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# Conceptual Planning of North Block Nickel Ore Mine PT Pacific Ore Resources, Bombana Regency, Southeast Sulawesi Province

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**ABSTRACT**

PT Pacific Ore Resources, a nickel laterite mining company in North Kabaena, Bombana Regency, Southeast Sulawesi Province, is conducting a study to determine optimal mining boundaries, pit design, production scheduling, cash flow, and sensitivity analysis in the North Block. The study uses quantitative methods and data processing with Micromine v.2023 and Microsoft Excel software. The report shows that the company has 262,996 tons of laterite nickel ore resources, with the optimal pit limit in pit shell 6 at USD 961.991. The evaluation of ore reserves in the pit design revealed 216,771 tons with an overburden of 683.255 BCM, requiring a waste dump design to accommodate up to 685.763 BCM of waste material. The mine haul road design includes new and existing roads with a road length of 687.31 meters and 5315.42 meters. The cash flow analysis results show an NPV value of USD 1,050,838.64, an IRR of 37.94%, and PBP is 70 days. The sensitivity analysis shows that changes in nickel prices affect the NPV most compared to changes in operating and capital costs.

## 1. INTRODUCTION

PT Pacific Ore Resources is a mining company in Southeast Sulawesi. This company holds a mining business permit (IUP) to carry out nickel ore mining activities in Larolanu Village, North Kabaena District, Bombana Regency, Southeast Sulawesi Province, covering an area of 2,672 Ha based on decree 583/DPM-PTSP/VII/2018. Currently, the division of the company's work area is divided into two blocks, namely the North and South Blocks. The South block is the focus of the mining production process. This block has several pits, namely Pit Kratos and Pit Luna. Meanwhile, the North Block is still in the mining exploration and planning stage.

Planning is determining the requirements for achieving the target activities and the technical sequence of implementing various activities to achieve the desired goals and object [1]. The concept of mine planning includes planning and designing a mine to obtain and transport minerals of economic value [2]. The mine planning process is a circular or iterative process. Elements of the mine planning cycle are developing the mine design and managing the layout of the mine (depth, stripping ratio, ore grade, selling price, spacing, etc.); determination of heavy equipment; production scheduling; estimation of mining costs and construction of financial models [3], [4], [5].

Determination of mining pit boundaries is an initial step that needs to be carried out before designing mine designs and mining directions in the mine planning stage [6]. Determination of mining pit boundaries is an attempt to determine the best mine boundaries and determine optimum reserves that provide the best profit margins [7]. The purpose of determining pit boundaries is to determine the ultimate opening limit of the ore body and the associated grade and tonnage, which will maximize some economic or technical criteria while meeting practical operational requirements [8], [9].

The design of the mining pit is made to determine the shape, size, and volume of mineral deposits so that the design process depends on the shape and direction of distribution of a mineral to be mined so that minerals with such a wide distribution lead to a wide mining pit design as well [10]. Mine design is needed to estimate or predict an area of potential ore resources to be developed into a mining pit location [11].

After the mining reserves are known, the next stage is production planning, which is in the form of production scheduling and sequence planning activities [7]. The mine production schedule is stated in a certain period, including data on tonnage, overburden, and total material removal from the mine. The basic principle of production scheduling is to maximize NPV (net present value), and ROR (rate of return). Mining sequence design is designing mining shapes (mineable geometries) to mine out reserves starting from the initial entry limit to the final pit boundary. Mining sequences are mining forms that indicate how a pit will be mined from the initial point of entry to the final shape of the pit. Sequence design or mining stages divide the ultimate pit into smaller and more manageable planning units, this will make complex three-dimensional mine design problems simpler, at this stage, the time element has begun to be incorporated into the design mining due to mining sequences (pushback) has begun to be considered [12].

The final stage of the mine planning process is the appraisal of the mining investment. Mining investment analysis is a systematic step taken to evaluate the profit potential of a mining project [13]. Mining investment feasibility assessment is carried out by determining economic indicators (financial/economic model) such as net present value, internal rate of return (IRR), which takes into account the equivalent concept, and payback period (PBP) which does not take into account the equivalent concept. It is very important in investment analysis that the project evaluation criteria do not by themselves provide investment decisions, but only provide guidelines for making decisions. This is because, in the process, mining activities require very large capital. Good financial planning will make the possibility of loss smaller and the amount of profit and return on capital can be estimated [14].

Based on this description, this research was conducted to carry out conceptual planning in the North Block, starting from determining optimal mining boundaries (ultimate pit limit), mine design and reserve calculation, production scheduling, mining pushback design, cash flow analysis, and sensitivity analysis.

## 2. RESEARCH METHODS

The mine conceptual plan aims to determining pit boundaries, production scheduling, mining pushback design, heavy equipment selection, and mining investment analysis for the North Block. The research stages consist of data collection, data processing, and analysis.

