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Calculation of reserve estimation in the new pit design using mining software at PT. Tanjung Alam Jaya pit x, Banjar, South Borneo.

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Abstract

The mining planning and design were carried out in PT. Tanjung Alam Jaya, a coal mining company in South Kalimantan. The company intends to re-mine the Pit X area and requires a comprehensive mine planning approach to achieve its mining objectives. The study focuses on long-term planning, specifically optimizing the pit design while considering the company's specified stripping ratio limit and calculating the potential reserve volumes. The research aims to develop an optimized pit design and estimate the quantity of mineable reserves based on the optimization results. The findings include a mining layout design drawing and the calculated coal reserves that can be extracted from the optimized pit design. The excavation area spans 38.1 hectares, with excavation limits reaching a depth of -56 meters above sea level. The shape of the excavation extends from northeast to southwest, with a length of 1,065 meters and a variable width of 310 to 460 meters. The excavation features a slope height of 10 meters and a single slope angle of 65 degrees. Moreover, the haul road measures 21 meters in width with a 10% grade. The pit design indicates a total mineable coal reserve of 1,400,263.48 tons across all seams. Additionally, it reveals that 21,565,312.42 bcm of overburden / interburden must be stripped, resulting in a stripping ratio of 15.40 for the specific pit design. The haul road measures 21 meters in width with a 10% grade. In conclusion, this research demonstrates PT Tanjung Alam Jaya's efforts to optimize their pit design for re-mining in the Pit X area. The study provides valuable insights through a comprehensive mine planning approach, aiding the company in achieving their mining objectives while adhering to specified limits.

1. Introduction

PT Tanjung Alam Jaya is a coal mining company located in Mangkauk Village, Pengaron District, Banjar Regency, South Kalimantan. The company plans to re-mine in the Pit X area, requiring comprehensive mine planning to achieve its mining objectives. Mine planning involves determining the technical requirements and implementing techniques to accomplish activity targets and objectives [1]. However, mine planning is a complex task due to the three-dimensional nature of the mining geometry, which constantly changes over time [2]. Apart from the shape of the mine, economic parameters also fluctuate, emphasizing the need for proper planning to ensure effective mining operations [3].

Long-term planning, spanning more than five years, is vital for sustainable production and optimizing potential coal resources within the company's mining permit area. One crucial aspect of mine planning is pit optimization, which focuses on designing the pit layout and calculating the mineable reserve quantities, considering the company's specified stripping ratio limit [4]. The aim is to maximize profitability by adjusting input parameters, such as slope size, to reach the optimal point where output is improved [4]. Optimizing the pit design allows for the efficient utilization of coal resources, increased company profits, and simplified mining processes. It also enables crucial information regarding mineable reserves, which is essential for determining mine lifespan, establishing mining stages, and developing mining schedules.

