tonnes to 231 million tonnes. These results prove that an increase in the cut-off grade decreases the tonnes above that cut-off grade and an increase in the block model decreases the tonnes above cut-off grade.

4.7.3. NPV

A DCF's were created in Excel for the different block model sizes with the input parameters mentioned. The detailed cashflow are placed in Appendix 2. Figure 39 shows the NPV at varying cut-off grades and varying block model.

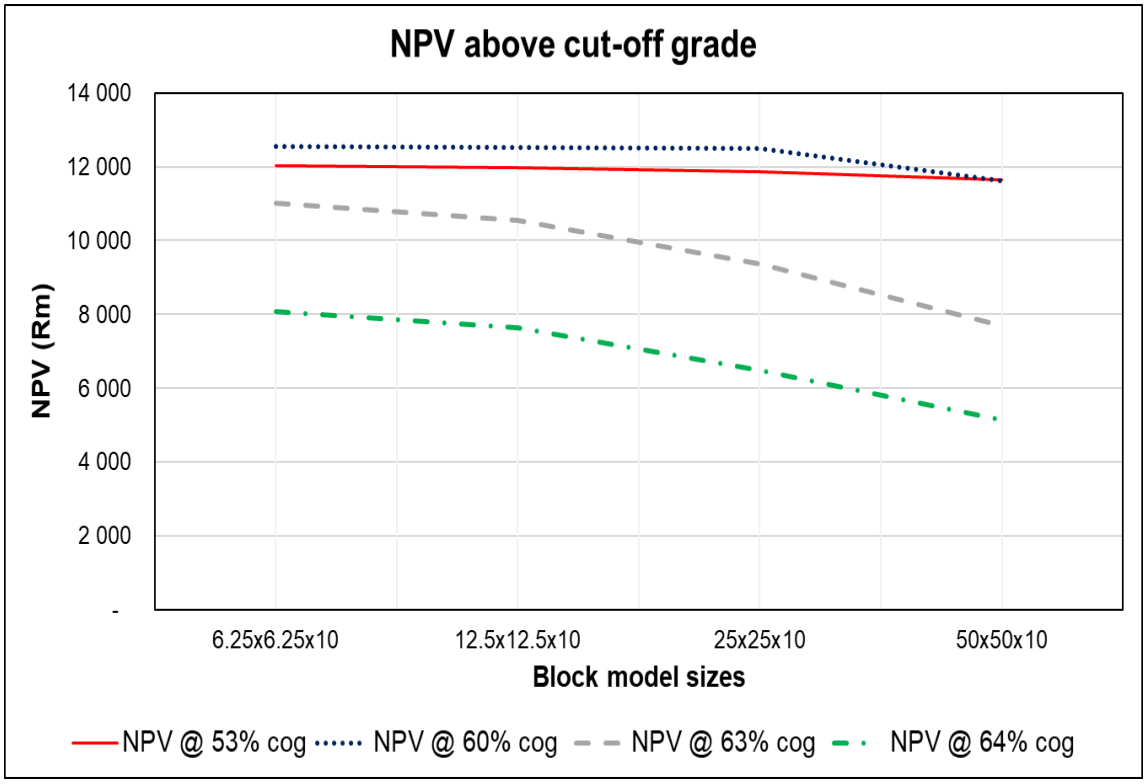


Figure 39: NPV at varying cog and varying BM sizes

Figure 39 shows the difference in NPV when comparing the base block model size of 6.25m x 6.25m x 10m and the rest of the re-blocked block models. The NPV slightly decreases from R12 billion in the base block models to R11.9 billion in the re-blocked block model size of 12.5m x 12.5m x10m at a cut-off grade of 53%. When the cut-off grade is increased to 60%, the NPV remains constant throughout all the block model sizes at approximately R12.5 billion with a slight decrease to R11.6 billion for the 50m x 50m x 10m block model size, however, the NPV is higher when compared to the NPV of 53% cut-off grade at the 6.25m x 6.25m x 10m; 12.5m x 12.5m x 10m and 25m x 25m x

10m block model. This is because 60% cut-off grade results in a higher grade, that is, more ON grade being mined earlier in the life of the operation.

When the cut-off grade is increased to 63 %, the NPV decreases below R11 billion. The base block model results in an NPV of R11 billion, the 12.5m x 12.5m x 10m block model results in an NPV of R10.5 billion, the 25m x 25m x10m results in an NPV of R9.3 billion and the 50m x 50m x 10m block model results in an NPV of R7.7 billion. When the cut-off grade is increased to 64%, there is a further decrease in the in the NPV. The base block model results in an NPV of R8 billion, the 12.5m x 12.5m x 10m block model results in an NPV of R7.7 billion, the 25m x 25m x10m results in an NPV of R6.5 billion and the 50m x 50m x10m block model results in a NPV of R5 billion.

These results prove that an increase in the block model size leads to a decrease in the NPV and an increase in the cut-off grade results in a decrease in the NPV. The effect of an increased block model size on the NPV is mainly due to an increase in dilution, therefore, leading to a decrease in average grade and therefore resulting in the downgrading of material from ON grade to OFF grade. A small block model size requires the extraction of the ore through selective mining. In these cash flows, the cost of selectively mining the ore was not taken into consideration.

4.7.4. NPV considering selective mining

To mine selectively for an iron ore deposit, the loading equipment size should be taken into consideration, that is, a shovel with a smaller bucket size should be used in order to decrease dilution. A smaller bucket size results in a decreased production rate. The production rate was the only parameter that was changed when creating the DCF's considering the effects of selective mining. Figure 40 shows the NPV obtained when considering the effects of selective mining.

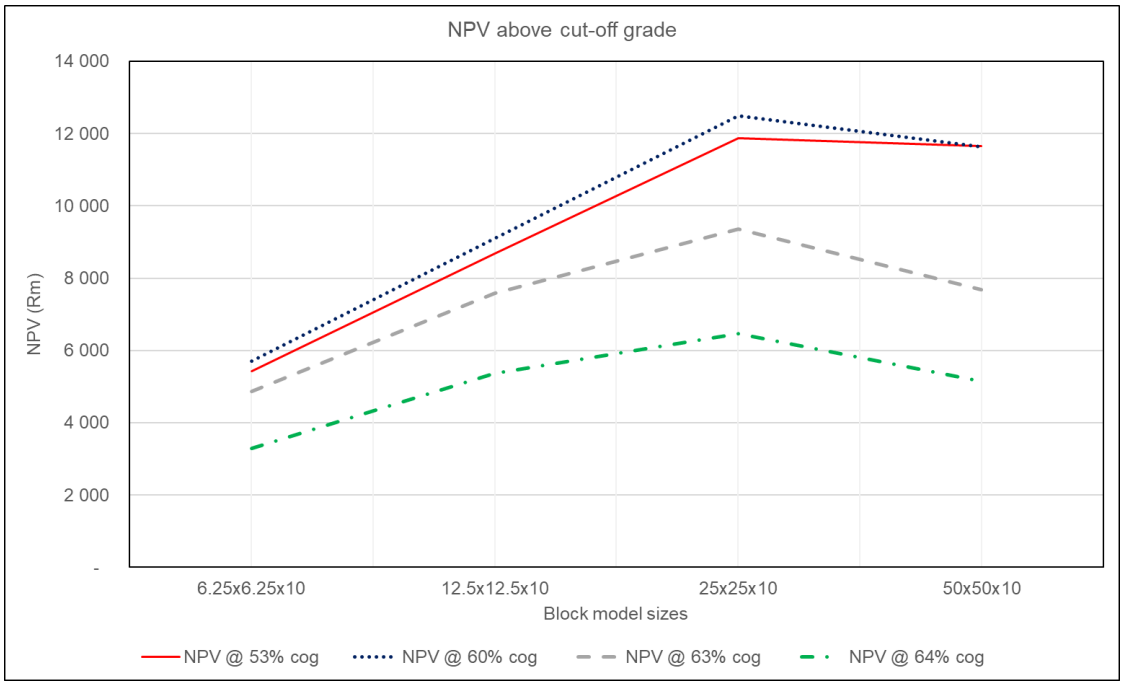


Figure 40: NPV at varying cut-off grades and block model sizes considering the effects of selective mining

Selective mining has an effect on annual production and therefore consequently has an effect on the NPV. The NPV of the 6.25m x 6.25m x 10m reduces from R12 billion to approximately R5.4 billion when considering the effects of selective mining for a cut-off grade of 53%. And when compared with the larger re-blocked block models, the NPV increases. Figure 40 shows that the NPV increases from R5.4 billion in the base block models to R8 billion in the re-blocked block model size of 12.5m x 12.5m x 10m at a cut-off grade of 53%. The 25m x 25m x 10m and the 50m x 50m x10m block model size's NPV remain the same since selective mining was not considered for these block models.

When the cut-off grade is increased to 60%, the NPV is higher when compared to the NPV of 53% cut-off grade at the 6.25m x 6.25m x 10m, 12.5m x 12.5m x 10m and 25m x 25m x 10m block model. When the cut-off grade is increased to 63 %, the NPV decreases below R10 billion. The base block model results

in an NPV of R4.8 billion, the 12.5m x 12.m x 10m block model results in an NPV of R7.6 billion, the 25m x 25m x10m remains at an NPV of R9.3 billion and the 50m x 50m x10m block model remains at an NPV of R7.7 billion.

When the cut-off grade is increased to 64%, there is a further decrease in the in the NPV. The base block model results in an NPV of R3 billion, the 12.5m x 12.5m x 10m block model results in an NPV of 5 billion, the 25m x 25m x10m remains at an NPV of R6.5 billion which is higher than the NPV of the 12.5m x 12.5m x 10m and the 50m x 50m x10m block model remains at an NPV of R5 billion. Therefore, a 12.5m x 12.5m x 10m block model results in a higher NPV when considering the effects of selective mining since the 25m x 25m x 10m and 50m x 50m x 10m block models were not mined selectively. These shows that larger block model sizes are better to work with since they do not require to be mined selectively.The detailed cash flows are in Appendix 3.

Chapter 5: Conclusions and recommendations

5.1 Conclusions

The main objectives of this research report were: to understand the importance of cut-off grade; to determine the effect of block model sizes on the average grade; to determine the effects of the block sizes and cut-off grade on the NPV and to determine which block sizes and cut-off grade maximise the NPV. The main findings of the research report are summarised as follows:

A cut-off grade determines whether the material is taken further for processing or is classified as waste. Cut-off grades can be represented in a grade-tonnage curve which analyses how much tonnage is available and the average grade above a certain cut-off grade. A low cut-off grade results in a higher tonnage and a low average grade. A high cut-off grade results in a lower tonnage and a higher average grade, therefore fewer reserves and a decrease in the LOM.

Block sizes have an effect on the average grade. The larger the block size, the lower the average grade due to an increase in dilution. The smaller the block size, the higher the average grade despite the cut-off grade selected because there is less dilution. To summarise, an increase in the cut-off grade decreases the tonnes above the cut-off grade and an increase in the block size decreases the tonnes above the cut-off grade. It was found that the cut-off grade and the block size have an effect on the NPV. The effects of selective mining on the NPV were also analysed considering the decrease in production because of selective mining.

Small block sizes result in an optimised NPV while larger block sizes result in a low NPV despite the cut-off grade selected when the effects of selective mining are not taken into account. Larger block sizes result in an optimised NPV while smaller block sizes result in a low NPV despite the cut-off grade selected when the effects of selective mining are taken into account. The 12.5m

x 12.5m x 10m block model resulted in an optimised NPV when the effects of selective mining were not considered; and it resulted in an optimised NPV when the effects of selective mining where considered. The 25m x 25m x 10m which is a larger block model size is not affected by selective mining and it resulted in a higher NPV when compared to the 12.5m x 12.5m x 10m,therefore,it is better to work with larger block model sizes to avoid selective mining.

Smaller block model sizes can have a disadvantage in terms of the resolution.The smaller block size of 6.25m x 6.25m x 10m does not show a true reflection of the individual block size due to the sample spacing of 50m x 50m that was used to get the information to create the block model. The literature review states that the block size should be one-half or one-fourth of the sample spacing.