### 2.1 Data collection

Data used are divided into primary data and secondary data. Primary data is data obtained directly from the company, while secondary data is data obtained from literature studies or related references. Data collection was carried out for one month considering the research objectives.

1. Block model

Block model data is used to determine the distribution of ore and as a reference for making pits, waste dump, and mine haul road with the total measurable resources of 263,996 tons of nickel ore and 625,898 BCM of waste.

2. Topographic data

Topographic data provide an overview of the earth's surface from the study area to the North Block pit design. The topographic data obtained has a height range from 0 to 690 above sea level with the area of 2,672 m$^2$.

3. Material classification

This data provides an overview of the distribution of material types based on their quality. The data can be seen in Table 1.

**Table 1.** Material classification

| Material classification | Material code | Description (%) |
|---|---|---|
| Waste | Waste | Ni < 1.3 |
| Low grade ore | LGO | Ni ≥ 1.3 and Ni < 1.6 |
| Medium grade ore | MGO | Ni ≥ 1.6 and Ni < 1.9 |
| High grade ore | HGO | Ni ≥ 1.9 |

4. Mining factors

Mining factors used are mine design (ultimate pit) which refers to geotechnical recommendations, cut-off grade (COG), specific gravity, and dilution factor (Table 2).

**Table 2.** Mining factors

| | Factor | Value | Unit |
|---|---|---|---|
| Single slope dimension | Bench height | 5 | Meters |
| | Berm width | 3 | Meters |
| | Bench slope | 45 | Degree |
| | Interramp angle | 32 | Degree |
| Main haul road parameter | Width | 12 | Meters |
| | Grade | 10 | % |
| | Bench cut slope | 45 | Degree |
| | Bench fill slope | 45 | Degree |
| | Cross-fall | 2 | % |
| Waste dump parameter | Bench height | 10 | Meters |
| | Berm width | - | Meters |
| | Bench slope | 33 | Degree |
| | Specific gravity | 1.59 | |
| | Cut-off grade | 1.3 | % |
| | Recovery | 95 | % |
| | Dilution | 2% | % |

5. Optimization data

This data is a combination of economic data such as capital, mineral commodity prices, expenses, production costs, discount rates, which are used to calculate the optimal pit limit. Optimization data can be seen in Table 3.

**Table 3.** Optimization parameters

| Parameter | Value | Unit |
|---|---|---|
| Capital cost | 464,167 | USD |
| Expenses | 37,051 | USD |
| Ore mining cost | 1.99 | USD/t |
| Waste mining cost | 0.74 | USD/t |
| Rehabilitation cost | 0.12 | USD/t |
| Processing cost | 0 | USD/t |
| General and administration cost | 0 | USD/t |
| Selling cost | 0.48 | USD/t |
| Nickel price | 30 | USD/t |
| Discount rate | 10 | % |
| Royalty | 10 | % |
| Bearing | 32 | Degree |

6. Effective working hours

Effective work hours is an estimate of the amount of time that is actually available and can be used to work and produce something. The amount is calculated from the estimated time lost, the level of physical availability of the equipment, and the use of availability. Effective working duration will be one of the bases in calculating the need for heavy equipment. The data can be seen in Table 4.

**Table 4.** Effective working hours

| Parameter | Number | Unit |
|---|---|---|
| Work hours per day | 18 | hours |
| Shifts per day | 2 | shifts |
| Reduced: | | |
| Machine heating | 0.25 | hours |
| Pre-check/safety talk | 0.17 | hours |
| Moving area | 0.25 | hours |
| Mechanical lost time | 1 | hours |
| Rest and eat | 1 | hours |
| Standby | 0.25 | hours |
| Fuel filling | 0.25 | hours |
| Total loss time | 3.17 | hours |
| Effective work hours per day | 14.83 | hours |
| Effective work hours per shift | 5.83 | hours |

7. Bucket fill factor and swell factor.

The bucket fill factor affects the fulfillment of bucket capacity, while the Swell factor is the development of the volume of a material after it is excavated from its place. The bucket fill factor value is based on when the excavator picks up material using a bucket so the bucket fill factor value is 110%. Determination of the swell factor is based on the type of material so based on the research area which has a type of dry sand soil material, the swell factor value is 99%.

8. Specifications and availability of heavy equipment

The digging equipment used by the company is the Kobelco SK-200 excavator while the loading equipment used is of two types, namely Hino 500 and Mercy Axor 2528. The choice of equipment is based on the relatively thin thickness of the ore layer and the lack of rock material for road pavement. The data consists of primary data obtained from the company and secondary data, such as laws and government regulations (Table 5).