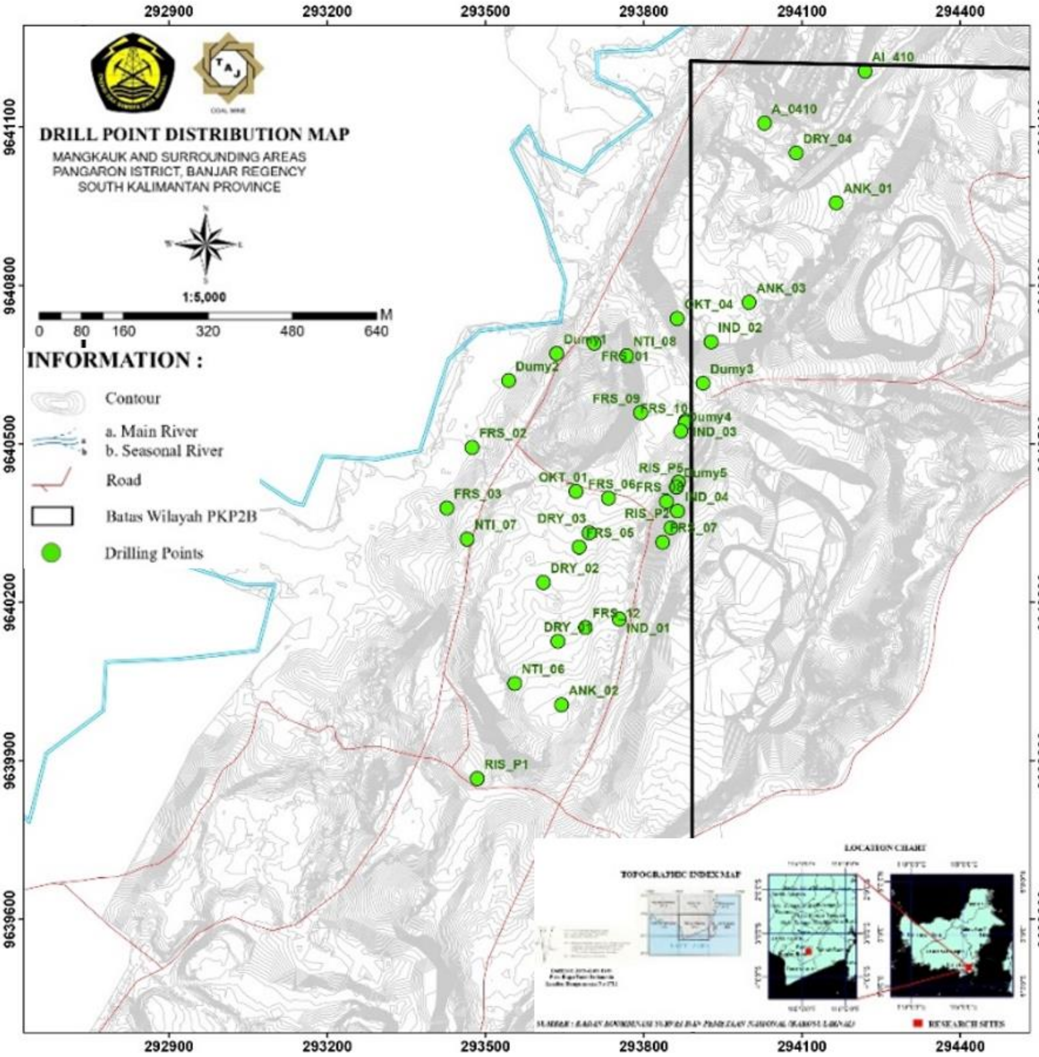

Figure 1. Actual Topographic Map & Drill Point Distribution.

This research addresses the lack of a mining plan in PT Tanjung Alam Jaya's Pit X area, as the company has recently completed exploration activities. Detailed mineral and coal exploration provides accurate and comprehensive information about the deposit's location, shape, dimensions, quality distribution, and estimated resources [5]. While exploitation activities are scheduled to commence in 2022, further planning is required. Currently, the focus is primarily on optimizing the pit design and calculating the mineable reserves.

In conclusion, PT Tanjung Alam Jaya recognizes the significance of mine planning in achieving their mining objectives. By undertaking pit optimization efforts, considering factors such as slope size and stripping ratio, the company aims to maximize profitability and efficiently utilize its available coal reserves. This ongoing research addresses the absence of a mining plan in Pit X, ensuring effective and sustainable mining operations in the future.

2. Methodology

2.1 Data collection:

The research takes place at Pit X of PT Tanjung Alam Jaya within the PKP2B area in Banjar Regency, South Kalimantan Province. The chosen methodology is descriptive research, which involves the collection, compilation, classification, analysis, and interpretation of data to explore potential solutions for the problem at hand [6]. Data collection encompasses both primary and secondary data. Primary data consists of survey data capturing the actual conditions at PT TAJ's Pit X from 2022 onwards, along with drilling location data represented by coordinates (x, y). Secondary data include relevant information such as coal modeling, stripping ratio limits, and material density data.

Table 1. Drill Point Distribution Coordinates

No	Hole Name	North	East	Height	Depth	No	Hole Name	North	East	Height	Depth
1	FRS_01	293706.5	9640690.6	74.09	61.30	19	DRY_02	293609.9	9640237.7	121.38	110.85
2	FRS_02	293474.9	9640493.1	69.26	60.20	20	DRY_03	293696.9	9640331.7	96.12	60.00
3	FRS_03	293427.1	9640378.5	76.17	131.90	21	DRY_04	294089.1	9641050.9	102.34	82.90
4	RIS_P1	293484.7	9639866.0	126.43	65.10	22	DRY_05	294152.9	9641466.8	80.10	103.00
5	RIS_P2	293851.9	9640341.0	129.35	36.00	23	NTI_08	293767.5	9640667.0	73,75	57.80
6	RIS_P5	293866.0	9640427.2	122.19	32.00	24	NTI_06	293555.9	9640046.2	85.87	65.00
7	AI_410	294219.9	9641205.7	99.71	51.30	25	NTI_07	293465.6	9640319.5	86.86	105.20
8	A_0410	294029.0	9641107.4	83.66	60.30	26	FRS_09	293794.5	9640559.1	99.32	32.05
9	OCT_04	293863.6	9640737.2	69,97	63.25	27	FRS_12	293689.7	9640152.2	102.22	20.85
10	OCT_01	293671.8	9640410.0	83.36	67.35	28	FRS_05	293677.8	9640304.6	97.54	34.65
11	ANK_01	294165.1	9640956.4	114.39	34.30	29	FRS_06	293733.5	9640397.2	99.39	27.20
12	ANK_02	293644.6	9640005.8	106.34	45.00	30	FRS_07	293836.3	9640313.7	122.61	18.75
13	IND_01	293754.1	9640168.1	115.36	37.30	31	FRS_08	293843.5	9640390.7	124.16	32.85
14	IND_02	293928.0	9640693.2	72.88	35.00	32	FRS_10	293879.5	9640540.5	104.97	42.90
15	IND_03	293879.7	9640543.7	104.75	42.35	33	Dumy1	293635.3	9640671.0	81.00	81.00
16	IND_04	293864.4	9640372.8	134.73	34.90	34	Dumy2	293544.2	9640620.0	80.00	100.00
17	ANK_03	293999.9	9640767.9	98.00	36.70	35	Dumy3	293912.8	9640615.0	100.00	50.00
18	DRY_01	293637.5	9640126.1	98.91	65.80	36	Dummy4	293870.5	9640524.0	100.00	50.00
19	DRY_02	293609.9	9640237.7	121.38	110.85	37	Dummy5	293862.2	9640418.0	120.00	50.00

2.2 Data Processing and Analysis

The data processing and analysis phase plays a crucial role in transforming the collected data into meaningful information that can be used for effective mine planning and decision-making. In this study, Minescape 5.7 software is employed to carry out various stages of data processing and analysis.

2.2.1 Processing of survey data and coal models

Situational survey data, provided in (.dxf) format, is imported into the Minescape 5.7 software to transform it into topographical data, represented by contour lines. Additionally, the coal schematic data obtained from the company is incorporated into the imported topographical data [6].