5.2 Recommendations

It is recommended that a 60% Fe cut-off grade paired with a 12.5m x 12.5m x 10m block size to be used when the effects of selective mining are not considered since it increases the tonnes above the cut-off grade, thus increasing the LOM and the NPV is optimised. A 12.5m x 12.5m x 10m block model paired with a 60% cut-off grade is recommended when the effect of selective mining are considered. A 60% Fe cut-off grade paired with a 25m x 25m x 10m block size is recommended since it does not require to be mined selectively. The 25m x 25m x 10m is also accurate because the assigning of the individual grades of the original block model were done on this size and it is one half of the borehole spacing.

To increase the accuracy of the individual block grades for smaller block sizes of 6.25m x 6.25m x 10m, a 25m x 25m borehole/sample spacing is

recommended as the literature review showed that the block sizes should be one -half or one-fourth of the sample spacing

In the section where the effects of selective mining are taken into account, the report was done with the assumption that selective mining is occurring throughout the deposit and that all the loaders meet the criteria to mine selectively. It is recommended that detailed results should be recorded on areas where selective mining is occurring and in areas where there is no selective mining. This will assist in determining whether selective mining adds value. If the value of selective mining is not shown, then larger block sizes are recommended.

The report also assumed that the base block size of 6.25m x 6.25m x 10m was the correct SMU since it was already being used for this deposit. It is recommended that research should be done to determine whether the 6.25m x 6.25m x 10m is the correct SMU and how the SMU was determined.

Selective mining for this deposit was considered when the mine was already in operation, therefore, selective mining was not part of the initial studies before the start of operations. Therefore, mining the SMU should be taken into account when loader requirements studies are done in order to take into account the cost of selective mining at the initial phase of a project. And specifically for the deposit that was discussed in this report as there is a lot of opportunities to upgrade the ore, therefore leading to decreased plant costs, thus increase the NPV.

Investigate selective mining in detail for an iron ore deposit at an existing open pit mine. The investigation should include block sizes, equipment required, the results from the selective mining and criteria of areas suitable for selective mining in order to show the benefits of selecting the correct equipment in conjunction with the SMU.

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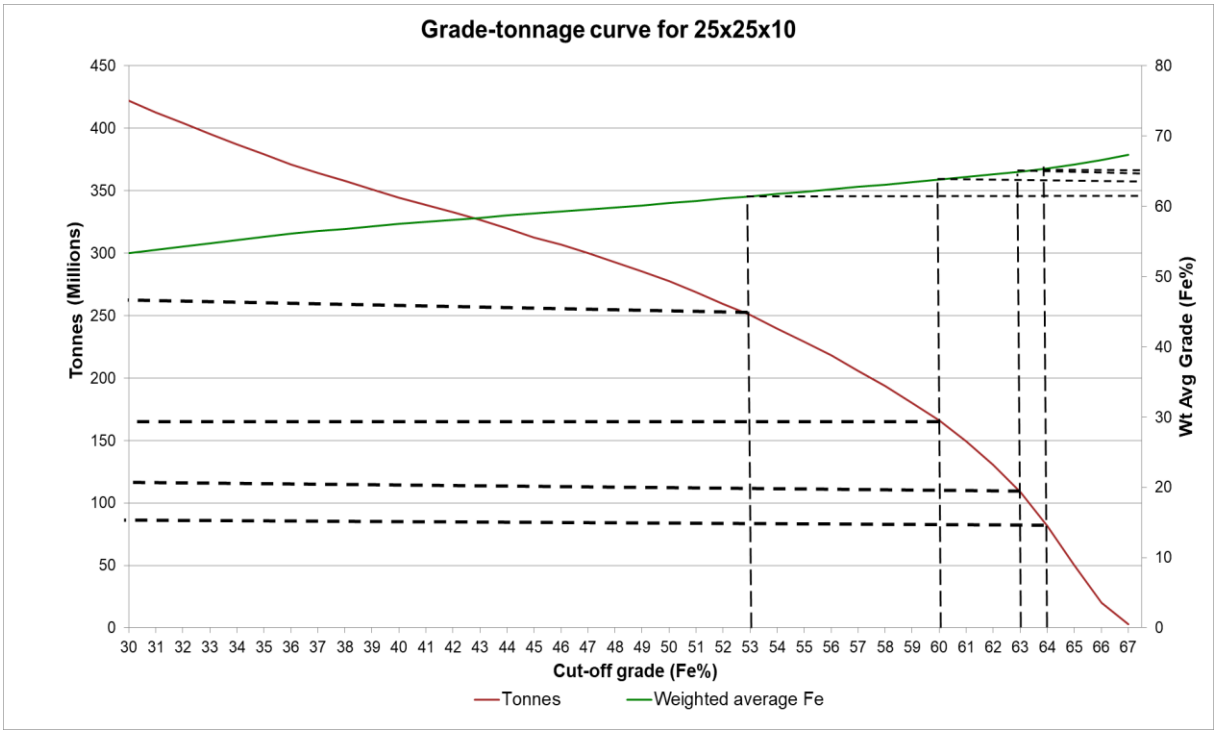
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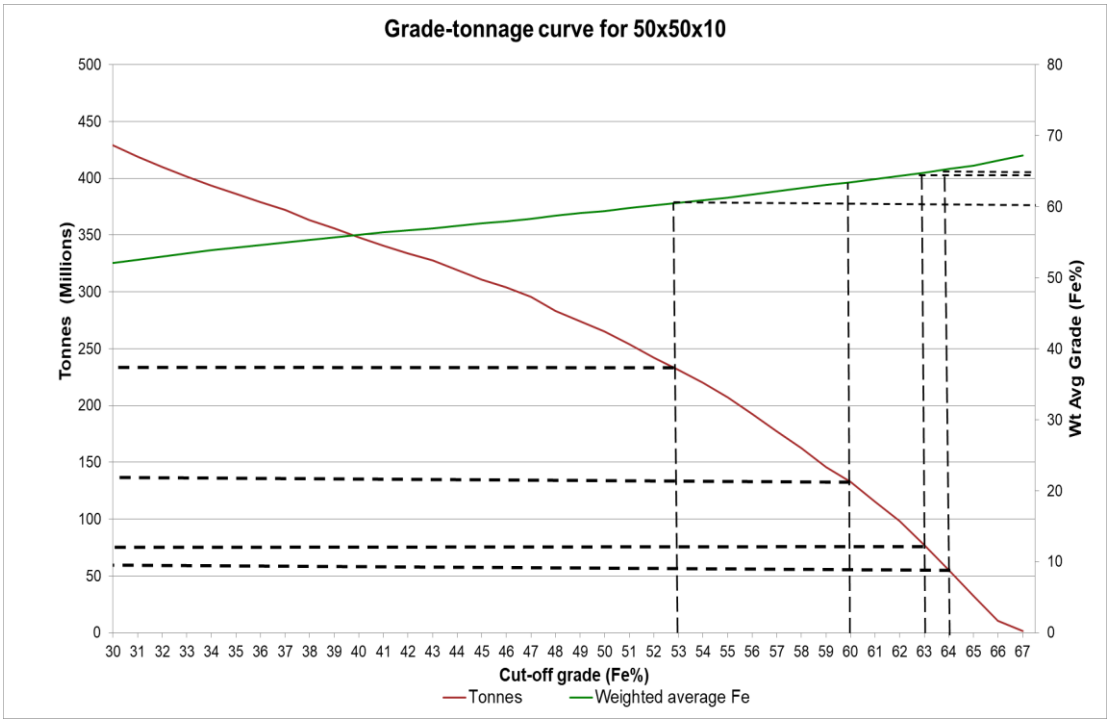
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Appendix 1: Grade-tonnage curves

Grade-tonnage curve for 25m x 25m x 10m block size



Grade-tonnage curve for 50m x 50m x 10m block size



Appendix 2

Appendix 2.1: Discounted cash flows at 53% cut-off grade

6.25m x 6.25m x 10m at 53% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.53	2.10	1.51	1.13	1.45	2.05	2.75	2.64	3.13	3.83
OFF grade ore	Mt		4.24	4.73	4.06	4.24	4.33	4.28	3.43	3.61	3.92	3.26
Total product produced	Mt		6.77	6.83	5.57	5.37	5.78	6.33	6.18	6.25	7.05	7.08
Total lumpy produced	Mt		3.59	3.62	2.95	2.85	3.06	3.35	3.28	3.31	3.74	3.75
Total fines produced	Mt		3.18	3.21	2.62	2.52	2.72	2.97	2.91	2.94	3.31	3.33
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 733.90	2 757.91	2 248.36	2 168.06	2 334.66	2 556.04	2 496.76	2 525.27	2 847.22	2 859.98
Fines	Rm		1 924.89	1 941.79	1 583.02	1 526.49	1 643.79	1 799.66	1 757.92	1 778.00	2 004.67	2 013.65
Gross sales revenue	Rm		**4 658.78**	**4 699.71**	**3 831.38**	**3 694.55**	**3 978.45**	**4 355.70**	**4 254.67**	**4 303.27**	**4 851.89**	**4 873.63**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		113.97	94.57	67.90	50.92	65.47	92.15	123.67	118.82	140.65	172.17
OFF grade ore	Rm		283.86	316.73	271.91	283.86	289.83	286.85	230.07	242.03	262.94	218.12
Total plant costs	Rm		397.83	411.30	339.81	334.78	355.31	378.99	353.75	360.85	403.59	390.29
Total costs	Rm		-1361.04	-1383.78	-1231.87	-1217.57	-1262.84	-1317.46	-1273.65	-1286.94	-1379.17	-1359.69
Net sales revenue (Operating profit) before CAPEX	Rm		**3 297.75**	**3 315.92**	**2 599.51**	**2 476.97**	**2 715.61**	**3 038.24**	**2 981.02**	**3 016.33**	**3 472.72**	**3 513.94**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			70.79	70.56	67.85	67.04	68.26	69.75	70.06	70.09	71.57	72.10
Royalty rate (0.5+x/9)	%		8.37	8.34	8.04	7.95	8.08	8.25	8.28	8.29	8.45	8.51
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		326.11	328.98	268.20	258.62	278.49	304.90	297.83	301.23	339.63	341.15
Taxable income (Net sales revenue - Royalty)	Rm		2971.63	2986.94	2331.31	2218.36	2437.11	2733.35	2683.19	2715.10	3133.09	3172.79
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**832.06**	**836.34**	**652.77**	**621.14**	**682.39**	**765.34**	**751.29**	**760.23**	**877.26**	**888.38**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		**2 140**	**2 151**	**1 679**	**1 597**	**1 755**	**1 968**	**1 932**	**1 955**	**2 256**	**2 284**
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 945.07	1 777.35	1 261.12	1 090.92	1 089.54	1 110.89	991.37	911.96	956.69	880.74
NPV @ discount rate	Rm	**12 015.65**										