**Table 5.** Heavy equipment specification and availability

| Equipment type | Parameter | | Value |
|---|---|---|---|
| Loading and digging equipment | Number of equipment | SK 200 | 4 Units |
| | | SK 330 | 1 Unit |
| | The capacity of bucket | SK 200 | 0.81 $m^3$/bucket |
| | | SK 330 | 1.4 $m^3$/bucket |
| | Cycle time | SK 200 | 17 second |
| | | SK 330 | 20 second |
| | Efficiency | SK 200 | 73% |
| | | SK 330 | 56% |
| Hauling equipment | Number of equipment | Hino 500 | 15 units |
| | | Mercy Axor 2528 | 8 units |
| | The capacity of a dump truck | SK 200 | 12 times bucket charging |
| | | SK 330 | 8 times bucket charging |
| | Cycle time | Hino 500 | 67.6 minutes |
| | | Mercy Axor 2528 | 64.37 minutes |
| | Efficiency | Hino 500 | 67% |
| | | Mercy Axor 2528 | 67% |

9. The economic data

Cash flow analysis is the final stage in this research. The data used are economic data from various stages of mining operations. The data consist of primary data obtained from the company and secondary data, such as laws and government regulations. The economic data are generally divided into data on capital expenditure, operation expenditure, taxes, and royalties. The data is shown in Tables 6, 7, and 8.

**Table 6.** Capital expenditure

| Capital cost | USD |
|---|---|
| Mineral resource drilling and reporting | 271,777 |
| Mine infrastructure | 592,334.40 |
| Stockpile construction | 55,749.20 |
| Disposal preparation | 55,749.20 |
| Land acquisition | 139,372.80 |
| Sustaining capital | 4% from gross revenue |

**Table 7.** Operational expenditure

| Operation cost | Unit cost (USD/wmt ore) |
|---|---|
| Digging and hauling | 4.92 |
| Grade control | 0.23 |
| Surveying and drilling | 0.13 |
| Environmental protection and monitoring | 0.15 |
| Land acquisition | 0.06 |
| K3 and work equipment | 0.19 |
| Salary | 0.64 |
| Reclamation and mine closure | 0.04 |
| Maintenance and repair | 0.06 |
| More | 0.39 |
| Selling cost | 0.18 |
| Administration and overhead | 0.41 |

**Table 8.** Parameters of taxes, royalties, depreciation, and debt

| Parameter | Value |
|---|---|
| Long term debt | 60% |
| Interest | 8% |
| Debt age | 5 years |
| Royalty | 10% |
| Tax | 22% |
| Asset economic year | 10 years |
| Dead rent | USD 4.18 per Ha |

### 2.2 Data Processing

Processing and data analysis is carried out in Mine Planning and Valuation Laboratory Mining Engineering Department Hasanuddin University. The data has been collected is processed and analysis to determine the ultimate pit limit, design pit and mine haul road, schedule mining production and conduct mining investment analysis.

1. Resource reporting using block model data.
2. Pit optimization
   Pit optimization using the Lerchs & Grossman method [15] with by using Micromine 2023 software. The data used are block model, topographic data, capital cost, operating cost, and geotechnical data.
3. Mine design
   Pit, waste dump, and mine haul road designs were made using the Micromine 2023 software by entering topographical data, block models, and bench geometry. The data produces a pit design, waste dump design, mine haul road design, total tonnage of material from overburden and waste, and estimates of reserves from the pit.
4. Schedule production using Minesched 9.0. The data used are block model, pit design, waste dump design, and mine haul road design.
5. Calculation of the equipment needed was carried out using Microsoft Excel.
6. Analyzing the feasibility of a mining investment by calculating the net present value and analyzing the sensitivity by looking at changes in the net present value (NPV) resulting in changes in the level of output indicated by an alternative investment. This study used several parameters whose sensitivity was tested, namely nickel prices, operating expenditure (opex), and capital expenditure (capex). Sensitivity analysis was carried out on the parameters if there is an increase and decrease by 5% - 20% with an interval of 5%.

## 3. RESULT AND DISCUSSION

Resource estimation on the North Block was carried out on laterite nickel deposits with a cut-off grade of 1.3%. The estimation results are classified into three classes, namely high-grade ore (HGO) with a grade range greater than 1.9%, low-grade ore (LGO) with a grade range of 1.3%-1.6%, and medium-grade ore (MGO) with a grade range of 1.6%-1.9%.

The resource estimation at the North Block shows the grades of nickel (Ni) and iron (Fe). The nickel specific gravity used in this research is 1.59. This specific gravity is used to determine the tonnage of laterite nickel resources. The North Block resource estimation results consisting of tonnage, volume, and grade of laterite nickel are shown in Table 9.

