Hydrological monitoring in open PIT mining areas using geodatabase attribute in Geographic Information Systems (GIS)

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Abstract. In open mining systems, the most important problem in mining production activities is surface water management, where surface water management is integrated water management activity with the aim of minimizing the negative influence of surface water which consists of mine drainage methods, mine drainage, sediment separation and control. Geographic Information Systems (GIS) can be used for hydrological analysis using spatial data, especially in calculating runoff discharges from surface water. The method used in calculating runoff discharge is in the form of daily rainfall data. This rainfall data can show the influence of the catchment area which is useful for knowing precisely and accurately the runoff water discharge. Geographic Information Systems (GIS) are used to calculate variables in rational formula equations by overlay analysis. Information about digital-based hydrological conditions is very useful as a means of decision making and policies undertaken in monitoring hydrological conditions in open mines. By using a geographic information system (GIS) with a geodatabase attribute, it can be used to view general conditions in a mining area in monitoring hydrological conditions. So it is very appropriate to be used as hydrological monitoring in the mining area in making decisions that are fast, precise and accurate. Apart from that the geodatabase attribute can see the actual conditions of a mining area.

1. Introduction
A common problem that occurs in companies engaged in mining by implementing an Open Mining System (Surface Mining) is the problem of surface water management in which surface water management is an integrated surface water management activity with the aim of minimizing the negative effects of water the surface consists of mine drainage, mine dewatering, separation (natural and disturbed water separation) and sediment control [1].

With this rapidly advancing technology, work on monitoring surface water management in the mining area can certainly be reduced slightly by using the help of Geographic Information Systems (GIS) [2]. The development of Geographic Information Systems (GIS) provides new hope in optimizing efforts to solve problems regarding surface water management so that the existence of the geographic information system is felt to be very necessary. Geographic Information Systems (GIS) can be used in conducting hydrological analysis with spatial data based [2]. In its use, GIS software can be used in measuring and obtaining the data needed in the calculation of runoff discharge [3]. Variable calculation of surface runoff discharge using the rational method requires the value of the measurement results of
Catchment Area boundary area, channel length and topography of the area under review [4]. Besides being able to be used for the calculation of runoff water discharge, GIS can also be developed as a medium to provide hydrological information at the mine site [5]. Considering the use of GIS is not optimal, this research is expected to be used as a pilot project or example in building a geographic information system (GIS) based hydrological information system which can be used by engineers in mining companies as a medium to monitor the hydrological state at the mine site and make decisions correct [6]. The construction of a GIS-based hydrological information system can also be beneficial for needs other than the hydrology field at the mine because the information presented is systematic and can be updated [7].

Monitoring the hydrological system in an open pit can be done using a geographic information system (GIS). Geographic Information Systems (GIS) can be used in conducting hydrological analysis with spatial data based. In addition, the use of the geodatabase attribute that has been widely used in GIS for various purposes has been done. Therefore, a study was conducted in monitoring hydrology in the open pit area by using the geodatabase attribute on the geographic information system (GIS).

2. Methods

2.1. Geographic Information System (GIS)

Geographic Information System or abbreviated GIS is a system that has the ability to collect, store, transform data (edit, manipulate, etc.) [8]. GIS is a computer-based system, consisting of hardware in the form of a computer (hardware), software (software), geographic data and human resources (Brainware) that is capable of recording, storing, updating, and analysing and displaying the referenced information geographical [9]. Glenn O. Schwab in Prahasta that the Geographic Information System (GIS) is a comprehensive information management system, which includes surveying, mapping, cartography, photogrammetry, remote sensing and computer science [10]. This system allows users to enter data, organize, analyse, manipulate and display spatial data. GIS has the ability to conduct spatial investigations and overlays so that it can produce new information. GIS consists of several sub-systems, namely data input systems, data storage systems, data analysis systems, and data output systems.

GIS can represent real world (real world) on a computer monitor as a map sheet that can represent the real world on paper. But GIS has more strength and flexibility than paper map sheets. Maps are graphical representations of the real world, the objects represented on the map are called map elements or map features (for example, rivers, gardens, roads, etc.). Because maps organize elements based on their location, maps are very good at looking at relationships or relationships that are owned by the elements. The ability of GIS can also be recognized by the analytical functions it can perform. Generally there are two types of analysis functions, namely the spatial analysis function and the attribute analysis function. The attribute analysis function consists of basic database operations which include create database, drop database, create table, drop table, record and insert, field, seek, find, search, retrieve, edit, update, delete, zap, pack, create indexes for each database tables, and expansion of database operations that include exports and imports, structured query languages, and other analytical operations or functions that are routinely used in database systems. Spatial analysis functions consist of reclassify, overlays, and buffering [10]. One of the most powerful and basic functions of GIS tools is data integration in new ways. One example is overlay, which combines different data layers. GIS can also integrate data mathematically by carrying out operations on certain attributes of the data [10].