2.2.2 Determination of mining locations and Boundaries

The mining locations are determined based on the planned pit location, specifically PT TAJ's Pit X. The pit location design is derived from the results of drilling activities, aiming to minimize discrepancies between the coal model and the actual conditions. Mining boundaries are established by creating a reserve graphic model (resgrahics) within the Minescape 5.7 software. Starting from the bottom of the pit, the resgrapics modeling is performed in accordance with the estimated stripping ratio (SR) limit. Subsequently, the boundaries are defined to estimate the target SR limits [7].

2.2.3 Determination of stair and haul road geometry

This stage involves considering theoretical calculations for the mining geometry design and adhering to company recommendations. The stair geometry includes parameters such as stair height, stair width, and slope angle, which are adjusted to meet the specifications of the excavation and loading equipment. PT TAJ provides recommendations for single stair height, slope angle, and stair width. For haul road geometry, the planned parameters include the width of the haul road on straight sections and the haul road grade [8].

2.2.4 Calculation of mineable coal reserves

The final mine pit design is utilized to calculate the quantity of mineable reserves for each coal seam using Minescape 5.7 software. This calculation also includes determining the volume of material (in bcm) that needs to be moved. The output of this calculation provides the stripping ratio (SR) value for the final pit design [6].

The data processing and analysis stage plays a crucial role in transforming raw data into meaningful information. By employing advanced software tools like Minescape 5.7, it becomes possible to accurately process the collected data and derive valuable insights for the optimization of pit design, determination of mining boundaries, and calculation of mineable coal reserves. These steps contribute to effective mine planning and aid in achieving the aims and objectives of PT Tanjung Alam Jaya's mining activities.

3. Results and discussions

3.1 Initial Topographical Conditions in 2022

The imported survey data provides a comprehensive overview of the initial topographical conditions in 2022, which is visually depicted on the actual Pit X topographic map (refer to Figure 1). The research area exhibits a generally slightly hilly topography with various natural and anthropogenic features. Pit X is situated in the northern region, specifically between the UTM coordinates of 293179.438 – 293889.906 (east-west) and 9639719.000 – 9640745.000 (north-south) in the UTM coordinate system, or universal transverse mercator. The altitude ranges from a maximum of 115 meters above sea level to a minimum of 70 meters above sea level. These altitudinal variations contribute to the overall topographical diversity within the area. However, it is important to note that the topography in this research area is not entirely natural due to previous mining activities and associated land modifications. Former mining operations have left their mark, resulting in changes to the original topography. Additionally, landfilling and reclamation activities have been carried out in areas that will be subjected to future mining operations. These measures aim to restore and prepare the land for subsequent mining activities while adhering to environmental regulations and sustainability principles.

Figure 1 provides a visual representation of the distribution of drill points conducted within the research area. The strategic positioning of these drill points serves as crucial reference markers for the subsequent coal modeling process. These data points to aid in reducing the level of discrepancy between the coal model that has been developed and the actual conditions on-site [9]. Table 1 contains the coordinates of the drill holes, enabling a comprehensive understanding of their spatial distribution and orientations. The southeast direction corresponds to the low wall side, while the northwest direction represents the high wall side. The southwest and northeast directions denote the sidewalls of the mining area.

By considering the initial topographical conditions, incorporating the distribution of drill points, and understanding the influence of previous mining and land modification activities, PT Tanjung Alam Jaya can make well-informed decisions regarding the design, planning, and implementation of mining operations in Pit X. These insights provide valuable guidance for optimizing the utilization of available resources, ensuring environmental sustainability, and mitigating discrepancies between the coal modeling and the actual topographic conditions of the mining site. Through a comprehensive understanding of the initial topographical conditions, the company can effectively manage the mining process and achieve its aims and objectives in a responsible and efficient manner.

3.2 Coal geological model

The data processing results are presented in the form of cross-sectional lines that are perpendicular to the modeling direction of the coal seams. These cross-sectional lines effectively illustrate the direction of continuity and slope of the coal seams within the study area [10]. The data processing outcomes reveal the presence of seven coal seams that are suitable for mining. The thickness of each coal seam varies across the area. Layer A, for instance, has an average thickness of 0.488 meters, while layer B1 has an average thickness of 0.583 meters. Layers B2 and B3 exhibit similar average thicknesses of 0.623 meters. Layer C1, on the other hand, has a substantial average thickness of 3.669 meters. Layer C2 has a slightly lower average thickness of 0.704 meters, and layer D possesses an average thickness of 1.607 meters. These variations in thickness contribute to the complexity of the coal deposit within Pit X [10].