**Table 9.** Laterite nickel resource estimation results

| Material | COG | Volume (BCM) | Tonnage (wmt) | Ni | Fe | SG |
|---|---|---|---|---|---|---|
| Waste | Ni < 1.3 | 625,89 | 995,17 | 0.89 | 50.01 | 1.59 |
| LGO | 1.3 < Ni < 1.6 | 97,36 | 154,80 | 1.45 | 31.94 | |
| MGO | 1.6 < Ni < 1.9 | 45,78 | 72,79 | 1.75 | 23.8 | |
| HGO | Ni > 1.9 | 22,89 | 36,39 | 2.04 | 20.63 | |
| Total | | 791,934 | 1,259,17 | 1.62 | 31.59 | |

The estimation results of laterite nickel resource in the research block model show the ore volume of 791,934 BCM with a tonnage of 1,259,174 tons. In the block model resource estimation results, it can be seen that the classification of ore with the highest volume and tonnage lies in the classification of low-grade ore (LGO) with an average Ni grade of 1.45% with a volume of 97,363 BCM and a tonnage of 154,808 tons. The classification of ore with the lowest volume and tonnage lies in the classification of high-grade ore (HGO) with an average Ni grade of 2.04% with a volume of 22,891 BCM and a tonnage of 36,396 tons.

### 3.1 Pit optimization

Pit optimization or determination of the optimal pit limit aims to provide the best profit reserve limit. Data processing to obtain the optimal pit limit was carried out using the Lerch-Grossman method on Micromine 2023 version. The Lerch-Grossman method is a pit optimization that is well applied to all deposits. The results of the data processing provide 19 pit shells with volume and tonnage of ore and overburden, stripping ratio, and the net present value of each pit shell. The pit shells are presented in several scenarios, namely best, worst, and lag scenario case.

The best-case scenario has a mining pattern starting from a pit shell with a small SR to enable faster ore delivery. The worst-case scenario has a mining pattern starting from the highest elevation to the lowest elevation without taking the pit shell SR into account to facilitate simpler implementation [16].

**Table 10.** North Block pit shells analysis results

| Pit Shells | Ore (ton) | Overburden (BCM) | SR | NPV (USD) |
|---|---|---|---|---|
| 1 | 6,922 | 1,018 | 0.15 | (291,661) |
| 2 | 216,550 | 453,556 | 2.09 | 870,328 |
| 3 | 237,885 | 526,871 | 2.21 | 941,385 |
| 4 | 243,205 | 554,195 | 2.28 | 955,014 |
| 5 | 244,408 | 563,024 | 2.30 | 958,940 |
| 6 | 248,982 | 599,492 | 2.41 | 961,991 |
| 7 | 249,995 | 609,977 | 2.44 | 964,326 |
| 8 | 252,432 | 636,312 | 2.52 | 965,258 |
| 9 | 252,703 | 639,931 | 2.53 | 965,735 |
| 10 | 253,004 | 644,920 | 2.55 | 966,264 |
| 11 | 253,064 | 645,823 | 2.55 | 966,347 |
| 12 | 253,124 | 647,034 | 2.56 | 966,420 |
| 13 | 253,184 | 648,240 | 2.56 | 966,481 |
| 14 | 253,335 | 651,678 | 2.57 | 966,627 |
| 15 | 253,455 | 654,289 | 2.58 | 963,858 |
| 16 | 253,575 | 657,607 | 2.59 | 963,851 |
| 17 | 253,636 | 659,824 | 2.60 | 963,837 |
| 18 | 253,696 | 661,776 | 2.61 | 963,804 |
| 19 | 253,726 | 663,007 | 2.61 | 963,777 |

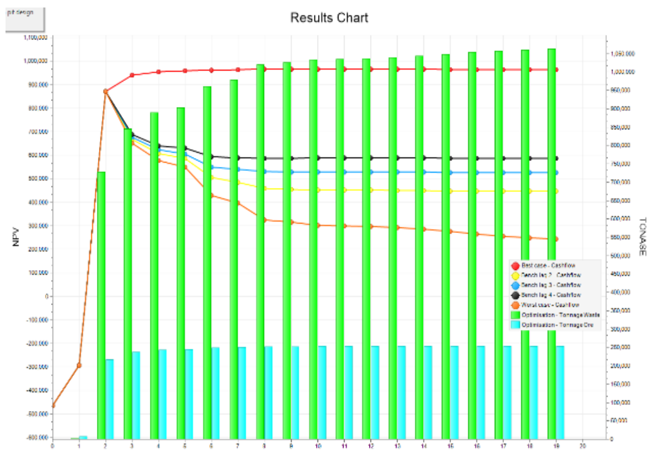


**Figure 1.** Pit shell analysis graphic

The results of the pit shell analysis are shown in Figure 1 which show the relation between pit shells with the amount of reserves and net present value. The value on the left y-axis shows the net present value, while the right shows the amount of laterite nickel ore reserves. The graph also shows diagrams with two different colors. The yellow color shows the amount of ore while the gray color shows the amount of the overburden. The pit shell analysis results of the northern block in detail are shown in Table 10.

The results of the pit shell analysis show three different types of scenarios, namely the best case, worst case, and constant lag. The best-case scenario is a scenario that shows mining is carried out sequentially starting from the smallest pit shell to the optimal pit limit. The worst-case scenario is a scenario where mining is not performed sequentially based on the pit shell, the constant lag scenario shows a combined best-case and worst-case scenario. Each pit shell provides the same amount of ore, overburden, and stripping ratio in one pit shell even though the scenarios are different. The NPV value from the analysis results show differences in each scenario, even though they are in the same pit shell. The NPV value is influenced by the type of scenario used for the mining operation.

