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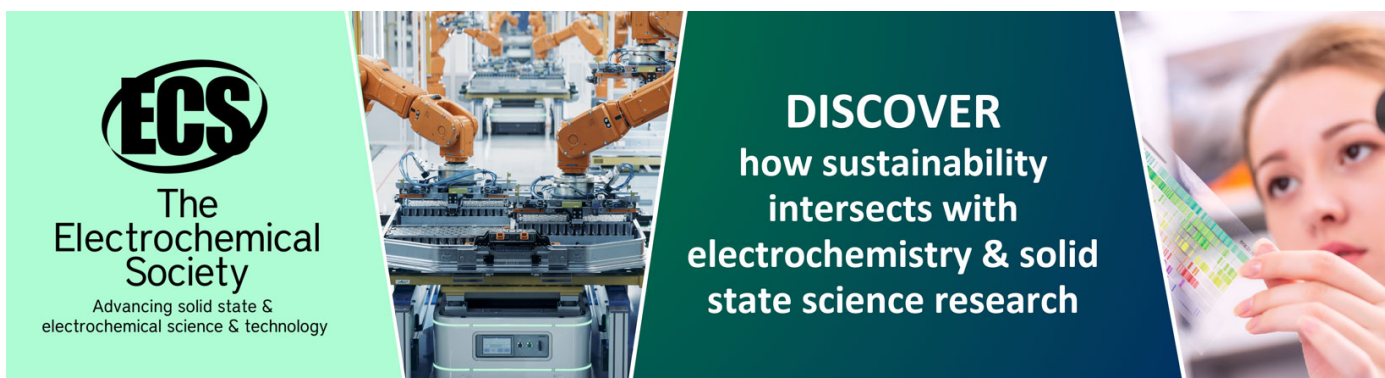
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To cite this article: D. Frangky B. Welkis *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **437** 012005

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Characteristics of Flood Water Level Based on Hydrologic Soil Group Analysis in Temef Watershed

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Abstract. Temef Watershed is located in the Benanain River Basin with a catchment area of 551.50 km². River characteristics in the Temef Watershed are influenced by three main river streams from upstream to downstream. Conventional collection of data on watershed characteristics requires a relatively long process and time. However, when based on Geographic Information Systems (GIS), the cost and time will be more efficient. The floodwater level is affected by the amount of rainwater runoff that occurs in the Temef Watershed. The amount of runoff depends on the level of soil permeability and land cover. To determine the level of soil permeability, hydrogeological maps are used. Based on this, a study of the characteristics of flood waters from GIS-based hydrogeology is needed. The analysis method used ArcGIS overlay on hydrogeological maps, while data on watershed characteristics used the Archydro and HEC-GeoHMS features. The results of the analysis showed a level 3 permeability type with limestone lithology, solid volcanic breccia, sandy marlene, conglomerate, and alluvium consisting of sand and gravel having moderate to high permeability. The metamorphic and basalt rocks have low to moderate permeability and the scaly clay has low to very low permeability. This condition causes runoff that turn into flood streams.

Keywords: curve number, hec hms, rainfall-runoff

1. Introduction

Temef Dam is located at Temef River, at approximately 09°43'6.24" S and 124°26'49.8" E, in Konbaki Village in Polen District and Oenino Village in Oenino District, in South-Central Timor Regency, Province of East Nusa Tenggara (see Figure 1). The South-Central Timor Regency has a tropical climate as in other regions in the Province of East Nusa Tenggara, with temperatures from 27-29 °C, and an average of annual rainfall of approximately 1446.4 mm/year [3]. This regency is an area of large irrigation potential and yet also lacks domestic water sources; one of the potential sources is by building the Temef Dam. Other technical data of Temef Dam are presented in Table 1.



Utilization of water resources to fulfil various demands continues to be optimally developed by the Government of the Province of NTT; various efforts have been made, and one of them is utilizing the potential of water discharge of the Temef River. The condition of the Temef River flow during the rainy season has a very large discharge, while in the dry season, the water flow of the Temef River decreases dramatically. The flood discharge every year is a problem along the Temef River itself and its downstream part, where the Malacca Region becomes a flooded area in every rainy season. Gaps in conditions due to seasonal changes need to be assessed so that the availability of water during the rainy season could be accommodated and utilized in the dry season.