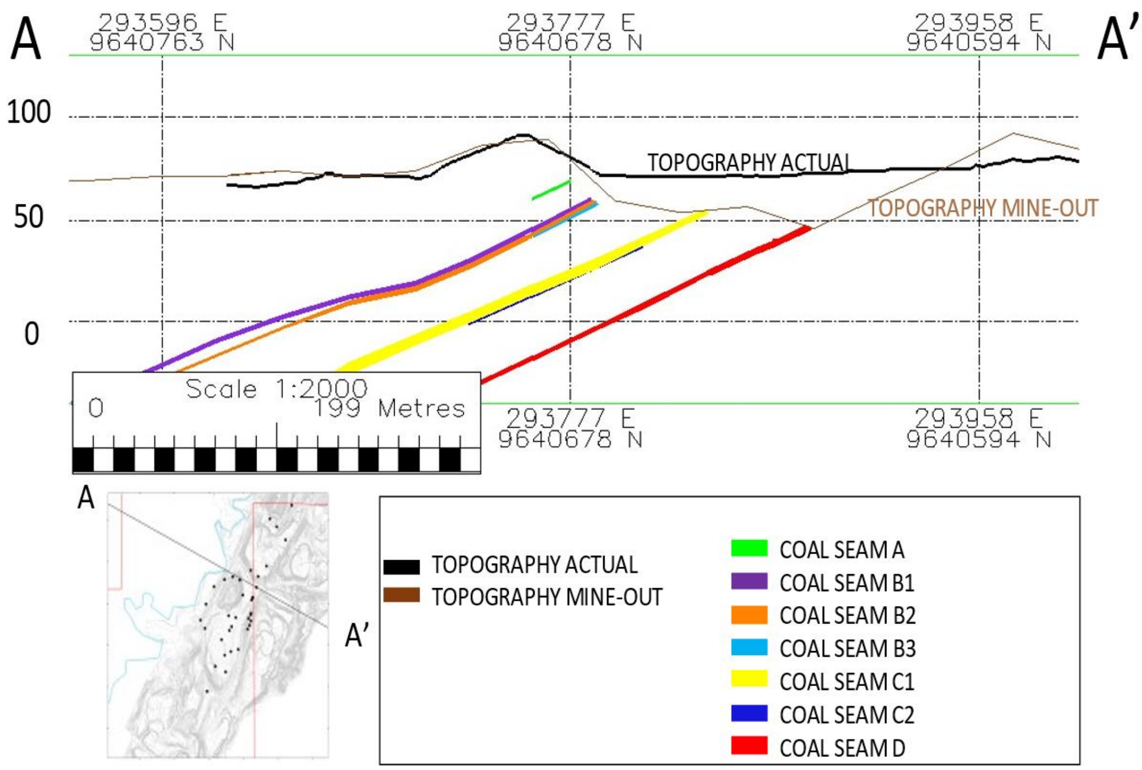

Figure 2. 2D cross-section of coal seams in the study area

To visually represent the data obtained from the actual topography processing and coal seam modeling, a 2D cross-sectional image of the coal seam in Pit X is presented (refer to Figure 2). This image provides a clear depiction of the spatial distribution of the coal seams, their relative thicknesses, and the topographic features surrounding them. By analyzing this visual representation, PT Tanjung Alam Jaya can gain valuable insights into the geological characteristics of the coal deposit. This information is essential for effectively planning mining operations, determining extraction methods, and optimizing resource utilization. The coal geological model, comprising the cross-sectional lines and the associated data, serves as a valuable tool for PT Tanjung Alam Jaya. It provides a comprehensive understanding of the coal seams' continuity, slope, and thickness within the study area. By incorporating this information into their mining plans, the company can make informed decisions and ensure efficient extraction of the coal resources present in Pit X.

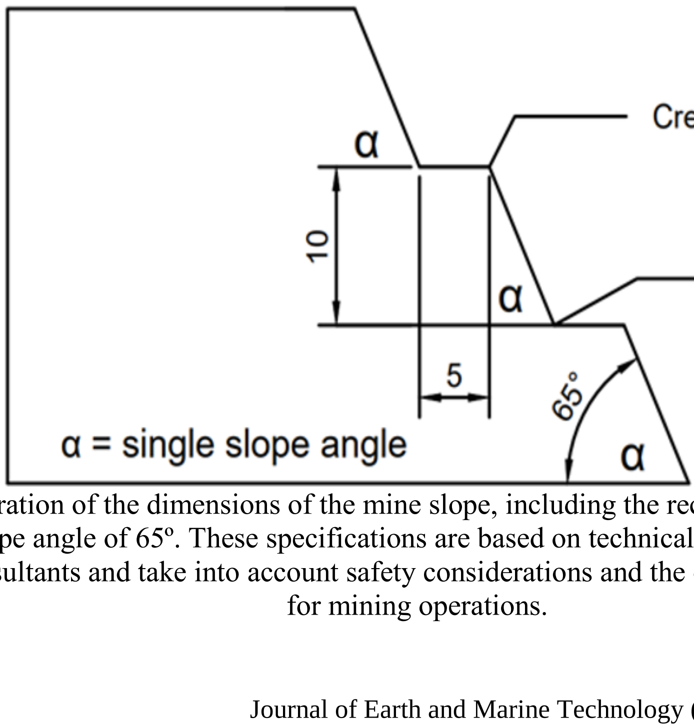

Figure 3. Illustration of the dimensions of the mine slope, including the recommended step height and the single slope angle of 65º. These specifications are based on technical studies conducted by the company's consultants and take into account safety considerations and the optimal working conditions for mining operations.