12.5m x 12.5m x 10m at 53% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.52	2.10	1.50	1.13	1.45	2.04	2.74	2.63	3.12	3.81
OFF grade ore	Mt		4.22	4.71	4.05	4.22	4.31	4.27	3.42	3.60	3.91	3.25
Total product produced	Mt		6.75	6.81	5.55	5.35	5.76	6.31	6.16	6.23	7.03	7.06
Total lumpy produced	Mt		3.58	3.61	2.94	2.84	3.05	3.34	3.27	3.30	3.73	3.74
Total fines produced	Mt		3.17	3.20	2.61	2.52	2.71	2.97	2.90	2.93	3.30	3.32
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 725.51	2 749.45	2 241.46	2 161.41	2 327.50	2 548.20	2 489.10	2 517.53	2 838.48	2 851.20
Fines	Rm		1 918.98	1 935.84	1 578.17	1 521.80	1 638.75	1 794.14	1 752.53	1 772.54	1 998.52	2 007.48
Gross sales revenue	Rm		**4 644.49**	**4 685.29**	**3 819.63**	**3 683.21**	**3 966.24**	**4 342.34**	**4 241.62**	**4 290.07**	**4 837.00**	**4 858.68**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		113.62	94.28	67.69	50.77	65.27	91.87	123.29	118.46	140.22	171.64
OFF grade ore	Rm		282.99	315.75	271.07	282.99	288.95	285.97	229.37	241.28	262.14	217.45
Total plant costs	Rm		396.61	410.04	338.76	333.76	354.22	377.83	352.66	359.74	402.35	389.10
Total costs	Rm		-1359.82	-1382.52	-1230.83	-1216.54	-1261.75	-1316.29	-1272.57	-1285.83	-1377.93	-1358.49
Net sales revenue (Operating profit) before CAPEX	Rm		**3 284.68**	**3 302.77**	**2 588.80**	**2 466.67**	**2 704.49**	**3 026.05**	**2 969.06**	**3 004.24**	**3 459.07**	**3 500.19**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			70.72	70.49	67.78	66.97	68.19	69.69	70.00	70.03	71.51	72.04
Royalty rate (0.5+x/9)	%		8.36	8.33	8.03	7.94	8.08	8.24	8.28	8.28	8.45	8.50
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		325.11	327.97	267.37	257.82	277.64	303.96	296.91	300.30	338.59	340.11
Taxable income (Net sales revenue - Royalty)	Rm		2 959.56	2 974.80	2 321.42	2 208.84	2 426.85	2 722.08	2 672.14	2 703.93	3 120.48	3 160.08
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**828.68**	**832.94**	**650.00**	**618.48**	**679.52**	**762.18**	**748.20**	**757.10**	**873.74**	**884.82**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		**2 131**	**2 142**	**1 671**	**1 590**	**1 747**	**1 960**	**1 924**	**1 947**	**2 247**	**2 275**
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 937.17	1 770.13	1 255.77	1 086.24	1 084.96	1 106.31	987.29	908.21	952.84	877.21
NPV @ discount rate	Rm	**11 966.12**										

25m x 25m x 10m at 53% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.51	2.08	1.50	1.12	1.44	2.03	2.72	2.62	3.10	3.79
OFF grade ore	Mt		4.20	4.69	4.02	4.20	4.29	4.24	3.40	3.58	3.89	3.23
Total product produced	Mt		6.71	6.77	5.52	5.32	5.73	6.27	6.13	6.20	6.99	7.02
Total lumpy produced	Mt		3.56	3.59	2.92	2.82	3.04	3.32	3.25	3.28	3.70	3.72
Total fines produced	Mt		3.15	3.18	2.59	2.50	2.69	2.95	2.88	2.91	3.28	3.30
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 709.62	2 733.42	2 228.39	2 148.81	2 313.93	2 533.35	2 474.59	2 502.85	2 821.94	2 834.58
Fines	Rm		1 907.79	1 924.55	1 568.97	1 512.93	1 629.19	1 783.68	1 742.31	1 762.21	1 986.87	1 995.77
Gross sales revenue	Rm		**4 617.42**	**4 657.98**	**3 797.36**	**3 661.74**	**3 943.12**	**4 317.02**	**4 216.89**	**4 265.06**	**4 808.81**	**4 830.35**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		112.96	93.73	67.30	50.47	64.89	91.33	122.57	117.77	139.40	170.64
OFF grade ore	Rm		281.34	313.91	269.49	281.34	287.26	284.30	228.03	239.88	260.61	216.19
Total plant costs	Rm		394.30	407.65	336.79	331.81	352.15	375.63	350.61	357.65	400.01	386.83
Total costs	Rm		-1357.50	-1380.13	-1228.85	-1214.60	-1259.69	-1314.09	-1270.51	-1283.74	-1375.58	-1356.22
Net sales revenue (Operating profit) before CAPEX	Rm		**3 259.91**	**3 277.84**	**2 568.50**	**2 447.14**	**2 683.43**	**3 002.93**	**2 946.38**	**2 981.32**	**3 433.22**	**3 474.13**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			70.60	70.37	67.64	66.83	68.05	69.56	69.87	69.90	71.39	71.92
Royalty rate (0.5+x/9)	%		8.34	8.32	8.02	7.93	8.06	8.23	8.26	8.27	8.43	8.49
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		323.22	326.06	265.82	256.32	276.02	302.19	295.18	298.55	336.62	338.12
Taxable income (Net sales revenue - Royalty)	Rm		2 936.69	2 951.78	2 302.69	2 190.82	2 407.42	2 700.74	2 651.20	2 682.77	3 096.60	3 136.01
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**822.27**	**826.50**	**644.75**	**613.43**	**674.08**	**756.21**	**742.34**	**751.18**	**867.05**	**878.08**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 114	2 125	1 658	1 577	1 733	1 945	1 909	1 932	2 230	2 258
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 922.20	1 756.43	1 245.63	1 077.38	1 076.27	1 097.64	979.55	901.10	945.55	870.53
NPV @ discount rate	Rm	**11 872.28**										

50m x 50m x 10m at 53% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.48	2.05	1.47	1.11	1.42	2.00	2.69	2.58	3.05	3.74
OFF grade ore	Mt		4.14	4.62	3.97	4.14	4.23	4.18	3.36	3.53	3.84	3.18
Total product produced	Mt		6.62	6.67	5.44	5.25	5.65	6.19	6.04	6.11	6.89	6.92
Total lumpy produced	Mt		3.51	3.54	2.88	2.78	2.99	3.28	3.20	3.24	3.65	3.67
Total fines produced	Mt		3.11	3.14	2.56	2.47	2.66	2.91	2.84	2.87	3.24	3.25
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 672.11	2 695.58	2 197.54	2 119.05	2 281.89	2 498.27	2 440.32	2 468.20	2 782.86	2 795.33
Fines	Rm		1 881.38	1 897.90	1 547.24	1 491.98	1 606.63	1 758.98	1 718.18	1 737.81	1 959.36	1 968.14
Gross sales revenue	Rm		**4 553.48**	**4 593.48**	**3 744.78**	**3 611.04**	**3 888.52**	**4 257.25**	**4 158.51**	**4 206.00**	**4 742.22**	**4 763.47**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		111.40	92.44	66.36	49.77	63.99	90.07	120.88	116.14	137.47	168.28
OFF grade ore	Rm		277.44	309.57	265.76	277.44	283.28	280.36	224.87	236.56	257.00	213.19
Total plant costs	Rm		388.84	402.00	332.12	327.22	347.28	370.43	345.75	352.69	394.47	381.47
Total costs	Rm		-1352.05	-1374.49	-1224.19	-1210.00	-1254.81	-1308.89	-1265.66	-1278.78	-1370.05	-1350.86
Net sales revenue (Operating profit) before CAPEX	Rm		**3 201.44**	**3 218.99**	**2 520.59**	**2 401.04**	**2 633.71**	**2 948.36**	**2 892.85**	**2 927.22**	**3 372.18**	**3 412.61**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			70.31	70.08	67.31	66.49	67.73	69.26	69.56	69.60	71.11	71.64
Royalty rate (0.5+x/9)	%		8.31	8.29	7.98	7.89	8.03	8.20	8.23	8.23	8.40	8.46
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		318.74	321.54	262.13	252.77	272.20	298.01	291.10	294.42	331.96	333.44
Taxable income (Net sales revenue - Royalty)	Rm		2 882.69	2 897.45	2 258.45	2 148.26	2 361.52	2 650.35	2 601.76	2 632.80	3 040.22	3 079.16
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**807.15**	**811.29**	**632.37**	**601.51**	**661.22**	**742.10**	**728.49**	**737.18**	**851.26**	**862.17**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 076	2 086	1 626	1 547	1 700	1 908	1 873	1 896	2 189	2 217
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 886.85	1 724.10	1 221.70	1 056.45	1 055.75	1 077.16	961.28	884.32	928.33	854.75
NPV @ discount rate	Rm	**11 650.70**										

Appendix 2.2: Discounted cash flows at 60% cut-off grade

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x 10m @ 60% cut-off grade	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.61	2.17	1.56	1.17	1.50	2.11	2.84	2.73	3.23	3.95
OFF grade ore	Mt		4.37	4.88	4.19	4.37	4.47	4.42	3.54	3.73	4.05	3.36
Total product produced	Mt		6.99	7.05	5.75	5.54	5.97	6.53	6.38	6.45	7.28	7.31
Total lumpy produced	Mt		3.70	3.74	3.05	2.94	3.16	3.46	3.38	3.42	3.86	3.87
Total fines produced	Mt		3.28	3.31	2.70	2.60	2.80	3.07	3.00	3.03	3.42	3.44
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 822.17	2 846.96	2 320.95	2 238.06	2 410.04	2 638.57	2 577.37	2 606.81	2 939.15	2 952.32
Fines	Rm		1 987.04	2 004.49	1 634.14	1 575.78	1 696.86	1 857.77	1 814.68	1 835.41	2 069.40	2 078.67
Gross sales revenue	Rm		**4 809.21**	**4 851.46**	**3 955.09**	**3 813.84**	**4 106.91**	**4 496.34**	**4 392.05**	**4 442.22**	**5 008.55**	**5 030.99**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		117.65	97.63	70.09	52.57	67.59	95.12	127.67	122.66	145.19	177.73
OFF grade ore	Rm		293.02	326.95	280.69	293.02	299.19	296.11	237.50	249.84	271.43	225.17
Total plant costs	Rm		410.68	424.58	350.78	345.59	366.78	391.23	365.17	372.50	416.62	402.90
Total costs	Rm		-1373.88	-1397.07	-1242.84	-1228.38	-1274.31	-1329.69	-1285.07	-1298.59	-1392.20	-1372.29
Net sales revenue (Operating profit) before CAPEX	Rm		**3 435.33**	**3 454.39**	**2 712.25**	**2 585.46**	**2 832.59**	**3 166.65**	**3 106.98**	**3 143.63**	**3 616.35**	**3 658.71**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.43	71.20	68.58	67.79	68.97	70.43	70.74	70.77	72.20	72.72
Royalty rate (0.5+x/9)	%		8.44	8.41	8.12	8.03	8.16	8.33	8.36	8.36	8.52	8.58
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		336.64	339.60	276.86	266.97	287.48	314.74	307.44	310.96	350.60	352.17
Taxable income (Net sales revenue - Royalty)	Rm		3 098.69	3 114.79	2 435.39	2 318.49	2 545.11	2 851.91	2 799.54	2 832.67	3 265.75	3 306.54
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**867.63**	**872.14**	**681.91**	**649.18**	**712.63**	**798.53**	**783.87**	**793.15**	**914.41**	**925.83**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 231	2 243	1 753	1 669	1 832	2 053	2 016	2 040	2 351	2 381
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 028.23	1 853.43	1 317.42	1 140.16	1 137.83	1 159.07	1 034.36	951.45	997.20	917.87
NPV @ discount rate	Rm	**12 537.01**										