Selection of the optimal pit shell is based on the results of nested pit shell analysis. As a rule of thumb, the average between the best and worst case NPV curves is most likely to be a curve of an optimal pit. Also, it is very important to avoid the selection of the optimal pit shell that exhibits a sudden change of ore/waste tonnage in comparison to the previous pit shell. The optimal pit should be stable as much as possible in the event of a slight reduction of the commodity price, or an increase in the operating cost [17].

The pit shell chosen as the optimal pit limit in this research is pit shell 6. The pit shell 6 shown in Figure 101 gives an NPV value of USD 961,991 if implemented in the best case. This pit shell shows an ore value of 248,982 tons, an overburden of 599,492 BCM, and a stripping ratio of 2,41.

### 3.2 Pit Design

The pit design was created using the Micromine 2023 software. The input data is in the form of a pit area block model and recommendation bench geometry from the geotechnical section. Making a pit design from the lowest elevation in a block model to the highest elevation and is a manual pit design method.

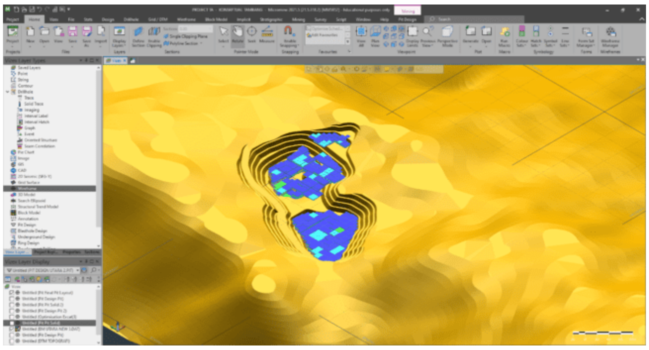

**Figure 2.** North Block pit design

**Table 11.** North Block pit design evaluation results

| Material | COG | Volume (BCM) | Tonnage (wmt) | Ni (%) | Fe (%) | SG |
|---|---|---|---|---|---|---|
| Waste | Ni < 1.3 | 683,255 | 1,086,37 | 0.92 | 50.01 | 1.59 |
| LGO | 1.3 < Ni < 1.6 | 80,880 | 128,599 | 1.45 | 31.94 | |
| MGO | 1.6 < Ni < 1.9 | 37,906 | 60,271 | 1.75 | 23.8 | |
| HGO | Ni > 1.9 | 17,548 | 27,901 | 2.03 | 20.63 | |
| Total | | 819,589 | 1,303,14 | 1.62 | 31.59 | |

The pit compartment design results in the volume of waste and ore materials to be mined. Material tonnage (wmt) is calculated by multiplying the design volume by the material specific gravity value, which is 1.59. The results of calculating the tonnage of material from the pit can be seen in Table 11.

### 3.3 Waste dump design

Design, age, and disposal expenses are all considered in disposal planning. The volume and tonnage of material that will fill the disposal will also be determined by the disposal design [18]. A good disposal design should be made by following a predetermined production plan and following predetermined geometry rules or geotechnical parameters, so that the design can accommodate production and is safe to implement in the field [19].

The waste dump design uses Micromine 2023 software based on topographical data and the geometry of the waste dump bench. The results of the pit design obtained a total of 683,255 bcm of waste, so that only one waste dump is needed as a storage area. The designed waste dump is of the induced flow type because it has an initial dumping point height of 42 meters with an area of 85m$^2$. The tonnage accommodated by the waste dump is 685,763 BCM or 1,090,362.64 wmt.

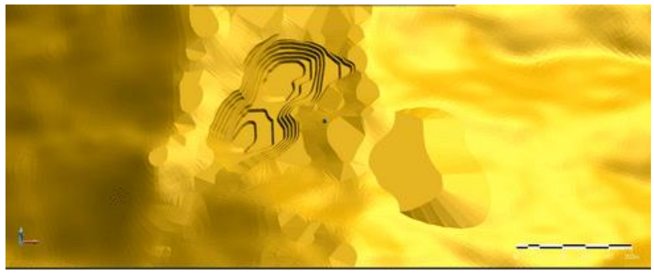

**Figure 3.** North Block waste dump design

### 3.4 Mine haul road design

Mine haul road is one of the important parts that support the success of the mine. Ramps (or declines for underground) are often used in mines to transport ore, waste, materials, and personnel [20]. Efficient mine haul road design is very important because the cost of transporting ore and waste is highly dependent on the outcome of the road design [21]. The new road and existing road designs use the Micromine 2023 software by entering topographical data and the geometry bench of the haul road. The volume of fill and cut material is the result of the design of the new road and the existing road. Material tonnage (wmt) is calculated by multiplying the material volume by the mine haul road material specific gravity value, which is 1.59. The results of calculating the tonnage of cut and fill materials can be seen in Table 12 and mine haul road design in Figure 4.