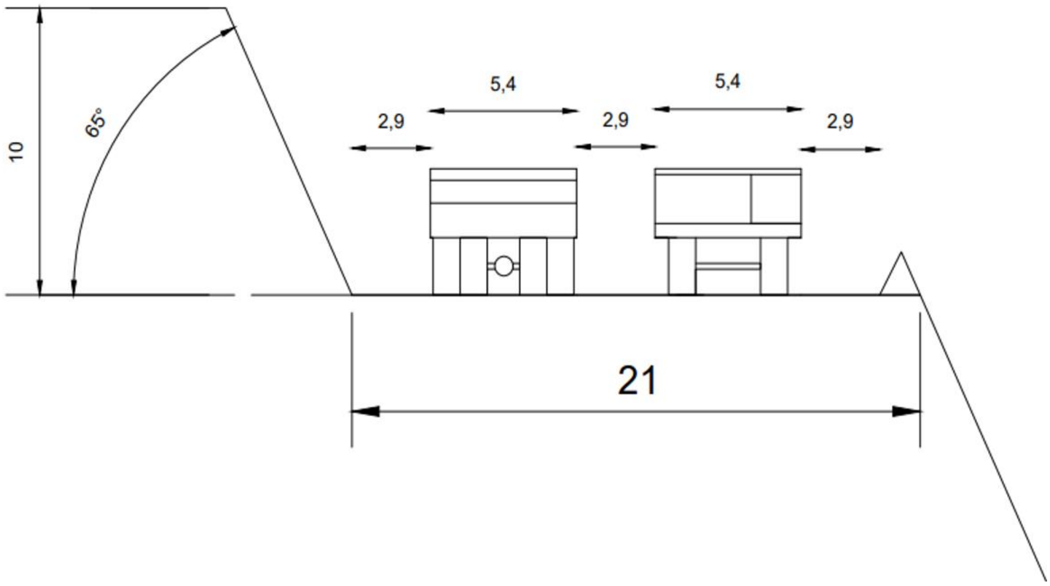

Figure 4. Mine road dimensions.

3.3 Geometry of Stairs and Haul Paths

The geometry of stairs and haul paths plays a crucial role in the design and efficiency of mining operations. In the case of Pit X, PT Tanjung Alam Jaya follows recommended step geometry for creating the pit design. The recommended step height is set at 10 meters (refer to Figure 3), which aligns with the capabilities of the equipment, including the Komatsu PC1250 excavator, with a maximum reach of 13 meters.

The embankment width is another important aspect of the pit design. Based on technical studies, a minimum embankment width of 5 meters is recommended for a slope height of 10 meters [11]. This width ensures the safety of the embankment as it serves as a retaining ladder in the event of rockfalls. With a width of 5 meters, the embankment provides sufficient stability. When planning haul roads, considerations are given to the specifications of the equipment and the desired number of lanes. For instance, the widest means of conveyance used in Pit X is the Komatsu HD465 dump truck, which has a width of 5. meters. Based on this information and the planned number of lanes (2 lanes), embankments are made on the sides of the haul road, with a width of 1.5 meters each. The calculated results demonstrate that the recommended 21-meter haul road width meets the requirements and dimensions of the dump truck (refer to Figure 4).

Figure 4 showcases the dimensions of the mine road, including the width of the haul road and the presence of embankments on the sides. These dimensions are carefully determined to ensure safe and efficient transportation of materials within the mining site. Furthermore, the slope of the haul road is set at a maximum of 10%, taking into account production efficiency factors. The selected slope considers the capabilities of the Komatsu HD465 dump truck, ensuring it can successfully navigate the road [12]. By adhering to these recommended geometries for stairs and haul paths, PT Tanjung Alam Jaya can optimize their mining operations, ensure safe transportation of materials, and enhance overall productivity within the Pit X area. These design considerations, based on technical studies and equipment specifications, contribute to the successful implementation of mining activities while maintaining operational efficiency.

3.4 Mining Limits

The determination of mining boundaries is a crucial step in the mine planning process. In this study, the mining boundaries are established through resgrahics modeling in Minescape 5.7 software. The modeling process starts from the bottom of the pit, using the most basic seam as a reference. The resgrahics modeling is performed in relation to the estimated stripping ratio (SR) limit, with the company utilizing an SR value of approximately 15.5.

