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Alternative Study of River Maintenance Based on the Morphological Conditions of the Sumber Pinang River Pasuruan

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ABSTRACT

The Sumber Pinang River often overflows, especially in the rainy season due to the ability of the river's capacity to not be able to accommodate water discharge, causing flooding in Sidogiri Village, Pasuruan Regency every year. This study aims to determine the performance of rivers and river infrastructure, as well as the necessary maintenance actions on the Sumber Pinang River guided by the Circular Letter of the Directorate General of Water Resources No.05/SE/D/2016. This study uses primary data in the form of an inventory of the existing conditions of sumgai and river infrastructure, as well as secondary data in the form of technical drawings of rivers and unit prices of goods and services in Pasuruan Regency. The results of the study showed that the Sumber Pinang River had a performance value of 63.12 with the category of corrective maintenance actions. In a total of 8 observation point segments, the performance value is <50, namely at point 4, point 7, point 14, point 48 and requires maintenance actions in the rehabilitative category. Priority improvements are in the form of normalization of rivers and repair of river embankments in the form of earthen embankments and parapets. The total maintenance cost on the Sumber Pinang River was obtained as Rp 23.670.546.185.

INTRODUCTION

A river is a surface trajectory that moves from upstream to and empties into a larger sea or river (Pranida, 2021). The existence of rivers not only serves to accommodate water, but also as a transportation route, a place for various species of flora and fauna, as well as a center of economic and social activities for the surrounding community. Rivers have a vital role in maintaining the balance of nature and human life. Therefore, it is necessary to maintain rivers and river infrastructure as an effort to maintain the function of river service (Yunanto, et al., 2016). River maintenance is carried out as an effort to prevent or repair river damage before it poses a greater risk through the process of observation and assessment of river performance. River performance assessment is a study of the physical condition and function of the river as well as river infrastructure based on standard criteria that have been prepared to determine the level of river damage from the results of surveys in the field (Putra, et al., 2023).

The Sumber Pinang River in Pasuruan Regency has experienced a decline in its physical and functional performance as can be seen from frequent floods, as well as damage to several river infrastructure. The Sumber Pinang River overflows almost every year in the rainy season which causes flooding in residential areas (National Disaster Management Agency, 2024; Directorate General of Water Resources, 2020). It is necessary to take maintenance steps to prevent material losses and greater maintenance costs due to decreased river performance (Wafiyah, et al., 2024).

Maintenance is carried out through observations carried out along the river flow to obtain accurate data on the existing condition of the river so that appropriate maintenance actions can be planned as well as the Real Needs Figures for River Operation and Maintenance and River Infrastructure (AKNOP) on the Sumber Pinang River. AKNOP is a method of calculating the estimated costs needed in the implementation of river maintenance activities and river infrastructure (Retraubun, et al., 2020).

Based on the above background description, it is necessary to conduct a study on the performance assessment and river AKNOP on the Sumber Pinang River. Analysis of river performance and river infrastructure is needed to determine the level of damage that occurs to the river and determine maintenance actions as an effort to overcome the flood problem that occurs every year in the Sumber Pinang Pasuruan River. The performance assessment and calculation of river AKNOP is carried out based on the Circular Letter of the Directorate General of Water Resources No.05/SE/D/2016 (SE DJSDA No.05/SE/D/2016) concerning Guidelines for the Implementation of River Infrastructure Activities and Maintenance of Rivers.

RESEARCH METHODS`

Study Location

The location of the study of river performance analysis and AKNOP was carried out on the Sumber Pinang River which administratively crosses the Sidogiri Village area and is a tributary of the Welang river part of the Welang watershed. The Sumber Pinang River has a length of ±8.5 km which has a river headwaters in Siyar Village, Rembang District, Pasuruan Regency at coordinates 7°40'39.93'S - 112°48'52.926"E and downstream of the river in Dhompo Village, Kraton District, Pasuruan Regency at coordinates 7°39'31.524"S - 112°51'33.378"E. Sumber Pinang River in the Welang watershed and a map of the flow situation of the Sumber Pinang River can be seen in Figure 1 and Figure 2.