Table 1. Technical Data of Temef Dam

No.	Parameter (unit)	Magnitude (remarks)
1	Name of Dam (Reservoir)	Temef
2	District/Regency	South-Central Timor
3	Province	East Nusa Tenggara
4	Position/Coordinate	09°43'6.24" S and 124°26'49.8" E
5	Length of Dam Crest (m)	535
6	Height of Dam (m)	53
7	Dam Crest Elevation (m)	+ 383 m
8	Spillway Crest Elevation (m)	+ 375 m
9	Length of Spillway Crest (m)	70
10	$Q_{100\text{-yr}}$ (m^3/s)	889.61 m^3/s
11	Q_{PMF} (m^3/s)	3238 m^3/s
12	Reservoir Volume at Dam Crest (m^3)	45,780,000
13	Reservoir Volume at Dead Storage (m^3)	32,060,000
14	Catchment Area (km^2)	551.5

Source: PT. Catur Bina Guna Persada, 2019

The selection of the right method for estimating flood discharge for dam safety is very important. The rainfall-runoff relationship model using HEC HMS software is an often-used method because this model is easily accessible and offers many combinations of methods from calculations of losses, hydrograph transformation (hydrograph unit), base flow, and flood routing. The calculation of excess discharge due to flooding occurrences affects the peak discharge and volume of the flood. One of the most widely-used methods to estimate effective rainfall that is the same as the estimated total loss of rainfall is SCS (Soil Conservation Service), or now called NRCS.



Figure 1. Location of Temef Reservoir

This method is based on the Curve Number (CN) value, which is an index value to determine the amount of rainfall that flows and enters the river network system. The determining of CN requires the availability of Hydrologic Soil Group (HSG) maps, which must be made from other maps containing parameters required by the Hydrologic Soil Group [1]. The CN value is derived from the HSG map and the land use map; if both maps are available, the CN can be determined by the Lookup Table. The purpose of this study is to determine the CN value in the Bijeli sub-watershed in the Temef watershed using a Hydrologic Soil Group Map.

2. Materials and Methods

The collection of data on a watershed is not easy and requires large costs when performed conventionally. The process and time required are relatively long. If the watershed data collection is based on a Geographic Information System, then the costs and time allocated can be more efficient by obtaining complete results in the form of watershed morphological extraction. This contains the parameters of watershed area, river length, watershed width, river slope, and watershed shape [7].

The Hydrogeology Map of Indonesia, published by the Centre for Geological Environment of the Geology Agency with a scale of 1:250,000, contains information about soil permeability and groundwater depth. The composition of lithology and gradation provides information on the permeability condition of the soil in a qualitative manner. Groundwater and aquifer productivity are presented, given a picture of the depth of the aquifer in general. Based on hydrogeological maps, the hydraulic conductivity is obtained, which is the measure of the ease of water movement through soil pores depending on the permeability (gradation) of rocks [1]. Watershed soil characteristics taken from digital hydrogeological maps include:

- The type of rock lithology associated with the level of gradation; and
- The depth of groundwater, especially when less than 100 cm.

Information from the two items above results in the Hydrologic Soil Groups (A, B, C, and D)

2.1 Hydrologic Soil Group (HSG)

Hydrological soil type grouping is based on soil maps containing similar properties such as depth of layers or depth of groundwater level, water transmission rate, texture, and structure as well as the level of development when a saturated condition is reached, resulting in almost the same runoff [1].

Hydrological soil types are divided into four groups of soil types: A (high potential to absorb water), B (moderate potential to absorb water), C (low potential to absorb water) and D (very low potential to absorb water). The determining of soil permeability utilizes the conversion of hydrogeological maps through conversion to HSG, as shown in Table 2 and Table 3.

Table 2. The conversion of hydrogeological maps to HSG for deep groundwater (without blue colour), greater than 100 cm

Permeability				
Very high	High	Medium	Low	Very Low
A				
	B			
		C		
			D	

Source: Adidarma, 2013

Table 3. The conversion of hydrogeological maps to HSG for shallow groundwater (with blue colour), less than 100 cm

Permeability				
Very high	High	Medium	Low	Very Low
A				
	B			
		C		
				D

Source: Adidarma, 2013

2.2 The Curve Number

The runoff Curve Number (CN) model from the Soil Conservation Service estimates excess rainfall as a function of cumulative rain, cover soil type, land use, and soil moisture. In this method, the thickness of runoff or effective rain is a function of the total rain thickness and the reflection parameter of the runoff Curve Number. This method used the ArcGIS software to overlay and unite data on land cover and soil type maps. Hydrological soil type maps utilized hydrogeological maps [4]. Hydrogeological maps with complete information about the parameters needed to determine HSG such as soil permeability and groundwater level from the surface can be used as a basis for determining the Hydrologic Soil Group (HSG). Hydrological soil types are divided into four groups, which are the soil types A (high potential to absorb water), B (moderate potential to absorb water), C (low potential to absorb water) and D (very low potential to absorb water) [1]

3. Results and Discussion

One of the five sub-watersheds in Temef is the Bijeli Sub-Watershed with a catchment area of 192.123 km², which is shown in Figure 2. The technique of determining CN to be the primary analysis for this study required testing through a calibration test. The map used to determine Hydrologic Soil Groups with complete information about the parameters needed for the process, such as HSG permeability by

conversion, is shown in Table 4. The position of the groundwater level was estimated and permeability was determined by the explanation of rock lithology or hydrogeology map legend.