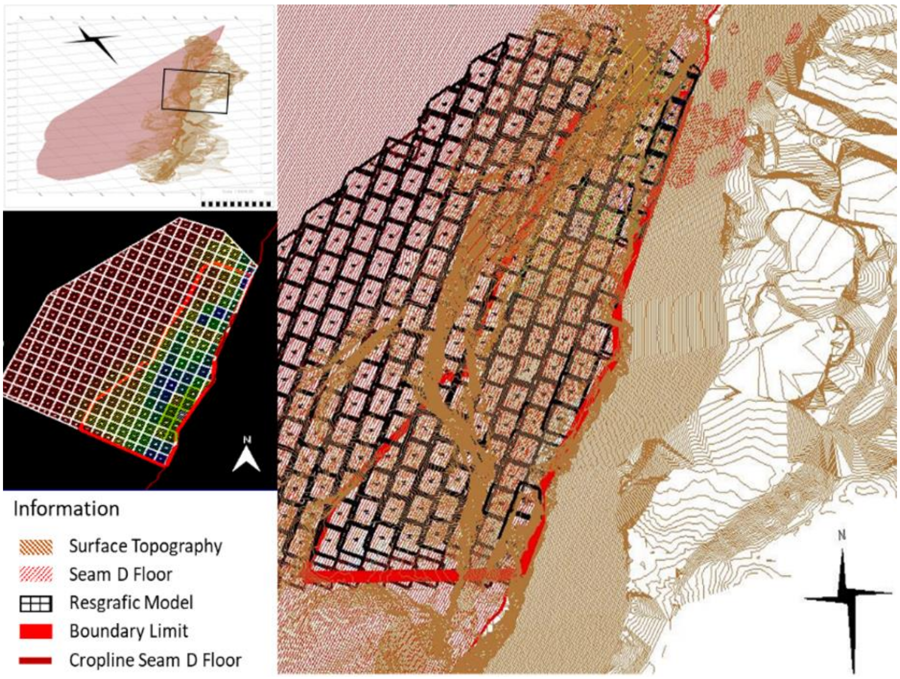

Figure 5. Determination of Mining Limit Limits

Figure 5 depicts the determination of the mining limits that will be utilized in designing the pit. To estimate the stripping ratio for each area, block strips are created on the contour of the floor seam structure D, which serves as the bottom of the pit. These block strips have dimensions of 40x50 meters and allow for the assessment of the stripping ratio within each cell. The SR block display in Figure 5 provides a visual representation of the estimated stripping ratio values for different areas. The display utilizes colors such as purple, blue, green, yellow, and orange to indicate SR values below the predetermined limit of 15. Conversely, SR values above the limit are depicted in red. This representation enables the determination of mining limits based on the desired SR limit, with a target range of 15 to 16. By establishing the mining limits according to the desired SR limit, PT Tanjung Alam Jaya can optimize their mining activities. These limits ensure that the extraction of coal reserves aligns with the defined stripping ratio threshold, allowing for effective resource utilization and economic viability. The use of resgrahics modeling and the visualization of SR values in Figure 5 assist in making informed decisions regarding mining boundaries, ultimately contributing to the success of the mining operations within the Pit X area.

3.5 Pit Limits

The pit design represents the final stage of the mine planning process, outlining the boundaries and parameters for the excavation of coal reserves. In this study, the pit design incorporates various design parameters, including the height of the ladder set at 10 meters, the embankment width of 5 meters, a single tilt angle of 65º, a haul road width of 21 meters with a 10% slope (grade), and a pit bottom at an altitude of -56 meters above sea level. One important consideration in the pit design is the strip ratio, which determines the ratio of overburden to coal that needs to be removed during mining operations. The maximum strip ratio allowed in this study is set at 15.5. This value is derived from a comprehensive analysis of coal selling prices and mining production costs at the Pit X mine, aiming to achieve a breakeven stripping ratio. The final pit design (refer to Figure 6) serves as the foundation for the annual mining sequence planning, guiding the extraction of coal reserves [13]. Figure 6 presents the final pit design, which is based on the actual topographic map from January 2022. The mining direction is elongated to the southeast, resulting in a pit length of 1,065 meters and a pit width ranging from 310 to 460 meters. The total mining area amounts to 38.1 hectares. The ramp slope within the final pit design is set at 10%, ensuring safe and efficient access for mining operations. The boundaries established by the final pit design serve to define the excavation limits for both overburden and coal, extending until the end of the mining process, while adhering to the planned stripping ratio value [14].

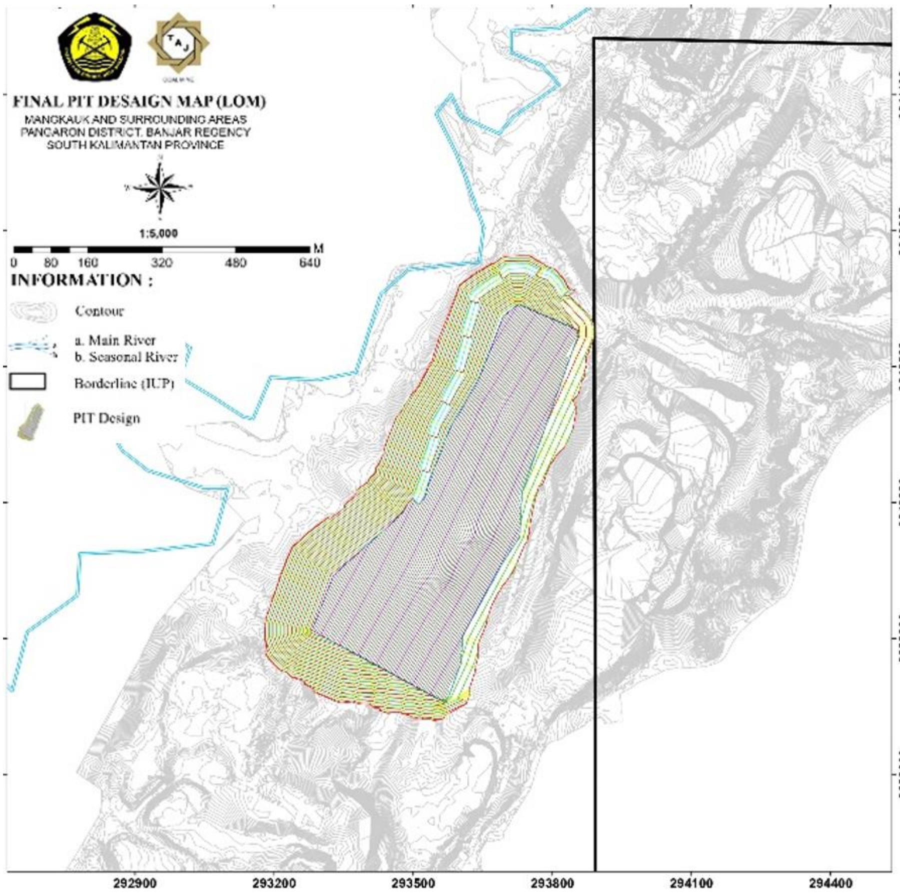

Figure 6. Final planning of the pit design.