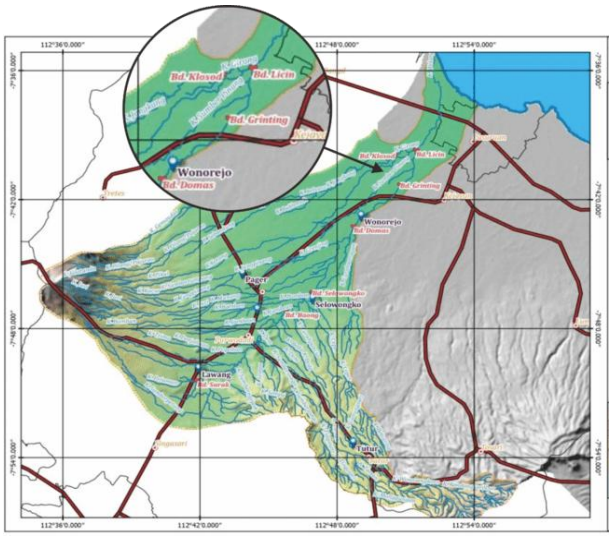


Figure 1. Welang Watershed (DAS Welang)

Figure 2. Stream Map of Kali Sumber Pinang

Research Stages

This study aims to determine the performance and maintenance actions of the Sumber Pinang River using an scoring method based on the SE DJSDA guidelines No.05/SE/D/2016. Figure 3 shows the research stages carried out in this study.

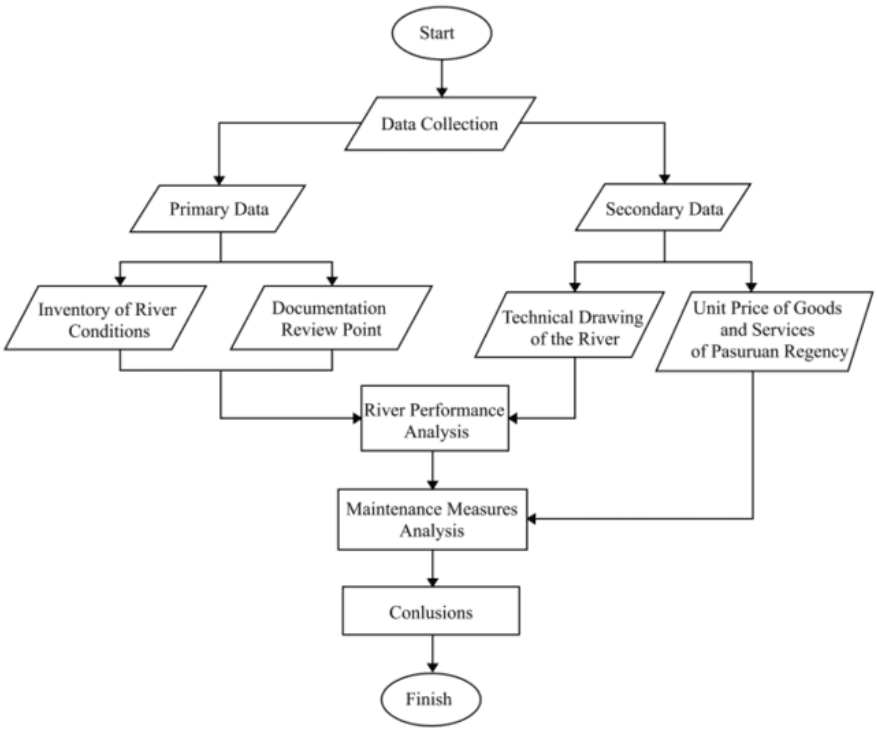


Figure 3. Research Flow Diagram

The data used in this study consisted of primary data and secondary data. Primary data were obtained through direct observation along the river flow. Secondary data is in the form of river technical drawing data and Pasuruan Regency work unit prices, as well as other supporting data obtained from related agencies. Observations along the river flow are carried out from upstream to downstream to obtain a physical inventory of the river and river buildings as a step in compiling maintenance actions and river infrastructure (Pranida, 2022). River inventory is in the form of physical conditions and morphological functions of rivers and river infrastructure. The analysis of the performance and maintenance actions of the river and river infrastructure was carried out based on the results of the inventory of existing river conditions using the scoring method with assessment criteria prepared based on SE DJSDA No.05/SE/D/2016. River morphology assessment is carried out on the condition of cliffs, troughs, river channels, and the use of border areas. The assessment of river morphology performance and river infrastructure is divided into 9 (nine) segments of each river kilometer. Each segment is divided into several sections and an assessment of its physical condition and function is carried out using the scoring method by paying attention to the assessment criteria that have been prepared. After that, the performance value of each segment is accumulated to obtain the average performance value of the river. The results of the river performance analysis were used to determine the category of maintenance actions and AKNOP using the calculation method of unit price analysis (AHSP).