12.5m x 12.5m x 10m @ 60% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.61	2.17	1.56	1.17	1.50	2.11	2.83	2.72	3.22	3.95
OFF grade ore	Mt		4.37	4.87	4.18	4.37	4.46	4.41	3.54	3.72	4.05	3.36
Total product produced	Mt		6.98	7.04	5.74	5.54	5.96	6.53	6.37	6.45	7.27	7.30
Total lumpy produced	Mt		3.70	3.73	3.04	2.93	3.16	3.46	3.38	3.42	3.85	3.87
Total fines produced	Mt		3.28	3.31	2.70	2.60	2.80	3.07	3.00	3.03	3.42	3.43
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 819.09	2 843.85	2 318.41	2 235.61	2 407.40	2 635.69	2 574.55	2 603.96	2 935.93	2 949.09
Fines	Rm		1 984.86	2 002.30	1 632.35	1 574.05	1 695.01	1 855.74	1 812.69	1 833.40	2 067.13	2 076.40
Gross sales revenue	Rm		**4 803.95**	**4 846.15**	**3 950.76**	**3 809.66**	**4 102.41**	**4 491.42**	**4 387.25**	**4 437.36**	**5 003.07**	**5 025.49**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		117.52	97.52	70.01	52.51	67.51	95.02	127.53	122.53	145.03	177.54
OFF grade ore	Rm		292.70	326.60	280.38	292.70	298.87	295.78	237.24	249.57	271.14	224.92
Total plant costs	Rm		410.23	424.12	350.39	345.21	366.38	390.80	364.77	372.09	416.17	402.46
Total costs	Rm		-1373.43	-1396.60	-1242.46	-1228.00	-1273.91	-1329.27	-1284.67	-1298.18	-1391.74	-1371.85
Net sales revenue (Operating profit) before CAPEX	Rm		**3 430.51**	**3 449.55**	**2 708.30**	**2 581.66**	**2 828.50**	**3 162.16**	**3 102.57**	**3 139.17**	**3 611.33**	**3 653.64**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.41	71.18	68.55	67.77	68.95	70.40	70.72	70.74	72.18	72.70
Royalty rate (0.5+x/9)	%		8.43	8.41	8.12	8.03	8.16	8.32	8.36	8.36	8.52	8.58
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		336.28	339.23	276.55	266.68	287.17	314.40	307.11	310.61	350.21	351.78
Taxable income (Net sales revenue - Royalty)	Rm		3 094.24	3 110.32	2 431.75	2 314.99	2 541.33	2 847.76	2 795.46	2 828.56	3 261.11	3 301.85
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**866.39**	**870.89**	**680.89**	**648.20**	**711.57**	**797.37**	**782.73**	**792.00**	**913.11**	**924.52**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 228	2 239	1 751	1 667	1 830	2 050	2 013	2 037	2 348	2 377
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 025.32	1 850.77	1 315.45	1 138.44	1 136.14	1 157.39	1 032.85	950.07	995.78	916.57
NPV @ discount rate	Rm	**12 518.77**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
25m x 25m x 10m @ 60% cut-off grade	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	8.8	7.3
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	14.6	14.4
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.61	2.16	1.55	1.17	1.50	2.11	2.83	2.72	3.22	3.94
OFF grade ore	Mt		4.36	4.87	4.18	4.36	4.45	4.41	3.54	3.72	4.04	3.35
Total product produced	Mt		6.97	7.03	5.73	5.53	5.95	6.52	6.36	6.44	7.26	7.29
Total lumpy produced	Mt		3.69	3.73	3.04	2.93	3.15	3.45	3.37	3.41	3.85	3.86
Total fines produced	Mt		3.28	3.30	2.69	2.60	2.80	3.06	2.99	3.03	3.41	3.43
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 814.67	2 839.40	2 314.78	2 232.11	2 403.64	2 631.56	2 570.52	2 599.88	2 931.34	2 944.47
Fines	Rm		1 981.76	1 999.16	1 629.79	1 571.59	1 692.35	1 852.83	1 809.85	1 830.53	2 063.90	2 073.15
Gross sales revenue	Rm		**4 796.43**	**4 838.56**	**3 944.58**	**3 803.70**	**4 095.99**	**4 484.39**	**4 380.38**	**4 430.41**	**4 995.24**	**5 017.62**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	451.58	445.39
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		117.34	97.37	69.90	52.43	67.41	94.87	127.33	122.33	144.80	177.26
OFF grade ore	Rm		292.25	326.08	279.94	292.25	298.40	295.32	236.87	249.18	270.71	224.57
Total plant costs	Rm		409.59	423.45	349.84	344.67	365.81	390.19	364.20	371.51	415.51	401.83
Total costs	Rm		-1372.79	-1395.94	-1241.91	-1227.46	-1273.34	-1328.65	-1284.10	-1297.60	-1391.09	-1371.22
Net sales revenue (Operating profit) before CAPEX	Rm		**3 423.64**	**3 442.62**	**2 702.67**	**2 576.24**	**2 822.65**	**3 155.74**	**3 096.27**	**3 132.81**	**3 604.14**	**3 646.40**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.38	71.15	68.52	67.73	68.91	70.37	70.69	70.71	72.15	72.67
Royalty rate (0.5+x/9)	%		8.43	8.41	8.11	8.03	8.16	8.32	8.35	8.36	8.52	8.57
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		335.75	338.70	276.12	266.26	286.72	313.91	306.63	310.13	349.67	351.23
Taxable income (Net sales revenue - Royalty)	Rm		3 087.89	3 103.92	2 426.55	2 309.98	2 535.93	2 841.83	2 789.65	2 822.68	3 254.48	3 295.17
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**864.61**	**869.10**	**679.43**	**646.79**	**710.06**	**795.71**	**781.10**	**790.35**	**911.25**	**922.65**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 223	2 235	1 747	1 663	1 826	2 046	2 009	2 032	2 343	2 373
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 021.16	1 846.96	1 312.63	1 135.98	1 133.72	1 154.98	1 030.70	948.10	993.76	914.71
NPV @ discount rate	Rm	**12 492.70**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
50m x 50m x 10m at 60% cut-off grade	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.7	8.1	4.4	0
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.8	13	10.2	7.1
Average grade	%		63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.59	2.15	1.55	1.16	1.49	2.10	2.81	2.70	3.20	3.92
OFF grade ore	Mt		4.34	4.84	4.16	4.34	4.43	4.38	3.52	3.70	2.01	0.00
Total product produced	Mt		6.93	6.99	5.70	5.50	5.92	6.48	6.33	6.40	5.21	3.92
Total lumpy produced	Mt		3.67	3.71	3.02	2.91	3.14	3.44	3.36	3.39	2.76	2.08
Total fines produced	Mt		3.26	3.29	2.68	2.58	2.78	3.05	2.98	3.01	2.45	1.84
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 799.66	2 824.26	2 302.44	2 220.21	2 390.82	2 617.53	2 556.82	2 586.02	2 104.17	1 582.35
Fines	Rm		1 971.19	1 988.50	1 621.10	1 563.21	1 683.33	1 842.95	1 800.21	1 820.77	1 481.50	1 114.10
Gross sales revenue	Rm		**4 770.85**	**4 812.76**	**3 923.55**	**3 783.42**	**4 074.15**	**4 460.48**	**4 357.02**	**4 406.79**	**3 585.67**	**2 696.46**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	395.90	402.09	315.49	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		116.71	96.85	69.53	52.15	67.05	94.36	126.65	121.68	144.03	176.31
OFF grade ore	Rm		290.69	324.35	278.45	290.69	296.81	293.75	235.61	247.85	134.63	0.00
Total plant costs	Rm		407.40	421.19	347.98	342.84	363.86	388.11	362.26	369.53	278.66	176.31
Total costs	Rm		-1370.61	-1393.68	-1240.05	-1225.62	-1271.39	-1326.57	-1282.16	-1295.62	-1118.15	-919.92
Net sales revenue (Operating profit) before CAPEX	Rm		**3 400.25**	**3 419.08**	**2 683.50**	**2 557.80**	**2 802.76**	**3 133.91**	**3 074.86**	**3 111.17**	**2 467.52**	**1 776.54**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.27	71.04	68.39	67.61	68.79	70.26	70.57	70.60	68.82	65.88
Royalty rate (0.5+x/9)	%		8.42	8.39	8.10	8.01	8.14	8.31	8.34	8.34	8.15	7.82
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		333.96	336.89	274.65	264.84	285.19	312.23	304.99	308.48	251.00	188.75
Taxable income (Net sales revenue - Royalty)	Rm		3 066.29	3 082.19	2 408.85	2 292.96	2 517.57	2 821.67	2 769.87	2 802.69	2 216.52	1 587.79
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**858.56**	**863.01**	**674.48**	**642.03**	**704.92**	**790.07**	**775.56**	**784.75**	**620.63**	**444.58**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 208	2 219	1 734	1 651	1 813	2 032	1 994	2 018	1 596	1 143
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 007.02	1 834.03	1 303.06	1 127.61	1 125.51	1 146.79	1 023.39	941.38	676.82	440.76
NPV @ discount rate	Rm	**11 626.37**										

Appendix 2.3: Discounted cash flows at 63% cut-off grade

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x 10m @ 63% cut-off grade	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	7.3	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	12.4	4.9	5.8	7.1
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.66	2.20	1.58	1.19	1.53	2.15	2.88	2.77	3.28	4.01
OFF grade ore	Mt		4.44	4.96	4.25	4.44	4.54	4.49	3.41	0.00	0.00	0.00
Total product produced	Mt		7.10	7.16	5.84	5.63	6.06	6.64	6.29	2.77	3.28	4.01
Total lumpy produced	Mt		3.76	3.79	3.09	2.98	3.21	3.52	3.34	1.47	1.74	2.13
Total fines produced	Mt		3.34	3.37	2.74	2.65	2.85	3.12	2.96	1.30	1.54	1.89
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 866.31	2 891.49	2 357.25	2 273.07	2 447.73	2 679.84	2 542.15	1 118.04	1 323.40	1 620.02
Fines	Rm		2 018.12	2 035.84	1 659.70	1 600.42	1 723.40	1 886.82	1 789.88	787.19	931.78	1 140.63
Gross sales revenue	Rm		**4 884.43**	**4 927.33**	**4 016.95**	**3 873.49**	**4 171.14**	**4 566.67**	**4 332.03**	**1 905.24**	**2 255.18**	**2 760.65**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	383.53	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		119.49	99.15	71.19	53.39	68.64	96.61	129.66	124.58	147.46	180.51
OFF grade ore	Rm		297.61	332.07	285.08	297.61	303.87	300.74	228.69	0.00	0.00	0.00
Total plant costs	Rm		417.10	431.22	356.26	351.00	372.52	397.35	358.35	124.58	147.46	180.51
Total costs	Rm		-1380.31	-1403.71	-1248.33	-1233.79	-1280.05	-1335.81	-1265.88	-800.13	-850.85	-924.11
Net sales revenue (Operating profit) before CAPEX	Rm		**3 504.12**	**3 523.63**	**2 768.62**	**2 639.70**	**2 891.09**	**3 230.85**	**3 066.15**	**1 105.10**	**1 404.32**	**1 836.53**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.74	71.51	68.92	68.15	69.31	70.75	70.78	58.00	62.27	66.53
Royalty rate (0.5+x/9)	%		8.47	8.45	8.16	8.07	8.20	8.36	8.36	6.94	7.42	7.89
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		341.91	344.91	281.19	271.14	291.98	319.67	303.24	132.22	157.86	193.25
Taxable income (Net sales revenue - Royalty)	Rm		3 162.21	3 178.71	2 487.43	2 368.56	2 599.11	2 911.19	2 762.91	972.88	1 246.46	1 643.29
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**885.42**	**890.04**	**696.48**	**663.20**	**727.75**	**815.13**	**773.61**	**272.41**	**349.01**	**460.12**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 277	2 289	1 791	1 705	1 871	2 096	1 989	700	897	1 183
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 069.81	1 891.47	1 345.57	1 164.78	1 161.97	1 183.17	1 020.82	326.78	380.61	456.16
NPV @ discount rate	Rm	**11 001.13**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
12.5m x 12.5m x 10m @ 63% cut-off grade	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	9.6	2	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	13.4	7.1	4.9	5.8	7.1
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.65	2.20	1.58	1.19	1.53	2.15	2.88	2.77	3.28	4.01
OFF grade ore	Mt		4.44	4.96	4.25	4.44	4.53	4.49	0.93	0.00	0.00	0.00
Total product produced	Mt		7.10	7.16	5.84	5.63	6.06	6.63	3.82	2.77	3.28	4.01
Total lumpy produced	Mt		3.76	3.79	3.09	2.98	3.21	3.52	2.02	1.47	1.74	2.13
Total fines produced	Mt		3.34	3.36	2.74	2.64	2.85	3.12	1.79	1.30	1.54	1.89
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 865.87	2 891.04	2 356.89	2 272.72	2 447.36	2 679.43	1 541.10	1 117.87	1 323.19	1 619.77
Fines	Rm		2 017.80	2 035.53	1 659.44	1 600.17	1 723.14	1 886.53	1 085.06	787.07	931.64	1 140.45
Gross sales revenue	Rm		**4 883.68**	**4 926.57**	**4 016.33**	**3 872.89**	**4 170.50**	**4 565.96**	**2 626.17**	**1 904.94**	**2 254.83**	**2 760.22**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	414.46	219.60	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		119.47	99.14	71.18	53.38	68.63	96.60	129.64	124.56	147.44	180.48
OFF grade ore	Rm		297.56	332.02	285.03	297.56	303.83	300.69	62.64	0.00	0.00	0.00
Total plant costs	Rm		417.04	431.15	356.21	350.94	372.46	397.29	192.29	124.56	147.44	180.48
Total costs	Rm		-1380.24	-1403.64	-1248.28	-1233.73	-1279.99	-1335.75	-935.89	-800.12	-850.83	-924.09
Net sales revenue (Operating profit) before CAPEX	Rm		**3 503.43**	**3 522.93**	**2 768.05**	**2 639.16**	**2 890.50**	**3 230.21**	**1 690.28**	**1 104.83**	**1 404.00**	**1 836.14**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.74	71.51	68.92	68.14	69.31	70.75	64.36	58.00	62.27	66.52
Royalty rate (0.5+x/9)	%		8.47	8.45	8.16	8.07	8.20	8.36	7.65	6.94	7.42	7.89
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		341.86	344.86	281.14	271.10	291.93	319.62	183.83	132.20	157.84	193.22
Taxable income (Net sales revenue - Royalty)	Rm		3 161.58	3 178.07	2 486.91	2 368.06	2 598.57	2 910.59	1 506.44	972.62	1 246.16	1 642.92
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**885.24**	**889.86**	**696.34**	**663.06**	**727.60**	**814.97**	**421.80**	**272.33**	**348.92**	**460.02**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 276	2 288	1 791	1 705	1 871	2 096	1 085	700	897	1 183
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 069.40	1 891.09	1 345.29	1 164.54	1 161.72	1 182.93	556.59	326.69	380.52	456.06
NPV @ discount rate	Rm	**10 534.82**										