Figure 7 provides a 2D section illustrating the mining direction within the designated area. This visual representation aids in understanding the spatial arrangement of the pit design and the planned sequence of mining activities. By implementing the final pit design, PT Tanjung Alam Jaya can effectively manage the extraction of coal reserves within the Pit X area. The design optimizes resource utilization, ensures safe mining operations, and facilitates the planning of mining sequences. The integration of topographic data, design parameters, and strip ratio considerations contributes to the overall success of the mining activities, supporting the company's objectives and sustainable mining practices.

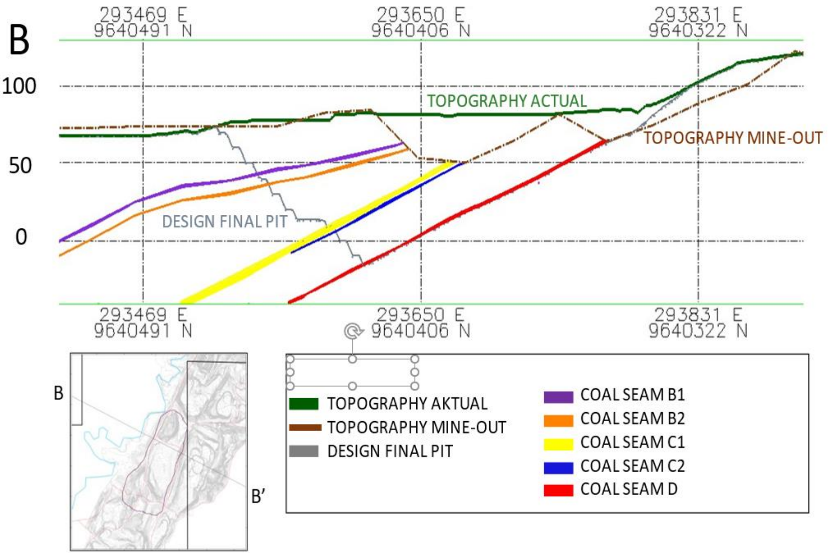

Figure 7. The B-B’ mine plan section.