**Table 12.** North Block mine haul road design evaluation results

| Information | | Tonnage (wmt) | Route length (m) |
|---|---|---|---|
| New Road | Cut | 8,455.39 | 687.31 |
| | Fill | 4,101.46 | |
| Existing Road | Cut | 68,878.06 | 5315.42 |
| | Fill | 59,996.36 | |

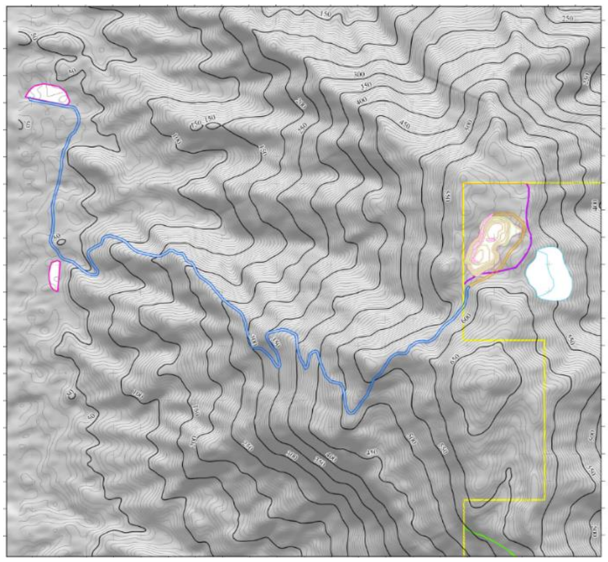

**Figure 4.** Mine haul road design

### 3.5 Mine scheduling

Production scheduling is the stage that divides the mining pit into smaller parts to facilitate the mining process. This section is called a pushback or sequence. The scheduling stage was created using Minesched 9.0 and the mining sequence design was created using Surpac software version 6.6.2 (Figure 5). The sequence design is generated at the mine scheduling stage so that it will produce a certain mining period considering the company's production ore target in one period, which is 40,000 tons.

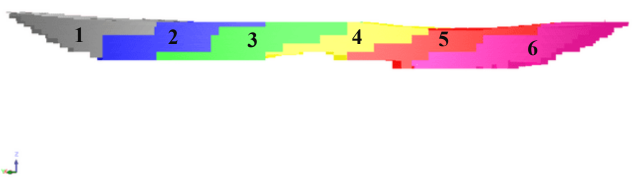


**Figure 5.** Model block production scheduling results period

One part of mine scheduling is determining the number of equipment is one part of mine planning. Determining the equipment to be carried out in this research can be seen based on the amount of lateritic nickel ore and overburden to be stripped in each sequence that has been designed. The data used to determine the number of equipment (bucket-based excavating, loading and transporting) are equipment specification, cycle time, bucket-fill factor, material-swell factor, reliability, availability, maintainability, utilization, and production efficiency so that equipment productivity can be obtained [22]. This productivity is used to determine the number of tools based on the amount of ore and waste production per month. The result of mine scheduling can be seen in Table 13.

**Table 13.** The result of scheduling

| Month | Waste (BCM) | Ore (tons) | Loader (unit) | Hauler (unit) |
|---|---|---|---|---|
| First | 129,279.20 | 23,237.67 | 3 | 16 |
| Second | 100,781.42 | 43,007.50 | 3 | 21 |
| Third | 119,065.02 | 41,249.08 | 3 | 22 |
| Fourth | 117,674.17 | 42,173.03 | 3 | 22 |
| Fifth | 113,629.61 | 42,891.38 | 3 | 22 |
| Sixth | 100,053.08 | 27,777.59 | 3 | 16 |

### 3.6 Mine investment analysis

Financial and economic evaluation is part of mine planning to find out whether a mining project is economically feasible or not for mining activities. Financial and economic analysis is often done using discounted cash flow analysis techniques. Cash flow analysis is performed at the last stage of a mine plan. This is because the required data such as the number of reserves, the sequence of mining, to the number of heavy equipment needed have been estimated so that economic data is obtained during mining such as gross revenue, operational costs, and others.

There are three components of cash flow analysis, namely net present value (NPV), The NPV obtained was USD 1,050,838.64, an IRR of 37.94%, and a PBP 70 days. The analysis was carried out with Microsoft Excel software. The results of the cash flow analysis from the northern block mining plan are shown in Table 14.