25m x 25m x 10m @ 63% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	9.5	9.7	1.6	0	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	11.6	12.4	5.4	5.1	4.9	5.8	7.1
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.61	2.16	1.55	1.17	1.50	2.11	2.83	2.72	3.22	3.94
OFF grade ore	Mt		4.36	4.87	4.18	4.36	4.45	0.73	0.00	0.00	0.00	0.00
Total product produced	Mt		6.97	7.03	5.73	5.53	5.95	2.84	2.83	2.72	3.22	3.94
Total lumpy produced	Mt		3.69	3.73	3.04	2.93	3.15	1.51	1.50	1.44	1.71	2.09
Total fines produced	Mt		3.28	3.30	2.69	2.60	2.80	1.34	1.33	1.28	1.51	1.85
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 814.67	2 839.40	2 314.78	2 232.11	2 403.64	1 148.12	1 142.71	1 097.90	1 299.55	1 590.83
Fines	Rm		1 981.76	1 999.16	1 629.79	1 571.59	1 692.35	808.37	804.56	773.01	914.99	1 120.08
Gross sales revenue	Rm		**4 796.43**	**4 838.56**	**3 944.58**	**3 803.70**	**4 095.99**	**1 956.49**	**1 947.27**	**1 870.91**	**2 214.55**	**2 710.91**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	358.79	383.53	167.02	157.74	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		117.34	97.37	69.90	52.43	67.41	94.87	127.33	122.33	144.80	177.26
OFF grade ore	Rm		292.25	326.08	279.94	292.25	298.40	49.22	0.00	0.00	0.00	0.00
Total plant costs	Rm		409.59	423.45	349.84	344.67	365.81	144.09	127.33	122.33	144.80	177.26
Total costs	Rm		-1372.79	-1395.94	-1241.91	-1227.46	-1273.34	-835.11	-809.07	-797.89	-848.20	-920.86
Net sales revenue (Operating profit) before CAPEX	Rm		**3 423.64**	**3 442.62**	**2 702.67**	**2 576.24**	**2 822.65**	**1 121.38**	**1 138.20**	**1 073.02**	**1 366.35**	**1 790.05**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.38	71.15	68.52	67.73	68.91	57.32	58.45	57.35	61.70	66.03
Royalty rate (0.5+x/9)	%		8.43	8.41	8.11	8.03	8.16	6.87	6.99	6.87	7.36	7.84
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		335.75	338.70	276.12	266.26	286.72	134.41	136.11	128.53	155.02	189.76
Taxable income (Net sales revenue - Royalty)	Rm		3 087.89	3 103.92	2 426.55	2 309.98	2 535.93	986.97	1 002.09	944.49	1 211.33	1 600.28
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**864.61**	**869.10**	**679.43**	**646.79**	**710.06**	**276.35**	**280.58**	**264.46**	**339.17**	**448.08**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 223	2 235	1 747	1 663	1 826	711	722	680	872	1 152
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 021.16	1 846.96	1 312.63	1 135.98	1 133.72	401.12	370.25	317.24	369.88	444.22
NPV @ discount rate	Rm	**9 353.17**										

50m x 50m x 10m @ 63% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	5.2
OFF grade ore	Mt		9.5	10.6	9.1	6.8	0	0	0	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	8.9	2.7	3.8	5.1	4.9	5.8	5.2
Average grade	%		63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.59	2.15	1.55	1.16	1.49	2.10	2.81	2.70	3.20	2.87
OFF grade ore	Mt		4.34	4.84	4.16	3.11	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		6.93	6.99	5.70	4.26	1.49	2.10	2.81	2.70	3.20	2.87
Total lumpy produced	Mt		3.67	3.71	3.02	2.26	0.79	1.11	1.49	1.43	1.70	1.52
Total fines produced	Mt		3.26	3.29	2.68	2.00	0.70	0.99	1.32	1.27	1.50	1.35
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 799.66	2 824.26	2 302.44	1 722.22	601.74	846.89	1 136.62	1 092.05	1 292.63	1 158.91
Fines	Rm		1 971.19	1 988.50	1 621.10	1 212.58	423.67	596.28	800.27	768.89	910.11	815.96
Gross sales revenue	Rm		**4 770.85**	**4 812.76**	**3 923.55**	**2 934.80**	**1 025.41**	**1 443.17**	**1 936.89**	**1 860.93**	**2 202.74**	**1 974.87**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	275.28	83.51	117.53	157.74	151.56	179.39	160.84
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		116.71	96.85	69.53	52.15	67.05	94.36	126.65	121.68	144.03	129.13
OFF grade ore	Rm		290.69	324.35	278.45	208.07	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		407.40	421.19	347.98	260.22	67.05	94.36	126.65	121.68	144.03	129.13
Total costs	Rm		-1370.61	-1393.68	-1240.05	-1059.50	-674.56	-735.90	-808.39	-797.24	-847.42	-813.97
Net sales revenue (Operating profit) before CAPEX	Rm		**3 400.25**	**3 419.08**	**2 683.50**	**1 875.31**	**350.85**	**707.27**	**1 128.50**	**1 063.70**	**1 355.31**	**1 160.90**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.27	71.04	68.39	63.90	34.22	49.01	58.26	57.16	61.53	58.78
Royalty rate (0.5+x/9)	%		8.42	8.39	8.10	7.60	4.30	5.95	6.97	6.85	7.34	7.03
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	4	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		333.96	336.89	274.65	205.44	44.09	85.87	135.00	127.47	154.19	138.24
Taxable income (Net sales revenue - Royalty)	Rm		3 066.29	3 082.19	2 408.85	1 669.87	306.76	621.41	993.50	936.22	1 201.12	1 022.66
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**858.56**	**863.01**	**674.48**	**467.56**	**85.89**	**173.99**	**278.18**	**262.14**	**336.31**	**286.35**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 208	2 219	1 734	1 202	221	447	715	674	865	736
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 007.02	1 834.03	1 303.06	821.19	137.14	252.55	367.07	314.46	366.76	283.88
NPV @ discount rate	Rm	**7 687.18**										

Appendix 2.4: Discounted cash flows at 64% cut-off grade

6.25m x 6.25m x 10m @ 64% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	5.8	0	0	0	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	7.9	2.7	3.8	5.1	4.9	5.8	7.1
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.67	2.22	1.59	1.19	1.54	2.16	2.90	2.79	3.30	4.04
OFF grade ore	Mt		4.47	4.99	4.28	2.73	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		7.15	7.21	5.88	3.93	1.54	2.16	2.90	2.79	3.30	4.04
Total lumpy produced	Mt		3.79	3.82	3.11	2.08	0.81	1.15	1.54	1.48	1.75	2.14
Total fines produced	Mt		3.36	3.39	2.76	1.84	0.72	1.02	1.36	1.31	1.55	1.90
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 886.17	2 911.53	2 373.59	1 585.30	620.33	873.06	1 171.74	1 125.79	1 332.57	1 631.25
Fines	Rm		2 032.10	2 049.95	1 671.20	1 116.18	436.76	614.71	825.00	792.65	938.24	1 148.53
Gross sales revenue	Rm		**4 918.27**	**4 961.48**	**4 044.78**	**2 701.47**	**1 057.10**	**1 487.77**	**1 996.74**	**1 918.44**	**2 270.80**	**2 779.78**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	244.35	83.51	117.53	157.74	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		120.32	99.84	71.68	53.76	69.12	97.28	130.56	125.44	148.48	181.76
OFF grade ore	Rm		299.67	334.37	287.05	182.96	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		419.99	434.21	358.73	236.72	69.12	97.28	130.56	125.44	148.48	181.76
Total costs	Rm		-1383.20	-1406.69	-1250.80	-1005.06	-676.63	-738.81	-812.30	-801.00	-851.88	-925.36
Net sales revenue (Operating profit) before CAPEX	Rm		**3 535.08**	**3 554.78**	**2 793.99**	**1 696.41**	**380.47**	**748.95**	**1 184.44**	**1 117.44**	**1 418.93**	**1 854.41**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.88	71.65	69.08	62.80	35.99	50.34	59.32	58.25	62.49	66.71
Royalty rate (0.5+x/9)	%		8.49	8.46	8.18	7.48	4.50	6.09	7.09	6.97	7.44	7.91
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	5	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		344.28	347.30	283.13	189.10	47.57	90.61	139.17	133.72	158.28	193.75
Taxable income (Net sales revenue - Royalty)	Rm		3 190.80	3 207.48	2 510.85	1 507.31	332.90	658.35	1 045.26	983.72	1 260.65	1 660.66
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**893.42**	**898.09**	**703.04**	**422.05**	**93.21**	**184.34**	**292.67**	**275.44**	**352.98**	**464.99**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 297	2 309	1 808	1 085	240	474	753	708	908	1 196
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 088.52	1 908.58	1 358.24	741.25	148.83	267.57	386.20	330.42	384.94	460.99
NPV @ discount rate	Rm	**8 075.52**										