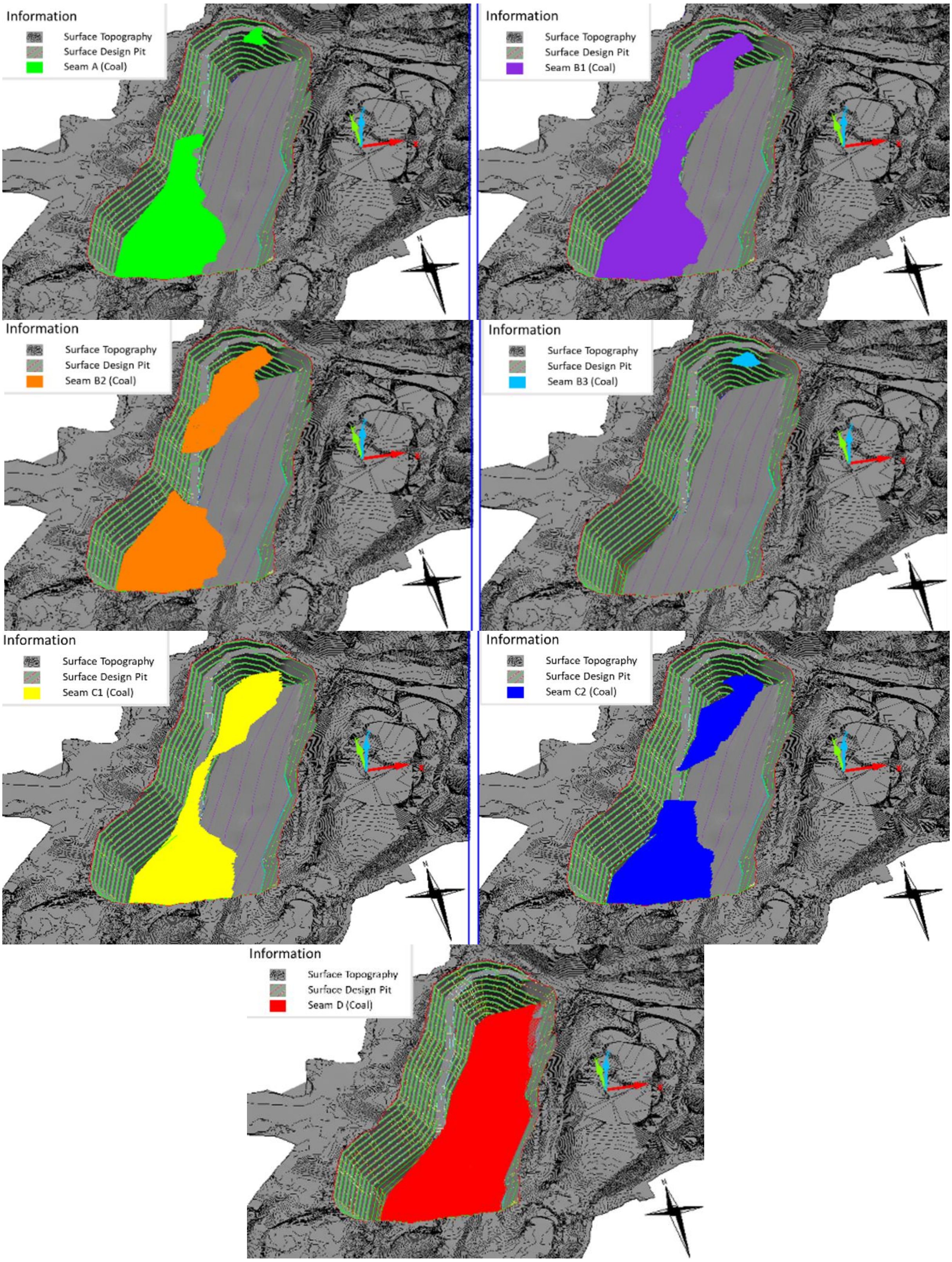

Figure 8. The 3D model of the whole coal seams within the pit boundary

3.6 Minable Coal Reserves

Accurately determining the minable coal reserves is a critical aspect of the mining planning process. This calculation enables PT Tanjung Alam Jaya to assess the quantity of both coal and overburden within the designed pit. The pit design incorporates seven coal seams: layers A, B1, B2, B3, C1, C2, and D, each contributing to the overall coal reserves. Considering the coal density in the study area, estimated at 1.3 grams per cubic centimeter, the 3D modeling of the pit design facilitates the calculation of minable reserves. To account for mining losses, a thickness below 0.3 meters is considered non-minable. Additionally, a reduction of 0.2 meters is applied to address mining techniques and impurities associated with the coal. These considerations ensure a realistic estimation of the actual coal reserves that can be economically extracted.

Figure 8 visually represents the comprehensive 3D modeling of all coal seams within the pit design, offering valuable insights into their spatial distribution and potential mining areas. By utilizing Minescape 5.7 software, the calculation of total minable coal reserves from the pit design reveals a quantity of 1,077,125.75 billion cubic meters (bcm), equivalent to 1,400,263.48 tons. Concurrently, the pit design also indicates the presence of 21,565,312.42 bcm of overburden/interburden that must be removed during the mining process. These quantities are crucial for determining the stripping ratio, which compares the amount of overburden excavated to the total coal obtained from the pit design [15]. In this case, the stripping ratio derived from the design is determined to be 15.4 (refer to Table 2).

The planning team at PT Tanjung Alam Jaya has established a maximum stripping ratio of 15.5 for the Pit X mine. This value is derived from comprehensive studies and analyses considering various factors, including coal prices, extraction costs, overburden removal costs, and other production expenses. The maximum stripping ratio serves as the break-even stripping ratio (BESR) and acts as a benchmark for economic viability [13]. Based on the pit design and the calculated stripping ratio of 15.4, the pit design can be deemed economically feasible. The total minable reserves of 1,400,263.48 tons highlight the significant coal resource available for extraction within the designed pit.

These accurate calculations of minable coal reserves provide PT Tanjung Alam Jaya with vital information for effective production planning, scheduling, and investment decision-making. The knowledge of available coal reserves and the associated stripping ratio empowers the company to optimize its mining operations, ensuring efficient resource utilization, cost-effectiveness, and sustainable profitability [16]. By leveraging this information, PT Tanjung Alam Jaya can drive their mining activities forward, contributing to their long-term success in the Pit X mine.

4. Conclusion

The designed excavation area covers a substantial 38.1 hectares, providing significant scope for mining operations. The excavation boundaries extend to a depth of -56 meters above sea level, ensuring an extensive mining depth. The shape of the excavation area follows a northeast-southwest direction, spanning a length of 1,065 meters [17]. The width of the excavation area ranges from 310 to 460 meters, accommodating the necessary space for efficient mining activities. The excavation area is characterized by a slope height of 10 meters, allowing for safe and practical excavation processes [18]. The embankment width of 5 meters contributes to the stability and structural integrity of the mining site. Furthermore, the single slope angle of 65º is designed to meet the required specifications. The haul road, with a width of 21 meters and a grade of 10%, provides a suitable pathway for transportation and logistical operations within the mining site [19].

Table 2. The coal reserves of all seams

Layers	**Coal**		**Overburden / Interburden (bcm)**
	(bcm)	**(ton)**	
A	70.953.47	92.239.51	5.523.363
B1	18.381.43	23.895.86	2.375.052
B2	46.696.30	60.705.19	909.633
B3	417.05	542.17	1.609
C1	420.059.78	546.077.71	5.241.553
C2	133.606.17	173.688.02	236.203
D	387.011.55	503.115.02	7.277.899
Total	1.077.125.75	1.400.263.48	21.565.312.42
	SR		**15.4**

Coal Reserves in Pit X is showing the evaluation of coal reserves within the Pit X area reveals substantial quantities of potential resources. Utilizing Minescape 5.7 software, the total coal reserves from all seams within the pit design are calculated to be 1,077,125.75 billion cubic meters (bcm), equivalent to an impressive 1,400,263.48 tons. These reserves showcase the substantial availability of coal within the designated mining area. Additionally, it is determined that the extraction process will require the removal of 21,565,312.42 bcm of overburden/interburden. This calculation provides valuable insights into the volume of material that needs to be excavated to access the valuable coal reserves [20].

These conclusions signify the significant potential and magnitude of the excavation area in Pit X. The ample space available for mining operations, combined with the substantial coal reserves, positions PT Tanjung Alam Jaya for productive and sustainable mining activities. The detailed calculations of coal reserves and overburden/interburden quantities empower the company to make informed decisions regarding resource utilization, operational planning, and environmental management. By leveraging this information, PT Tanjung Alam Jaya can strategically allocate resources, optimize production schedules, and ensure responsible mining practices within the Pit X area. This comprehensive understanding of the excavation area and coal reserves provides a solid foundation for successful mining operations and reinforces the company's commitment to efficient and sustainable resource extraction [21].

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