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Analysis of Water Level Changes in the Kelekar River Using the HEC-RAS Program

Afirly[1]; Achmad Syarifudin[2*]
[1]*Post Graduate of Civil Engineering, Faculty of Engineering, Universitas Bina Darma, Indonesia*
[2]*Post Graduate of Civil Engineering, Faculty of Engineering, Universtas Bina Darma, Indonesia*
**Corresponding Author*

Abstract

This study aims to analyze the magnitude of water level changes along a 750-meter stretch of the Kelekar River—including the section at the TanjungSenai box culvert bridge—using HEC-RAS software (Version 4.1.0). A flow rate of Q25 = 34.047 m³/s was used as the input boundary condition, based on a 25-year flood return period for the Kelekar watershed.
The results indicate that the longitudinal profile of the Kelekar River experiences overtopping between Station 0+00 and Station +742.02, with a simulated average water level of 3.00 meters. Under these conditions, it is evident that the river overflows its banks, reaching a water level of 3 meters and a Water Surface Elevation (WSE) of 21.02 meters. At Station +196, where a box culvert bridge with a width of 16.52 meters is located, no overtopping occurs; the water level is 3.4 meters with a WSE of 20.9 meters.

Keywords: *Kelekar river, HEC-RAS Program, Water level, Overtopping*

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I. INTRODUCTION

OganIlir Regency features a bridge connecting the town of Indralaya to the TanjungSenai Government Complex. Spanning the Kelekar River, this bridge was constructed in 2015 and inaugurated by the Regent of OganIlir. It has become a new tourism icon in the area, attracting both local and out-of-town visitors who come to take photos and enjoy the sunset. The surrounding natural beauty—including vast green meadows and gentle breezes—further enhances the site's appeal.

The TanjungSenai area in OganIlir Regency houses a government office complex situated across the Kelekar River, served by the bridge built in 2015. High rainfall intensity in OganIlir Regency causes the water discharge of the Kelekar River in the TanjungSenai, Indralaya area to rise. During periods of highwater levels, the condition of the Kelekar River in TanjungSenai, Indralaya, poses a risk of inundation or even flooding (OganIlir in Figures, 2025).

Water resource management faces increasingly complex challenges driven by rising water demands—a consequence of population growth and socio-economic development. Furthermore, mismanagement has led to excessive exploitation of water resources, thereby diminishing the environment's carrying capacity and ultimately reducing the capacity for water supply (AlifiYunar et al., 2017).

Signs of the degradation of water resource environmental functions include increasingly sharp fluctuations in discharge rates between the rainy and dry seasons, water pollution, and reduced reservoir storage capacity, among others. Beyond these physical challenges, water resource management also faces operational hurdles—such as insufficient funding for operations and maintenance, weak inter-agency coordination, and a lack of accountability, transparency, and stakeholder participation aligned with good governance principles (RakhmadArmus et al., 2022).

Due to the hydrological cycle, water is considered a renewable resource. However, factors such as population growth, expanding economic development, increasingly intensive water use, water pollution over recent decades, and global climate change have created an imbalance between water availability and demand. This imbalance has triggered a water crisis across much of the globe. The various issues surrounding water resources—regarding both quantity and quality—must make all stakeholders realize that water-related problems require appropriate action to achieve optimal solutions. In other words, Integrated Water Resources Management is essential (SugengSutikno, 2014).

Addressing the destructive power of water can be achieved through disaster mitigation. Disaster mitigation involves activities designed to alleviate the suffering caused by disasters—such as providing evacuation facilities or resources for the emergency repair of breached embankments. Management is carried out in an integrated manner by relevant agencies and the community, coordinated by the National Agency for Disaster Countermeasure (BNPB) at the national level and the Regional Disaster Management Agencies (BPBD) at the provincial and regency/city levels. Specific provisions regarding the management of damage and disasters caused by the destructive power of water are further regulated by government regulations. Emergency Response: In situations of danger, the Governor and/or Regent/Mayor are authorized to take emergency measures to address the destructive power of water. A "situation of danger" refers to an extraordinary hydrological condition—specifically, one exceeding planned limits—where, absent emergency intervention, the situation is predicted to escalate into a major disaster threatening public safety (Arsyad, K. M., 2017).

High rainfall intensity in OganIlir Regency has caused the discharge of the Kelekar River in the TanjungSenaiIndralaya area to rise. During high-water periods, the condition of the Kelekar River in TanjungSenaiIndralaya poses a risk of inundation or even flooding.Water resource management faces increasingly complex challenges driven by rising water demands—a consequence of population growth and socio-economic development. Furthermore, mismanagement has led to excessive exploitation of water resources, thereby diminishing the environment's carrying capacity and, consequently, reducing the ability to supply water.