12.5m x 12.5m x 10m @ 64% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	9.1	2.8	0	0	0	0	0	0
Total ore tonnes	Mt		14.2	14.5	11.9	4.9	2.7	3.8	5.1	4.9	5.8	7.1
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.65	2.20	1.58	1.19	1.53	2.15	2.88	2.77	3.28	4.01
OFF grade ore	Mt		4.44	4.96	4.25	1.31	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		7.10	7.16	5.84	2.50	1.53	2.15	2.88	2.77	3.28	4.01
Total lumpy produced	Mt		3.76	3.79	3.09	1.32	0.81	1.14	1.53	1.47	1.74	2.13
Total fines produced	Mt		3.34	3.36	2.74	1.17	0.72	1.01	1.35	1.30	1.54	1.89
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 865.87	2 891.04	2 356.89	1 007.74	615.97	866.92	1 163.50	1 117.87	1 323.19	1 619.77
Fines	Rm		2 017.80	2 035.53	1 659.44	709.53	433.69	610.38	819.20	787.07	931.64	1 140.45
Gross sales revenue	Rm		**4 883.68**	**4 926.57**	**4 016.33**	**1 717.26**	**1 049.66**	**1 477.30**	**1 982.69**	**1 904.94**	**2 254.83**	**2 760.22**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	368.07	151.56	83.51	117.53	157.74	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		119.47	99.14	71.18	53.38	68.63	96.60	129.64	124.56	147.44	180.48
OFF grade ore	Rm		297.56	332.02	285.03	87.70	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		417.04	431.15	356.21	141.08	68.63	96.60	129.64	124.56	147.44	180.48
Total costs	Rm		-1380.24	-1403.64	-1248.28	-816.64	-676.15	-738.13	-811.39	-800.12	-850.83	-924.09
Net sales revenue (Operating profit) before CAPEX	Rm		**3 503.43**	**3 522.93**	**2 768.05**	**900.62**	**373.52**	**739.17**	**1 171.31**	**1 104.83**	**1 404.00**	**1 836.14**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.74	71.51	68.92	52.45	35.58	50.04	59.08	58.00	62.27	66.52
Royalty rate (0.5+x/9)	%		8.47	8.45	8.16	6.33	4.45	6.06	7.06	6.94	7.42	7.89
Royalty rate must not exceed 7% for unrefined	%		7	7	7	6	4	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		341.86	344.86	281.14	108.70	46.71	89.52	138.19	132.20	157.16	192.39
Taxable income (Net sales revenue - Royalty)	Rm		3 161.58	3 178.07	2 486.91	791.92	326.81	649.65	1 033.12	972.62	1 246.84	1 643.75
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**885.24**	**889.86**	**696.34**	**221.74**	**91.51**	**181.90**	**289.27**	**272.33**	**349.11**	**460.25**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 276	2 288	1 791	570	235	468	744	700	898	1 183
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 069.40	1 891.09	1 345.29	389.44	146.10	264.03	381.71	326.69	380.72	456.29
NPV @ discount rate	Rm	**7 650.75**										

25m x 25m x 10m @ 64% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5.8	7.1
OFF grade ore	Mt		9.5	10.6	7.3	0	0	0	0	0	0	0
Total ore tonnes	Mt		14.2	14.5	10.1	2.1	2.7	3.8	5.1	4.9	5.8	7.1
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.61	2.16	1.55	1.17	1.50	2.11	2.83	2.72	3.22	3.94
OFF grade ore	Mt		4.36	4.87	3.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		6.97	7.03	4.91	1.17	1.50	2.11	2.83	2.72	3.22	3.94
Total lumpy produced	Mt		3.69	3.73	2.60	0.62	0.79	1.12	1.50	1.44	1.71	2.09
Total fines produced	Mt		3.28	3.30	2.31	0.55	0.70	0.99	1.33	1.28	1.51	1.85
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 814.67	2 839.40	1 981.01	470.53	604.97	851.43	1 142.71	1 097.90	1 299.55	1 590.83
Fines	Rm		1 981.76	1 999.16	1 394.79	331.29	425.94	599.48	804.56	773.01	914.99	1 120.08
Gross sales revenue	Rm		**4 796.43**	**4 838.56**	**3 375.80**	**801.82**	**1 030.91**	**1 450.91**	**1 947.27**	**1 870.91**	**2 214.55**	**2 710.91**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	448.49	312.39	64.95	83.51	117.53	157.74	151.56	179.39	219.60
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		117.34	97.37	69.90	52.43	67.41	94.87	127.33	122.33	144.80	177.26
OFF grade ore	Rm		292.25	326.08	224.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		409.59	423.45	294.47	52.43	67.41	94.87	127.33	122.33	144.80	177.26
Total costs	Rm		-1372.79	-1395.94	-1130.87	-641.38	-674.92	-736.40	-809.07	-797.89	-848.20	-920.86
Net sales revenue (Operating profit) before CAPEX	Rm		**3 423.64**	**3 442.62**	**2 244.93**	**160.44**	**355.99**	**714.50**	**1 138.20**	**1 073.02**	**1 366.35**	**1 790.05**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.38	71.15	66.50	20.01	34.53	49.25	58.45	57.35	61.70	66.03
Royalty rate (0.5+x/9)	%		8.43	8.41	7.89	2.72	4.34	5.97	6.99	6.87	7.36	7.84
Royalty rate must not exceed 7% for unrefined	%		7	7	7	3	4	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		335.75	338.70	236.31	21.81	44.74	86.62	136.11	128.53	154.35	188.95
Taxable income (Net sales revenue - Royalty)	Rm		3 087.89	3 103.92	2 008.63	138.63	311.25	627.89	1 002.09	944.49	1 212.00	1 601.10
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	0%
Tax	Rm		**864.61**	**869.10**	**562.42**	**38.82**	**87.15**	**175.81**	**280.58**	**264.46**	**339.36**	**448.31**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 223	2 235	1 446	100	224	452	722	680	873	1 153
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.00
PV @ discount rate	Rm		2 021.16	1 846.96	1 086.56	68.17	139.15	255.19	370.25	317.24	370.08	-
NPV @ discount rate	Rm	**6 474.76**										

50m x 50m x 10m @ 64% cut-off grade	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Project year	0	1	2	3	4	5	6	7	8	9	10
Tonnes produced												
ON grade ore	Mt		4.7	3.9	2.8	2.1	2.7	3.8	5.1	4.9	5	0
OFF grade ore	Mt		9.5	9.5	0	0	0	0	0	0	0	0
Total ore tonnes	Mt		14.2	13.4	2.8	2.1	2.7	3.8	5.1	4.9	5	0
Average grade	%		63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.59	2.15	1.55	1.16	1.49	2.10	2.81	2.70	2.76	0.00
OFF grade ore	Mt		4.34	4.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		6.93	6.49	1.55	1.16	1.49	2.10	2.81	2.70	2.76	0.00
Total lumpy produced	Mt		3.67	3.44	0.82	0.61	0.79	1.11	1.49	1.43	1.46	0.00
Total fines produced	Mt		3.26	3.05	0.73	0.54	0.70	0.99	1.32	1.27	1.30	0.00
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 799.66	2 621.37	624.03	468.02	601.74	846.89	1 136.62	1 092.05	1 114.33	-
Fines	Rm		1 971.19	1 845.66	439.36	329.52	423.67	596.28	800.27	768.89	784.58	-
Gross sales revenue	Rm		**4 770.85**	**4 467.03**	**1 063.39**	**797.54**	**1 025.41**	**1 443.17**	**1 936.89**	**1 860.93**	**1 898.91**	-
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		439.21	414.46	86.60	64.95	83.51	117.53	157.74	151.56	154.65	0.00
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		116.71	96.85	69.53	52.15	67.05	94.36	126.65	121.68	124.16	0.00
OFF grade ore	Rm		290.69	290.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		407.40	387.54	69.53	52.15	67.05	94.36	126.65	121.68	124.16	0.00
Total costs	Rm		-1370.61	-1326.00	-680.14	-641.10	-674.56	-735.90	-808.39	-797.24	-802.81	-524.00
Net sales revenue (Operating profit) before CAPEX	Rm		**3 400.25**	**3 141.03**	**383.26**	**156.44**	**350.85**	**707.27**	**1 128.50**	**1 063.70**	**1 096.10**	**- 524.00**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			71.27	70.32	36.04	19.62	34.22	49.01	58.26	57.16	57.72	0.00
Royalty rate (0.5+x/9)	%		8.42	8.31	4.50	2.68	4.30	5.95	6.97	6.85	6.91	0.50
Royalty rate must not exceed 7% for unrefined	%		7	7	7	3	4	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		333.96	312.69	74.44	21.69	44.09	85.87	135.00	127.47	132.35	0.00
Taxable income (Net sales revenue - Royalty)	Rm		3 066.29	2 828.34	308.82	134.75	306.76	621.41	993.50	936.22	963.74	- 524.00
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**858.56**	**791.93**	**86.47**	**37.73**	**85.89**	**173.99**	**278.18**	**262.14**	**269.85**	**-146.72**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		2 208	2 036	222	97	221	447	715	674	694	- 377
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		2 007.02	1 682.98	167.05	66.27	137.14	252.55	367.07	314.46	294.28	- 145.46
NPV @ discount rate	Rm	**5 143.37**										

Appendix 3

Appendix 3.1: Discounted cash flows at 53% cut-off grade when the effects of selective mining are considered

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x10m @ 53% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		2.538	2.106	1.512	1.134	1.458	2.052	2.754	2.646	3.132	3.834
OFF grade ore	Mt		5.13	5.724	4.914	5.13	5.238	5.184	4.158	4.374	4.752	3.942
Total ore tonnes	Mt		7.668	7.83	6.426	6.264	6.696	7.236	6.912	7.02	7.884	7.776
Average grade	%		62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		1.37	1.13	0.81	0.61	0.79	1.11	1.48	1.43	1.69	2.07
OFF grade ore	Mt		2.29	2.55	2.19	2.29	2.34	2.31	1.85	1.95	2.12	1.76
Total product produced	Mt		3.66	3.69	3.01	2.90	3.12	3.42	3.34	3.38	3.81	3.82
Total lumpy produced	Mt		1.94	1.95	1.59	1.54	1.65	1.81	1.77	1.79	2.02	2.03
Total fines produced	Mt		1.72	1.73	1.41	1.36	1.47	1.61	1.57	1.59	1.79	1.80
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		1 476.31	1 489.27	1 214.11	1 170.75	1 260.72	1 380.26	1 348.25	1 363.65	1 537.50	1 544.39
Fines	Rm		1 039.44	1 048.57	854.83	824.30	887.65	971.82	949.28	960.12	1 082.52	1 087.37
Gross sales revenue	Rm		**2 515.74**	**2 537.84**	**2 068.95**	**1 995.05**	**2 148.36**	**2 352.08**	**2 297.52**	**2 323.77**	**2 620.02**	**2 631.76**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		237.17	242.18	198.76	193.75	207.11	223.81	213.79	217.13	243.85	240.51
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		61.55	51.07	36.67	27.50	35.36	49.76	66.78	64.16	75.95	92.97
OFF grade ore	Rm		153.28	171.03	146.83	153.28	156.51	154.90	124.24	130.69	141.99	117.79
Total plant costs	Rm		214.83	222.10	183.49	180.78	191.87	204.66	191.02	194.86	217.94	210.76
Total costs	Rm		-976.00	-988.28	-906.25	-898.53	-922.97	-952.47	-928.81	-935.99	-985.79	-975.27
Net sales revenue (Operating profit) before CAPEX	Rm		**1 539.74**	**1 549.56**	**1 162.69**	**1 096.53**	**1 225.39**	**1 399.61**	**1 368.71**	**1 387.78**	**1 634.23**	**1 656.49**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			61.20	61.06	56.20	54.96	57.04	59.51	59.57	59.72	62.37	62.94
Royalty rate (0.5+x/9)	%		7.30	7.28	6.74	6.61	6.84	7.11	7.12	7.14	7.43	7.49
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		176.10	177.65	144.83	139.65	150.39	164.65	160.83	162.66	183.40	184.22
Taxable income (Net sales revenue - Royalty)	Rm		1363.64	1371.91	1017.87	956.87	1075.00	1234.97	1207.89	1225.11	1450.83	1472.27
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**381.82**	**384.13**	**285.00**	**267.92**	**301.00**	**345.79**	**338.21**	**343.03**	**406.23**	**412.23**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		982	988	733	689	774	889	870	882	1 045	1 060
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		892.57	816.34	550.61	470.56	480.59	501.92	446.28	411.50	443.01	408.69
NPV @ discount rate	Rm	**5 422.07**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
12.5m x 12.5m x10m @ 53% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		3.619	3.003	2.156	1.617	2.079	2.926	3.927	3.773	4.466	5.467
OFF grade ore	Mt		7.315	8.162	7.007	7.315	7.469	7.392	5.929	6.237	6.776	5.621
Total ore tonnes	Mt		10.934	11.165	9.163	8.932	9.548	10.318	9.856	10.01	11.242	11.088
Average grade	%		62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		1.94	1.61	1.16	0.87	1.12	1.57	2.11	2.03	2.40	2.94
OFF grade ore	Mt		3.25	3.63	3.12	3.25	3.32	3.29	2.64	2.77	3.01	2.50
Total product produced	Mt		5.20	5.24	4.27	4.12	4.44	4.86	4.75	4.80	5.41	5.44
Total lumpy produced	Mt		2.75	2.78	2.26	2.18	2.35	2.57	2.52	2.54	2.87	2.88
Total fines produced	Mt		2.44	2.46	2.01	1.94	2.09	2.28	2.23	2.26	2.54	2.55
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 098.64	2 117.08	1 725.92	1 664.28	1 792.17	1 962.11	1 916.60	1 938.50	2 185.63	2 195.43
Fines	Rm		1 477.62	1 490.59	1 215.19	1 171.79	1 261.83	1 381.49	1 349.44	1 364.86	1 538.86	1 545.76
Gross sales revenue	Rm		**3 576.26**	**3 607.67**	**2 941.11**	**2 836.07**	**3 054.01**	**3 343.60**	**3 266.05**	**3 303.35**	**3 724.49**	**3 741.18**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		338.19	345.33	283.41	276.27	295.32	319.14	304.85	309.61	347.72	342.95
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		87.49	72.60	52.12	39.09	50.26	70.74	94.94	91.21	107.97	132.17
OFF grade ore	Rm		217.90	243.13	208.73	217.90	222.49	220.19	176.61	185.79	201.84	167.44
Total plant costs	Rm		305.39	315.73	260.85	256.99	272.75	290.93	271.55	277.00	309.81	299.60
Total costs	Rm		-1167.58	-1185.06	-1068.26	-1057.26	-1092.07	-1134.07	-1100.40	-1110.61	-1181.53	-1166.56
Net sales revenue (Operating profit) before CAPEX	Rm		**2 408.68**	**2 422.61**	**1 872.85**	**1 778.81**	**1 961.94**	**2 209.54**	**2 165.65**	**2 192.74**	**2 542.97**	**2 574.63**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			67.35	67.15	63.68	62.72	64.24	66.08	66.31	66.38	68.28	68.82
Royalty rate (0.5+x/9)	%		7.98	7.96	7.58	7.47	7.64	7.84	7.87	7.88	8.09	8.15
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		250.34	252.54	205.88	198.53	213.78	234.05	228.62	231.23	260.71	261.88
Taxable income (Net sales revenue - Royalty)	Rm		2 158.34	2 170.07	1 666.98	1 580.29	1 748.16	1 975.48	1 937.03	1 961.51	2 282.25	2 312.74
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**604.34**	**607.62**	**466.75**	**442.48**	**489.48**	**553.14**	**542.37**	**549.22**	**639.03**	**647.57**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		**1 554**	**1 562**	**1 200**	**1 138**	**1 259**	**1 422**	**1 395**	**1 412**	**1 643**	**1 665**
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 412.73	1 291.28	901.75	777.14	781.54	802.88	715.68	658.84	696.89	642.00
NPV @ discount rate	Rm	**8 680.72**										