3. Hydrology in open mines

3.1. Runoff water discharge

The calculation used to determine runoff water discharge is the Rational Method (US Soil Conservation Service 1973). This formula can be used only for research areas where the cup is small or ± 300 Ha and relatively homogeneous surface conditions [9]. With the following formula:
Q = 0.278 × C × I × A

where:
Q = maximum drainage (m\(^3\)/sec)
A = cross-sectional area (m\(^2\))
S = channel base slope (%)
R = hydraulic radius (meter)

3.2. Planning trenches
Plan trenching at the mine functions as a reservoir of surface water runoff in an area and flows it outside
the mining area [11]. In designing the shape of the trench channel, there are several things that need to
be considered, among others, the planned water discharge and the technical application in the field based
on adjustments to the topographic shape and soil type. Determination of the dimensions of the trench
can be calculated with the Manning equation as follows:

\[ v = \frac{1}{n} \times (R^{2/3}) \times S^{1/2} \]

4. Results and discussion

4.1. Runoff water discharge into the Mine Pit is open
From the delineation of the topographic map to get the Catchment Area, so it can know the potential of
runoff water that enters the Pit. After the runoff coefficient is known that is 0.854 rainfall intensity
0.00908 m/s, and the catchment area is 4.242 km\(^2\), the runoff water discharge into the Pit can be
calculated using the rational formula and the result is 23.997 m\(^3\)/sec.

4.2. Prevention of runoff water into open mine
The trench planning is carried out after it is known that the flow of water entering the mining area of
each segment of the catchment area. The trench section is made in the form of a trapezoid with planned
trench dimensions based on the maximum water volume during the heavy rainy season taking into
account the slope. Making the diversion channel is divided into 4 segments to accommodate a different
catchment area. From the calculation results, the results of the trench plan are as follows:

Table 1. Trenches dimension plans.

| Dimension                      | Segment 1 | Segment 2 | Segment 3 | Segment 4 |
|--------------------------------|-----------|-----------|-----------|-----------|
| Plan trench length (L)         | 1,556     | 6,9       | 2,089     | 5,04      |
| Channel Surface Width (B)      | 1,957     | 2,59      | 2,192     | 3,192     |
| Channel base width (b)         | 1,339     | 1,772     | 1,5       | 2,184     |
| Flow Depth (y)                 | 0,927     | 1,227     | 1,038     | 1,512     |
| Guard Height (f)               | 0,661     | 0,783     | 0,72      | 0,869     |
| Channel Height (H)             | 1,625     | 2,031     | 1,778     | 2,407     |
| Discharge (m\(^3\)/ s)         | 3,259     | 7,169     | 3,912     | 14,34     |
4.3. Hydrological monitoring based on GIS

The database that has been created and performed data attributing is then processed using ArcGIS software so that it will display the following information:

![Figure 1. GIS-Based hydrological information at channel location.](image1)

![Figure 2. GIS-based hydrological information at the research location.](image2)

From the results of the making of a GIS-based hydrological information system it can be analysed that there is a mismatch between the plan volume of the sediment pond and the actual situation in the WMP 38 field while for the channel as a whole it is sufficient. For the condition of TSS (Total Suspend Solid) content and pH at WMP 38, treatment must be taken to reduce the pH to conform to environmental
quality standards. In accordance with the Provincial Regulation of East Kalimantan No.2 in 2011 where the pH value in accordance with the quality standard is 6 - 9, TSS = 300 mg / l, Fe 7 mg / l, Mn = 4 mg / l.

5. Conclusion
In open mining, the role of hydrology is very important in the development of a mine. The hydrological input parameters used are topographic maps of whole conditions, disposal, and water monitoring points (WMP) and channels. By building a GIS-based information system, it can be used as a general / overall picture of the state of hydrological holes used in decision making in controlling hydrological monitoring. By using the geodatabase attribute used in this GIS, it can be used as an appropriate, fast and accurate decision making. From the results of this study, it can be seen that hydrological monitoring can be done by utilizing the geodatabase attribute as a decision in an action when something unexpected happens, so that it can make a mining area more conducive and safer for productivity.

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