**Table 14.** The result of the cashflow calculation

| Investment | First (USD) | Second (USD) | Third (USD) | Fourth (USD) | Fifth (USD) | Sixth (USD) |
|---|---|---|---|---|---|---|
| Production waste (BCM) | 129,279.20 | 100,781.42 | 119,065.02 | 117,674.17 | 113,629.61 | 100,053.08 |
| Production ore (ton) | 23,237.67 | 43,007.50 | 41,249.08 | 42,173.03 | 42,891.38 | 27,777.59 |
| Price | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 |
| **Gross revenue** | **697,130.10** | **1,290,225** | **1,237,472.** | **1,265,190** | **1,286,741** | **833,327.7** |
| Royalty | (69,713.01) | (129,022.5) | (123,747) | (126,519.) | (128,674) | (83,332.77) |
| Dead rent | (7.59) | (3.04) | (3.37) | (4.24) | (4.32) | (1.21) |
| **Net revenue** | **627,409.50** | **1,161,199.4** | **1,113,721.** | **1,138,667** | **1,158,062** | **749,993** |
| Sustaining capital | (27,885.20) | (51,609.00) | (49,498.9) | (50,607.6) | (51,469.6) | (33,333.11) |
| Digging and hauling | (114,329.34) | (211,596.9) | (202,945) | (207,491) | (211,025) | (136,665) |
| Grade control | (5,344.66) | (9,891.73) | (9,487.29) | (9,699.80) | (9,865.02) | (6,388.85) |
| Surveying and drilling | (3,020.90) | (5,590.98) | (5,362.38) | (5,482.49) | (5,575.88) | (3,611.09) |
| Land acquisition | (1,394.26) | (2,580.45) | (2,474.94) | (2,530.38) | (2,573.48) | (1,666.66) |
| Environmental protection and monitoring | (3,485.65) | (6,451.13) | (6,187.36) | (6,325.95) | (6,433.71) | (4,166.64) |
| K3 and work equipment | (4,415.16) | (8,171.43) | (7,837.33) | (8,012.88) | (8,149.36) | (5,277.74) |
| Salary | (14,872.11) | (27,524.80) | (26,399.4) | (26,990.7) | (27,450.4) | (17,777.66) |
| Reclamation and mine closure | (929.51) | (1,720.30) | (1,649.96) | (1,686.92) | (1,715.66) | (1,111.10) |
| Maintenance and repair | (1,394.26) | (2,580.45) | (2,474.94) | (2,530.38) | (2,573.48) | (1,666.66) |

| Investment | | First (USD) | Second (USD) | Third (USD) | Fourth (USD) | Fifth (USD) | Sixth (USD) |
|---|---|---|---|---|---|---|---|
| More | | (9,062.69) | (16,772.93) | (16,087) | (16,447.4) | (16,727.6) | (10,833.26) |
| Selling cost | | (4,182.78) | (7,741.35) | (7,424.83) | (7,591.15) | (7,720.45) | (4,999.97) |
| Administration and overhead | | (9,527.44) | (17,633.08) | (16,912.1) | (17,290.9) | (17,585.4) | (11,388.81) |
| **Operating income (EBITD)** | | **427,565.54** | **791,334.96** | **758,979.71** | **775,979.51** | **789,197.07** | **511,106.45** |
| Principal | | (11,149.83) | (11,149.83) | (11,149.83) | (11,149.83) | (11,149.83) | (11,149.83) |
| Interest expenses | | (4,459.93) | (4,459.93) | (4,459.93) | (4,459.93) | (4,459.93) | (4,459.93) |
| Deprecation | | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) |
| **Income before tax** | | **407,019.66** | **770,789.08** | **738,433.83** | **755,433.63** | **768,651.19** | **490,560.57** |
| Corporate tax (22%) | | (89,544.33) | (169,573.6) | (162,455.4) | (166,195.4) | (169,103.2) | (107,923.3) |
| **Net income** | | **317,475.33** | **601,215.48** | **575,978.39** | **589,238.24** | **599,547.93** | **382,637.25** |
| Deprecation | | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) | (4,936.12) |
| **Capital expenditure** | **(1,114,982.60)** | | | | | | |
| Mineral resources drilling and reporting | 271,777.00 | | | | | | |
| Mine infrastructure | 592,334.40 | | | | | | |
| Stockyard construction | 55,749.20 | | | | | | |
| Disposal construction | 55,749.20 | | | | | | |
| Land acquisition | 139,372.80 | | | | | | |
| Loan disbursement | 668,989.56 | | | | | | |
| **Cashflow** | **(1,114,982.60)** | **322,411.45** | **606,151.60** | **580,914.51** | **594,174.36** | **604,484.05** | **387,573.37** |
| **Discount rate** | **1.00** | **0.90** | **0.81** | **0.73** | **0.66** | **0.59** | **0.54** |
| **Discounted Cashflow** | **(1,114,982.60)** | **290,513.11** | **492,143.57** | **424,989.36** | **391,683.27** | **359,055.22** | **207,436.70** |

### 3.7 Sensitivity analysis

Sensitivity analysis is an analysis to determine the effect of changing the value of certain parameters on the resulting NPV value. Parameters that are suspected of influencing changes in net present value are nickel prices, operating expenditure (opex) [23] and capital expenditure (capex). The range of changes in the value of each parameter is -20% to +20% with 5% intervals.