Appendix 3.2: Discounted cash flows at 60% cut-off grade when the effects of selective mining are considered

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x10m @ 60% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		2.538	2.106	1.512	1.134	1.458	2.052	2.754	2.646	3.132	3.834
OFF grade ore	Mt		5.13	5.724	4.914	5.13	5.238	5.184	4.158	4.374	4.752	3.942
Total ore tonnes	Mt		7.668	7.83	6.426	6.264	6.696	7.236	6.912	7.02	7.884	7.776
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		1.41	1.17	0.84	0.63	0.81	1.14	1.53	1.47	1.74	2.13
OFF grade ore	Mt		2.36	2.64	2.26	2.36	2.41	2.39	1.91	2.01	2.19	1.81
Total product produced	Mt		3.77	3.81	3.10	2.99	3.22	3.53	3.45	3.49	3.93	3.95
Total lumpy produced	Mt		2.00	2.02	1.64	1.59	1.71	1.87	1.83	1.85	2.08	2.09
Total fines produced	Mt		1.77	1.79	1.46	1.41	1.51	1.66	1.62	1.64	1.85	1.86
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		1 523.97	1 537.36	1 253.32	1 208.55	1 301.42	1 424.83	1 391.78	1 407.68	1 587.14	1 594.25
Fines	Rm		1 073.00	1 082.43	882.43	850.92	916.31	1 003.20	979.93	991.12	1 117.48	1 122.48
Gross sales revenue	Rm		**2 596.98**	**2 619.79**	**2 135.75**	**2 059.47**	**2 217.73**	**2 428.03**	**2 371.71**	**2 398.80**	**2 704.62**	**2 716.74**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		237.17	242.18	198.76	193.75	207.11	223.81	213.79	217.13	243.85	240.51
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		63.53	52.72	37.85	28.39	36.50	51.37	68.94	66.24	78.40	95.97
OFF grade ore	Rm		158.23	176.55	151.57	158.23	161.56	159.90	128.25	134.91	146.57	121.59
Total plant costs	Rm		221.77	229.27	189.42	186.62	198.06	211.27	197.19	201.15	224.98	217.56
Total costs	Rm		-982.94	-995.46	-912.18	-904.37	-929.17	-959.07	-934.98	-942.28	-992.83	-982.08
Net sales revenue (Operating profit) before CAPEX	Rm		**1 614.04**	**1 624.33**	**1 223.57**	**1 155.11**	**1 288.56**	**1 468.95**	**1 436.73**	**1 456.52**	**1 711.79**	**1 734.66**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			62.15	62.00	57.29	56.09	58.10	60.50	60.58	60.72	63.29	63.85
Royalty rate (0.5+x/9)	%		7.41	7.39	6.87	6.73	6.96	7.22	7.23	7.25	7.53	7.59
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		181.79	183.39	149.50	144.16	155.24	169.96	166.02	167.92	189.32	190.17
Taxable income (Net sales revenue - Royalty)	Rm		1 432.25	1 440.95	1 074.07	1 010.94	1 133.32	1 298.99	1 270.71	1 288.60	1 522.47	1 544.49
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**401.03**	**403.47**	**300.74**	**283.06**	**317.33**	**363.72**	**355.80**	**360.81**	**426.29**	**432.46**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 031	1 037	773	728	816	935	915	928	1 096	1 112
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		937.47	857.42	581.02	497.15	506.67	527.94	469.49	432.82	464.89	428.74
NPV @ discount rate	Rm	**5 703.60**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
12.5m x 12.5m x10m @ 60% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		3.619	3.003	2.156	1.617	2.079	2.926	3.927	3.773	4.466	5.467
OFF grade ore	Mt		7.315	8.162	7.007	7.315	7.469	7.392	5.929	6.237	6.776	5.621
Total ore tonnes	Mt		10.934	11.165	9.163	8.932	9.548	10.318	9.856	10.01	11.242	11.088
Average grade	%		64%	64%	64%	64%	64%	64%	64%	64%	64%	64%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.01	1.67	1.20	0.90	1.16	1.63	2.18	2.10	2.48	3.04
OFF grade ore	Mt		3.36	3.75	3.22	3.36	3.43	3.40	2.73	2.87	3.12	2.58
Total product produced	Mt		5.37	5.42	4.42	4.26	4.59	5.03	4.91	4.96	5.60	5.62
Total lumpy produced	Mt		2.85	2.87	2.34	2.26	2.43	2.66	2.60	2.63	2.97	2.98
Total fines produced	Mt		2.53	2.55	2.08	2.00	2.16	2.36	2.31	2.33	2.63	2.64
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 170.70	2 189.76	1 785.18	1 721.42	1 853.70	2 029.48	1 982.41	2 005.05	2 260.67	2 270.80
Fines	Rm		1 528.34	1 541.77	1 256.91	1 212.02	1 305.16	1 428.92	1 395.77	1 411.72	1 591.69	1 598.83
Gross sales revenue	Rm		**3 699.04**	**3 731.53**	**3 042.09**	**2 933.44**	**3 158.86**	**3 458.39**	**3 378.18**	**3 416.76**	**3 852.36**	**3 869.62**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		338.19	345.33	283.41	276.27	295.32	319.14	304.85	309.61	347.72	342.95
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		90.49	75.09	53.91	40.43	51.99	73.16	98.20	94.34	111.67	136.70
OFF grade ore	Rm		225.38	251.48	215.89	225.38	230.13	227.75	182.68	192.17	208.77	173.19
Total plant costs	Rm		315.88	326.57	269.80	265.81	282.11	300.92	280.87	286.51	320.45	309.89
Total costs	Rm		-1178.06	-1195.90	-1077.21	-1066.08	-1101.43	-1144.05	-1109.72	-1120.12	-1192.16	-1176.84
Net sales revenue (Operating profit) before CAPEX	Rm		**2 520.98**	**2 535.63**	**1 964.87**	**1 867.36**	**2 057.42**	**2 314.34**	**2 268.46**	**2 296.64**	**2 660.20**	**2 692.78**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			68.15	67.95	64.59	63.66	65.13	66.92	67.15	67.22	69.05	69.59
Royalty rate (0.5+x/9)	%		8.07	8.05	7.68	7.57	7.74	7.94	7.96	7.97	8.17	8.23
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		258.93	261.21	212.95	205.34	221.12	242.09	236.47	239.17	269.67	270.87
Taxable income (Net sales revenue - Royalty)	Rm		2 262.04	2 274.42	1 751.93	1 662.02	1 836.30	2 072.25	2 031.99	2 057.47	2 390.54	2 421.91
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**633.37**	**636.84**	**490.54**	**465.37**	**514.17**	**580.23**	**568.96**	**576.09**	**669.35**	**678.13**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 629	1 638	1 261	1 197	1 322	1 492	1 463	1 481	1 721	1 744
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 480.61	1 353.38	947.70	817.33	820.94	842.21	750.77	691.07	729.95	672.30
NPV @ discount rate	Rm	**9 106.26**										

Appendix 3.3: Discounted cash flows at 63% cut-off grade when the effects of selective mining are considered