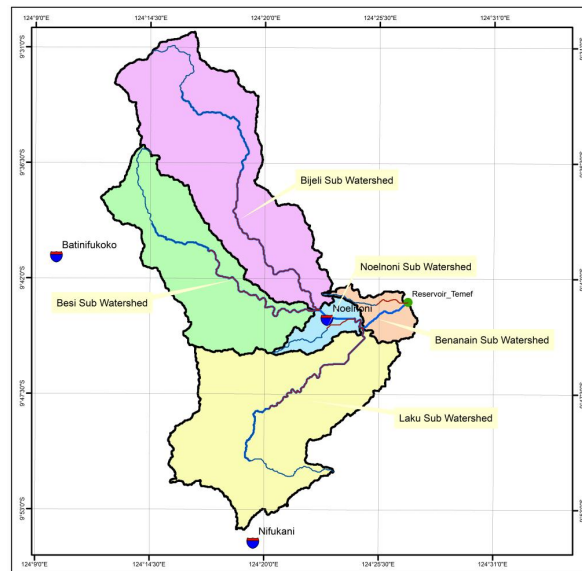
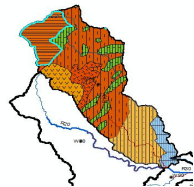
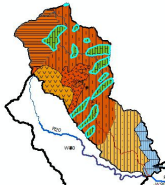
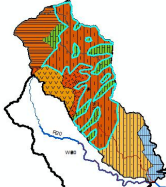
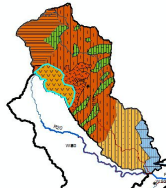
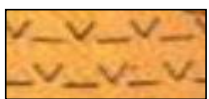
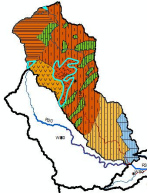
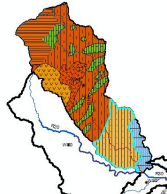
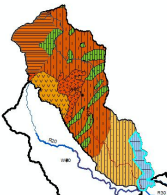


Figure 2. Location of the Bijeli Sub-Watershed in Temef Watershed

Table 4. Determining HSG in terms of aquifer condition and rock lithology

No	Object Sketch	Lithology and Permeability			HSG	Area (Km ²)	Weight (%)
		Picture	Lithology	Permeability			
1			Various types of metamorphic rocks from slate to gneiss, amphibolite, quartzite, and granulite	Low to medium	C	24.457	0.127
2			Massive limestone and calcilutite	Medium to high	B	21.675	0.113
3			Scaly clay containing exotic blocks of other rocks	Low to very low	D	71.697	0.373
4			Massive volcanic breccia, agglomerate lava, and tuff	Moderate to high	B	14.145	0.074



5		Basalt lherzolite and serpentinite	Low to moderate	C	12.262	0.064
6	 	Sandy marl interbedded with sand stone, conglomerate, and dacitic tuff	Moderate to high	B	37.194	0.194
7	 	Conglomerate and cobbles; the upper part appears to be unconsolidated, while the lower part is consolidated	Moderate to high	B	10.714	0.056
Total					192.144	1.000

Based on Table 4 above, it can be seen that the lithology and permeability of the Bijeli Sub-Watershed is dominated by scaly clay containing exotic blocks of other rocks by almost 37.3%. This means that the Bijeli Sub-Watershed can hold enough water because it has a low permeability. The other four sub-watersheds used the same method to obtain the CN values. The CN value is one parameter of hydrology analysis to calculate the peak of discharge for Temef Dam.

4. Conclusion

The results of the analysis showed a level 3 permeability type, with limestone lithology, solid volcanic breccia, sandy marlene, conglomerate and alluvium consisting of sand and gravel having moderate to high permeability. The lithology and permeability of the Bijeli Sub-Watershed is dominated by scaly clay containing exotic blocks of other rocks by almost 37.3%. The Bijeli Sub-Watershed can hold enough water because it has a low permeability, which can be used for the planning of hydrology analysis for Temef Dam.

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