1. Nickel prices

Prices are used to provide financial value to a product or service. The price of a nickel is a fee that consumers must pay to companies. Sensitivity analysis is used to determine the effect of changes in nickel prices on the NPV values obtained. Sensitivity analysis of the net present value of the northern block conceptual plan to changes in nickel prices can be seen in Table 15.

**Table 15.** The results of sensitivity analysis to changes in nickel prices

| Parameter | Change (%) | NPV (USD) |
|---|---|---|
| Nickel price | -25 | 275,163.96 |
| | -20 | 430,298.90 |
| | -15 | 585,433.83 |
| | -10 | 740,568.77 |
| | -5 | 895,703.71 |
| | 0 | 1,050,838.64 |
| | 5 | 1,205,973.58 |
| | 10 | 1,361,108.52 |
| | 15 | 1,516,243.46 |
| | 20 | 1,671,378.39 |
| | 25 | 1,826,513.33 |

Changes in nickel prices are directly proportional to the NPV value of the North Block conceptual planning. When nickel prices increase by 5%, the NPV value will increase by 12.86%.

2. Operating expenditure

Operating expenditure is the cost incurred by the company during the mining process. Sensitivity analysis is used to determine the effect of changes in operating expenditure on the NPV value. The results of the sensitivity analysis to changes in operating expenditure can be seen in Table 16.

Changes in operating expenditure are inversely proportional to the NPV value of the North Block conceptual planning. When operating expenditure increase by 5%, the NPV value will decrease by 4.42%.

**Table 16.** The results of sensitivity analysis to changes in operating expenditure

| Parameter | Change (%) | NPV (USD) |
|---|---|---|
| Operating Expenditure | -25 | 1,273,318.98 |
| | -20 | 1,228,822.91 |
| | -15 | 1,184,326.85 |
| | -10 | 1,139,830.78 |
| | -5 | 1,095,334.71 |
| | 0 | 1,050,838.64 |
| | 5 | 1,006,342.58 |
| | 10 | 961,846.51 |
| | 15 | 917,350.44 |
| | 20 | 872,854.37 |
| | 25 | 828,358.31 |

3. Capital expenditure

Capital expenditure is the cost incurred by the company during the nickel processing. Sensitivity analysis is used to determine the effect of changes in capital expenditure on the NPV value obtained. The results of the sensitivity analysis of the NPV value to changes in capital expenditure can be seen in Table 17.

**Table 17.** The results of sensitivity analysis to changes in capital expenditure

| Parameter | Changes (%) | NPV (USD) |
|---|---|---|
| Capital Expenditure | -25 | 1,342,469.06 |
| | -20 | 1,284,142.98 |
| | -15 | 1,225,816.89 |
| | -10 | 1,167,490.81 |
| | -5 | 1,109,164.73 |
| | 0 | 1,050,838.64 |
| | 5 | 992,512.56 |
| | 10 | 934,186.48 |
| | 15 | 875,860.39 |
| | 20 | 817,534.31 |
| | 25 | 759,208.23 |

Changes in capital expenditure are inversely proportional to the NPV value of the North Block conceptual planning. When operating expenditure increase by 5%, the NPV value will decrease by 5.88%.

The results of the sensitivity analysis show that if there is an increase in the parameter value by 25%, the NPV value becomes USD 1,826,513.33 for changes in nickel prices, USD 828,358.31 for changes in operating expenditure and USD 759,208.23 for capital expenditure. If there is a decrease in the parameter value of 25%, the NPV value becomes USD 275,163.96 for changes in nickel prices, USD 1,273,318.98 for changes in operating expenditure and USD 1,342,469.06 for capital expenditure. Nickel price is the variable that most influences the NPV value of the northern block conceptual planning because every increase in the sensitivity level of 5%, the NPV value increases by 12.86% resulting in the most significant change in the NPV value of the northern block conceptual planning.

## 4. CONCLUSION

Pit optimization and pit design were created with the help of the Micromine 2023 software using the block model as input data for bench geometry as input data. The design of the software works with the method of taking ore blocks starting from the lowest elevation to the highest elevation of the block model. As for the design of the mine haul road and waste dump using topography data, haul road geometry, and ladder geometry. The design for a pit, mine haul road, and disposal must be in accordance with the standard operating procedure (SOP) so that it is safe when mining activities are carried out so that technical factors cannot be ignored when designing. The most important technical factor to note is the recommendation of step geometry and haul road geometry from the geotechnical section. The results of the investment feasibility analysis with a discount rate of 10.98% per year obtained an NPV value of USD 1,050,838.64, an IRR of 37.94%, and PBP is 70 days. Based on the NPV value above, the development of the mining area is feasible and the results of the sensitivity analysis show that the most sensitive variable in cash flow to the NPV value is the price of nickel.

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## NOMENCLATURE

| | |
|---|---|
| BCM | Bank cubic meter |
| wmt | Wet metric ton |
| fe | iron |
| ni | nickel |