High rainfall intensity in OganIlir Regency causes the Kelekar River's discharge to increase. This condition creates a potential for inundation or flooding, particularly during high-water periods. Flooding is a natural phenomenon that occurs when water volume exceeds the capacity of rivers, lakes, or other waterways. In Indonesia, flooding is a frequent disaster with significant impacts.

Floodplain swamps are low-lying areas inundated with water for at least three months of the year. These swamps can be utilized for agriculture, fisheries, and livestock farming. Based on hydro-topography, Floodplain swamps are categorized into three types according to the duration of inundation. During the rainy season, these swamps become inundated due to overflowing nearby rivers; characterized by poor drainage, the water tends to stagnate and does not easily flow away.

HEC-RAS version 4.1.0 is a program capable of modeling one-dimensional unsteady flow with enhanced geometric accuracy; this is achieved because it allows for a greater number of data points when defining river or channel cross-sections compared to other commonly used one-dimensional unsteady flow models. Consequently, the representation of cross-sections for each profile within HEC-RAS version 4.1.0 yields results that more closely approximate actual conditions than previous methods (AchmadSyarifudin et al., 2022; Istiarto, 2016; Baitullah, 2014).

II. MATERIAL AND METHODS

This study is located in the TanjungSenai area of OganIlir Regency, covering a river stretch of approximately 750 meters, as shown in Figure 1.

Figure 1: Research location

2.1. Step of the Research

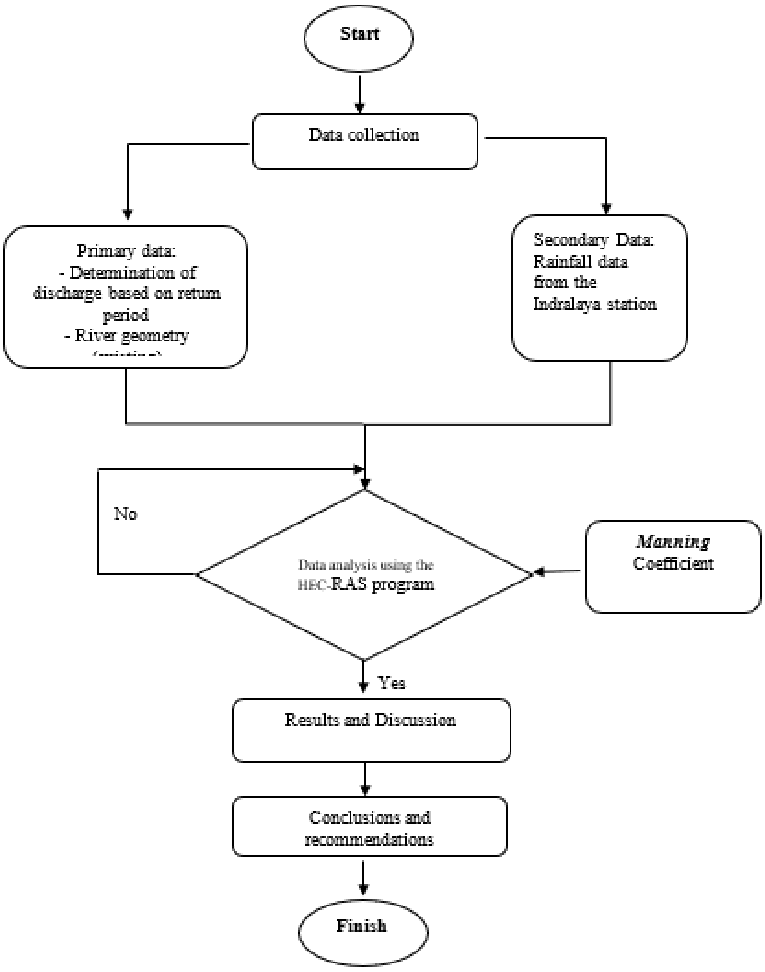

Figure 2: Step of the research

III. RESULTSAND DISCUSSION

3.1 Rainfall data

The rainfall data used in this analysis consists of annual maximum rainfall records from stations within the OganIlir sub-watershed, covering a 15-year period, as presented in Table 3.1.

Table 3.1 Maximum annual rainfall data

No.	Maximum Annual Rainfall (mm)
1	650
2	613
3	588
4	578
5	564
6	542
7	485
8	472
9	453
10	407
11	397
12	392
13	391
14	351
15	339

3. 2. Frequency Analysis

In the frequency analysis calculations, several statistical parameters regarding average rainfall are utilized, such as the sum, number of data points (n), mean value (X), standard deviation (S), coefficient of variation (Cv), coefficient of kurtosis (Ck), and coefficient of skewness (Cs). Table 2 presents the statistical analysis of the average rainfall.