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x10m @ 63% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		2.538	2.106	1.512	1.134	1.458	2.052	2.754	2.646	3.132	3.834
OFF grade ore	Mt		5.13	5.724	4.914	5.13	5.238	5.184	3.942	0	0	0
Total ore tonnes	Mt		7.668	7.83	6.426	6.264	6.696	7.236	6.696	2.646	3.132	3.834
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		1.43	1.19	0.85	0.64	0.82	1.16	1.56	1.49	1.77	2.17
OFF grade ore	Mt		2.40	2.68	2.30	2.40	2.45	2.42	1.84	0.00	0.00	0.00
Total product produced	Mt		3.83	3.87	3.15	3.04	3.27	3.58	3.40	1.49	1.77	2.17
Total lumpy produced	Mt		2.03	2.05	1.67	1.61	1.73	1.90	1.80	0.79	0.94	1.15
Total fines produced	Mt		1.80	1.82	1.48	1.43	1.54	1.68	1.60	0.70	0.83	1.02
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		1 547.81	1 561.40	1 272.92	1 227.46	1 321.78	1 447.11	1 372.76	603.74	714.63	874.81
Fines	Rm		1 089.78	1 099.35	896.24	864.23	930.64	1 018.89	966.53	425.08	503.16	615.94
Gross sales revenue	Rm		**2 637.59**	**2 660.76**	**2 169.15**	**2 091.68**	**2 252.41**	**2 466.00**	**2 339.30**	**1 028.83**	**1 217.80**	**1 490.75**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		237.17	242.18	198.76	193.75	207.11	223.81	207.11	81.84	96.87	118.59
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		64.53	53.54	38.44	28.83	37.07	52.17	70.02	67.27	79.63	97.48
OFF grade ore	Rm		160.71	179.32	153.94	160.71	164.09	162.40	123.49	0.00	0.00	0.00
Total plant costs	Rm		225.23	232.86	192.38	189.54	201.16	214.57	193.51	67.27	79.63	97.48
Total costs	Rm		-986.41	-999.04	-915.14	-907.28	-932.27	-962.38	-924.62	-673.11	-700.50	-740.06
Net sales revenue (Operating profit) before CAPEX	Rm		**1 651.19**	**1 661.72**	**1 254.01**	**1 184.40**	**1 320.15**	**1 503.62**	**1 414.68**	**355.71**	**517.29**	**750.69**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			62.60	62.45	57.81	56.62	58.61	60.97	60.47	34.57	42.48	50.36
Royalty rate (0.5+x/9)	%		7.46	7.44	6.92	6.79	7.01	7.27	7.22	4.34	5.22	6.10
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		184.63	186.25	151.84	146.42	157.67	172.62	163.75	71.40	85.25	104.35
Taxable income (Net sales revenue - Royalty)	Rm		1 466.55	1 475.47	1 102.17	1 037.98	1 162.48	1 331.00	1 250.93	284.31	432.05	646.34
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**410.64**	**413.13**	**308.61**	**290.63**	**325.49**	**372.68**	**350.26**	**79.61**	**120.97**	**180.97**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 056	1 062	794	747	837	958	901	205	311	465
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		959.93	877.96	596.22	510.45	519.70	540.95	462.19	95.50	131.93	179.42
NPV @ discount rate	Rm	**4 874.23**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
12.5m x 12.5 x10m @ 63% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		3.619	3.003	2.156	1.617	2.079	2.926	3.927	3.773	4.466	5.467
OFF grade ore	Mt		7.315	8.162	7.007	7.315	7.469	7.392	1.54	0	0	0
Total ore tonnes	Mt		10.934	11.165	9.163	8.932	9.548	10.318	5.467	3.773	4.466	5.467
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.04	1.70	1.22	0.91	1.17	1.65	2.22	2.13	2.52	3.09
OFF grade ore	Mt		3.42	3.82	3.28	3.42	3.49	3.46	0.72	0.00	0.00	0.00
Total product produced	Mt		5.46	5.51	4.49	4.33	4.67	5.11	2.94	2.13	2.52	3.09
Total lumpy produced	Mt		2.90	2.92	2.38	2.30	2.47	2.71	1.56	1.13	1.34	1.64
Total fines produced	Mt		2.57	2.59	2.11	2.04	2.19	2.40	1.38	1.00	1.19	1.45
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 206.72	2 226.10	1 814.81	1 749.99	1 884.47	2 063.16	1 186.65	860.76	1 018.86	1 247.22
Fines	Rm		1 553.71	1 567.36	1 277.77	1 232.13	1 326.82	1 452.63	835.50	606.04	717.36	878.15
Gross sales revenue	Rm		**3 760.43**	**3 793.46**	**3 092.57**	**2 982.13**	**3 211.28**	**3 515.79**	**2 022.15**	**1 466.81**	**1 736.22**	**2 125.37**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		338.19	345.33	283.41	276.27	295.32	319.14	169.09	116.70	138.13	169.09
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		92.00	76.34	54.81	41.10	52.85	74.38	99.82	95.91	113.53	138.97
OFF grade ore	Rm		229.12	255.65	219.47	229.12	233.95	231.53	48.24	0.00	0.00	0.00
Total plant costs	Rm		321.12	331.99	274.28	270.23	286.79	305.91	148.06	95.91	113.53	138.97
Total costs	Rm		-1183.31	-1201.32	-1081.69	-1070.49	-1106.11	-1149.05	-841.16	-736.61	-775.66	-832.07
Net sales revenue (Operating profit) before CAPEX	Rm		**2 577.12**	**2 592.14**	**2 010.88**	**1 911.63**	**2 105.17**	**2 366.74**	**1 180.99**	**730.20**	**960.56**	**1 293.30**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			68.53	68.33	65.02	64.10	65.56	67.32	58.40	49.78	55.32	60.85
Royalty rate (0.5+x/9)	%		8.11	8.09	7.72	7.62	7.78	7.98	6.99	6.03	6.65	7.26
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	7	7	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		263.23	265.54	216.48	208.75	224.79	246.11	141.55	101.80	121.54	148.78
Taxable income (Net sales revenue - Royalty)	Rm		2 313.89	2 326.60	1 794.40	1 702.88	1 880.38	2 120.64	1 039.44	628.40	839.02	1 144.53
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**647.89**	**651.45**	**502.43**	**476.81**	**526.51**	**593.78**	**291.04**	**175.95**	**234.93**	**320.47**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 666	1 675	1 292	1 226	1 354	1 527	748	452	604	824
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 514.55	1 384.42	970.68	837.43	840.65	861.87	384.05	211.07	256.20	317.71
NPV @ discount rate	Rm	**7 578.62**										

Appendix 3.4: Discounted cash flows at 64% cut-off grade when the effects of selective mining are considered

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6.25m x 6.25m x10m @ 64% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		2.538	2.106	1.512	1.134	1.458	2.052	2.754	2.646	3.132	3.834
OFF grade ore	Mt		5.13	5.724	4.914	3.132	0	0	0	0	0	0
Total ore tonnes	Mt		7.668	7.83	6.426	4.266	1.458	2.052	2.754	2.646	3.132	3.834
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		1.44	1.20	0.86	0.65	0.83	1.17	1.57	1.51	1.78	2.18
OFF grade ore	Mt		2.42	2.69	2.31	1.47	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		3.86	3.89	3.17	2.12	0.83	1.17	1.57	1.51	1.78	2.18
Total lumpy produced	Mt		2.05	2.06	1.68	1.12	0.44	0.62	0.83	0.80	0.94	1.16
Total fines produced	Mt		1.81	1.83	1.49	1.00	0.39	0.55	0.74	0.71	0.84	1.03
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		1 558.53	1 572.22	1 281.74	856.06	334.98	471.45	632.74	607.93	719.59	880.87
Fines	Rm		1 097.33	1 106.97	902.45	602.74	235.85	331.94	445.50	428.03	506.65	620.21
Gross sales revenue	Rm		**2 655.87**	**2 679.20**	**2 184.18**	**1 458.80**	**570.83**	**803.39**	**1 078.24**	**1 035.96**	**1 226.23**	**1 501.08**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		237.17	242.18	198.76	131.95	45.10	63.47	85.18	81.84	96.87	118.59
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		64.97	53.91	38.71	29.03	37.33	52.53	70.50	67.74	80.18	98.15
OFF grade ore	Rm		161.82	180.56	155.01	98.80	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		226.79	234.47	193.72	127.83	37.33	52.53	70.50	67.74	80.18	98.15
Total costs	Rm		-987.97	-1000.65	-916.47	-783.77	-606.42	-640.00	-679.68	-673.58	-701.05	-740.74
Net sales revenue (Operating profit) before CAPEX	Rm		**1 667.90**	**1 678.54**	**1 267.71**	**675.02**	**- 35.59**	**163.39**	**398.56**	**362.38**	**525.18**	**760.34**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			62.80	62.65	58.04	46.27	-6.23	20.34	36.96	34.98	42.83	50.65
Royalty rate (0.5+x/9)	%		7.48	7.46	6.95	5.64	-0.19	2.76	4.61	4.39	5.26	6.13
Royalty rate must not exceed 7% for unrefined	%		7	7	7	7	5	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		185.91	187.54	152.89	102.12	25.69	48.93	75.15	72.21	85.47	104.63
Taxable income (Net sales revenue - Royalty)	Rm		1 481.99	1 491.00	1 114.82	572.91	- 61.28	114.47	323.40	290.17	439.71	655.72
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**414.96**	**417.48**	**312.15**	**160.41**	**-17.16**	**32.05**	**90.55**	**81.25**	**123.12**	**183.60**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 067	1 074	803	412	- 44	82	233	209	317	472
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		970.03	887.21	603.06	281.74	- 27.39	46.52	119.49	97.46	134.27	182.02
NPV @ discount rate	Rm	**3 294.40**										

	Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
12.5m x 12.5m x10m @ 64% cog (selective mining considered)	Project year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes produced												
ON grade ore	Mt		3.619	3.003	2.156	1.617	2.079	2.926	3.927	3.773	4.466	5.467
OFF grade ore	Mt		7.315	8.162	7.007	2.156	0	0	0	0	0	0
Total ore tonnes	Mt		10.934	11.165	9.163	3.773	2.079	2.926	3.927	3.773	4.466	5.467
Average grade	%		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
Recovery												
ON grade ore	%		87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
OFF grade ore	%		72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
Product produced												
Lumpy	%		53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
Fines	%		47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
ON grade ore	Mt		2.04	1.70	1.22	0.91	1.17	1.65	2.22	2.13	2.52	3.09
OFF grade ore	Mt		3.42	3.82	3.28	1.01	0.00	0.00	0.00	0.00	0.00	0.00
Total product produced	Mt		5.46	5.51	4.49	1.92	1.17	1.65	2.22	2.13	2.52	3.09
Total lumpy produced	Mt		2.90	2.92	2.38	1.02	0.62	0.88	1.18	1.13	1.34	1.64
Total fines produced	Mt		2.57	2.59	2.11	0.90	0.55	0.78	1.04	1.00	1.19	1.45
Market inputs												
Exchange rate	$/t		14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Lumpy price	R/t		762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00	762.00
Fines price	R/t		605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00	605.00
Revenue												
Lumpy	Rm		2 206.72	2 226.10	1 814.81	775.96	474.30	667.53	895.89	860.76	1 018.86	1 247.22
Fines	Rm		1 553.71	1 567.36	1 277.77	546.34	333.94	469.99	630.78	606.04	717.36	878.15
Gross sales revenue	Rm		**3 760.43**	**3 793.46**	**3 092.57**	**1 322.29**	**808.24**	**1 137.52**	**1 526.67**	**1 466.81**	**1 736.22**	**2 125.37**
Costs												
Total fixed costs	Rm		524	524	524	524	524	524	524	524	524	524
Unit variable costs:												
Mining costs	R/t		30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
Total Mining costs	Rm		338.19	345.33	283.41	116.70	64.30	90.50	121.46	116.70	138.13	169.09
Plant costs:												
ON grade ore	R/t		45	45	45	45	45	45	45	45	45	45
OFF grade ore	R/t		67	67	67	67	67	67	67	67	67	67
ON grade ore	Rm		92.00	76.34	54.81	41.10	52.85	74.38	99.82	95.91	113.53	138.97
OFF grade ore	Rm		229.12	255.65	219.47	67.53	0.00	0.00	0.00	0.00	0.00	0.00
Total plant costs	Rm		321.12	331.99	274.28	108.64	52.85	74.38	99.82	95.91	113.53	138.97
Total costs	Rm		-1183.31	-1201.32	-1081.69	-749.33	-641.15	-688.88	-745.29	-736.61	-775.66	-832.07
Net sales revenue (Operating profit) before CAPEX	Rm		**2 577.12**	**2 592.14**	**2 010.88**	**572.96**	**167.09**	**448.64**	**781.39**	**730.20**	**960.56**	**1 293.30**
Capital Expenditure (CAPEX)			-	-	-	-	-	-	-	-	-	-
Unredeemed CAPEX			-	-	-	-	-	-	-	-	-	-
Royalties and taxes												
Royalty (x)			68.53	68.33	65.02	43.33	20.67	39.44	51.18	49.78	55.32	60.85
Royalty rate (0.5+x/9)	%		8.11	8.09	7.72	5.31	2.80	4.88	6.19	6.03	6.65	7.26
Royalty rate must not exceed 7% for unrefined	%		7	7	7	6	4	6	7	7	7	7
Royalty to be paid (rate xtotal revenue)	Rm		263.23	265.54	216.48	83.70	35.97	68.93	106.41	101.80	121.01	148.14
Taxable income (Net sales revenue - Royalty)	Rm		2 313.89	2 326.60	1 794.40	489.26	131.12	379.71	674.98	628.40	839.54	1 145.17
Tax rate	%		28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
Tax	Rm		**647.89**	**651.45**	**502.43**	**136.99**	**36.71**	**106.32**	**188.99**	**175.95**	**235.07**	**320.65**
Cashflow (operating profit -royalty to be paid-taxable income)	Rm		1 666	1 675	1 292	352	94	273	486	452	604	825
Discount rate	%	10%										
Discount factor			0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39
PV @ discount rate	Rm		1 514.55	1 384.42	970.68	240.60	58.62	154.32	249.39	211.07	256.36	317.89
NPV @ discount rate	Rm	**5 357.89**										