Table 3.2 Chi-Square and Smirnov-Kolmogorov Good Fit Tests

Frequency Distribution	Suitability Test			
	Chi-Square test		Smirnov-Kolmogorov test	
	∑X2	X2 critic	Δmax	Δcritic
Normal	10,667	14,07	0,4862	0,3380
Log-Normal	8,000	14,07	0,6013	0,3380
Log-Pearson Type III	6,6667	14,07	0,7667	0,3380
Gumbel	10,667	14,07	0,1451	0,3380

Based on the results of the Chi-square and Kolmogorov-Smirnov tests, the distribution used for subsequent analysis is the Gumbel frequency distribution.

3.2 Profile Changes of the water level of theKelekarRiver

A flow rate of Q25 = 34.047 m³/s was adopted as the input boundary condition, based on the selection of a 25-year flood return period for the Kelekar watershed.

Figure 3 illustrates the longitudinal profile of the Kelekar River, showing that the river channel experiences overtopping from Station 0+00 to Station +742.02; the average water levels recorded in the simulations were 3.00 meters for Model I, 4.50 meters for Model II, and 7.20 meters for Model III.

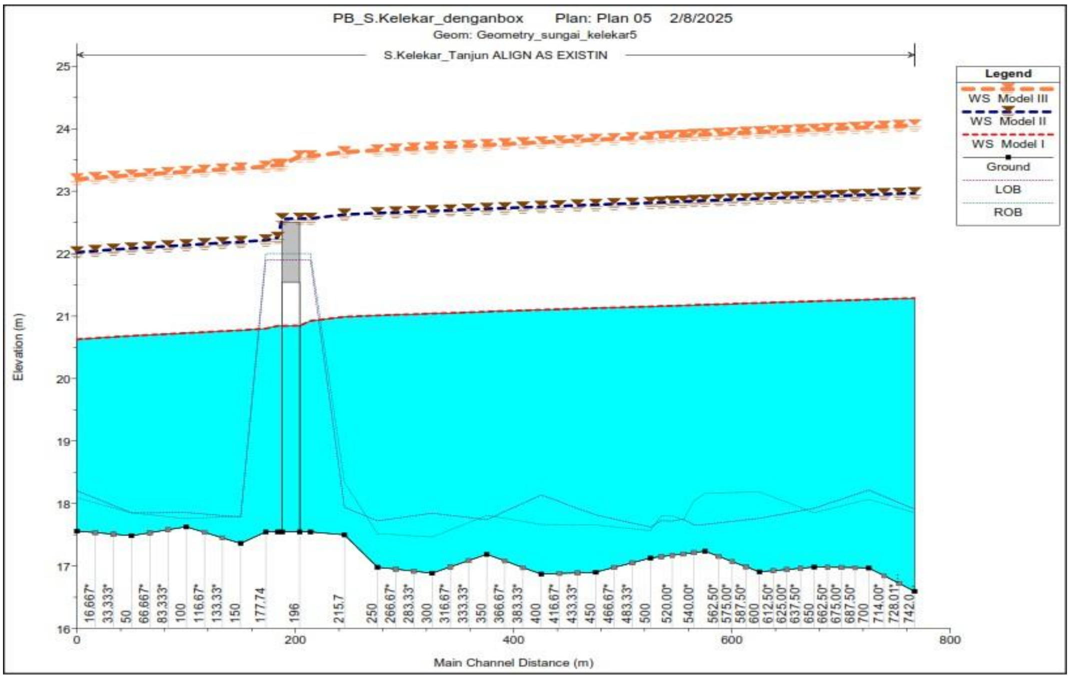

Figure 3: Longitudinal profile of the Kelekar river using discharge Q25 = 34.047 m3/sec

IV. CONCLUSION

Based on the data analysis and discussion, the conclusions of this study are as follows:

1. The longitudinal profile of the Kelekar River section shows overtopping occurring from Station 0+00 to Station +742.02, with an average simulated water level of 3.00 meters
2. Under these conditions, it is evident that the Kelekar River experiences overtopping, with a water level of 3 meters and a Water Surface Elevation (WSE) of 21.02 meters.
3. At Station +196, there is a box culvert bridge with a width of 16.52 meters; the box culvert does not experience overtopping, with a water level of 3.4 meters and a WSE of 20.9 meters.

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