River Performance

Specifically, the purpose of assessing the performance of rivers and river infrastructure is to obtain data on river conditions and river infrastructure, obtain river performance values, and obtain recommendations for actions to maintain and maximize the performance of rivers and river infrastructure (Wahyudi, 2020). Assessment of river performance and river infrastructure from observation data was carried out on the physical condition and function of rivers and river infrastructure using Table 1.

Table 1. Classification of Assessment of Physical Conditions and Functions of Rivers and River Infrastructure

Assessment		Physical Condition			
		50	**40**	**25**	**10**
		Very small risk (very good physical condition)	Small risk (good physical condition)	Moderate risk (fairly good physical condition)	Moderate risk (fairly good physical condition)
Function Conditions	10 Moderate risk (fairly good physical condition)	60	50	35	20
	25 Moderate risk (fairly good physical condition)	75	65	50	35
	40 Small risk (good physical condition)	90	80	65	50
	50 Very small risk (very good physical condition)	100	90	75	60

After the assessment is completed based on physical conditions and functions, it can be determined which maintenance actions must be carried out. Decision-making related to river repair and maintenance is determined from inventory data in the field and the results of performance analysis (Alfarobi & Tujni, 2023). The selection categories of maintenance actions are determined through Table 2.

Table 2. Categories of River Maintenance Actions and River Infrastructure

Index	Category	Maintenance Type	Scale of Activity
>90%	Good (very small risk and river performance very good)	Preventive	Routine maintenance, periodic maintenance
70-90%	Sufficient (low risk and good river performance)	Preventive	Periodic maintenance is light repair
50-70%	Insufficient (moderate risk and fairly good river performance)	Corrective	Special maintenance/ heavy repairs
<50%	Ugly (very high risk and poor river performance)	Rehabilitative	Heavy repairs/ rebuilds

Maintenance Cost Calculation (AKNOP)

The Operation and Maintenance Real Needs Score (AKNOP) is a method used to estimate the price of operation and maintenance activities through an analysis of work volume, unit price, and frequency (Suryanti, et al., 2022). The calculation of AKNOP is described through the following equation (Saputro, et al., 2022):

$$AKNOP = \sum V_i \; x \; F_i \; x \; HSP_i \qquad \text{Pers. 1}$$

with:

V_i : Volume of operation and maintenance work

F_i : Frequency of operation and maintenance work

HSP_i : Unit Price of Work

The stages of analyzing river maintenance actions to obtain the amount of maintenance price or river AKNOP needed based on inventory data of the physical condition and function of the river and the results of river performance analysis are as follows:

1. Measuring and calculating the volume of river maintenance work and river infrastructure to obtain a Bill of Quantity (BOQ)
2. Conducting a work unit price analysis based on the unit price of goods and services in Pasuruan Regency
3. 3. Prepare a Draft Cost Budget (RAB) for river maintenance activities based on the calculation of BOQ and unit price of work.

RESULTS AND DISCUSSION

Results of River Performance Analysis

The assessment of river performance was carried out based on the classification of the physical performance value and function of the river in Table 1 and the category of maintenance actions using Table 2. The results of the performance analysis of the Sumber Pinang River can be seen in Table 3 below.

Table 3. Results of the Performance Assessment Analysis of the Sumber Pinang River

Review point	Performance Value			Action Maintenance
	River Morphology	River Infrastructure	Average	
Km 0 - 1				
Point 1	64,38	60	62,19	Corrective
Point 2	62,5	55	58,38	Corrective
Point 3	63,13	55,83	59,48	Corrective
Point 4	50,63	49,17	49,9	Rehabilitative
Point 5	65	71,67	68,33	Corrective
Point 6	58,75	60	59,38	Corrective
Point 7	57,5	41,67	49,58	Rehabilitative
Point 8	58,75	58,33	58,54	Corrective
Point 9	60	56,67	58,33	Corrective
Performance Value kilometer 1			**58,21**	**Corrective**
Km 1 - 2				
Point 10	61,25	55	58,13	Corrective
Point 11	58,75	58,33	58,54	Corrective
Point 12	76,25	70	73,13	Preventive
Point 13	73,75	80	76,88	Preventive
Point 14	45	35	40	Rehabilitative
Point 15	58,75	56,67	57,71	Corrective
Point 16	63,75	65	64,38	Corrective
Point 17	66,25	75	70,63	Preventive
Performance Value kilometer 2			**62,42**	**CORRECTIVE**
Km 2 -3				

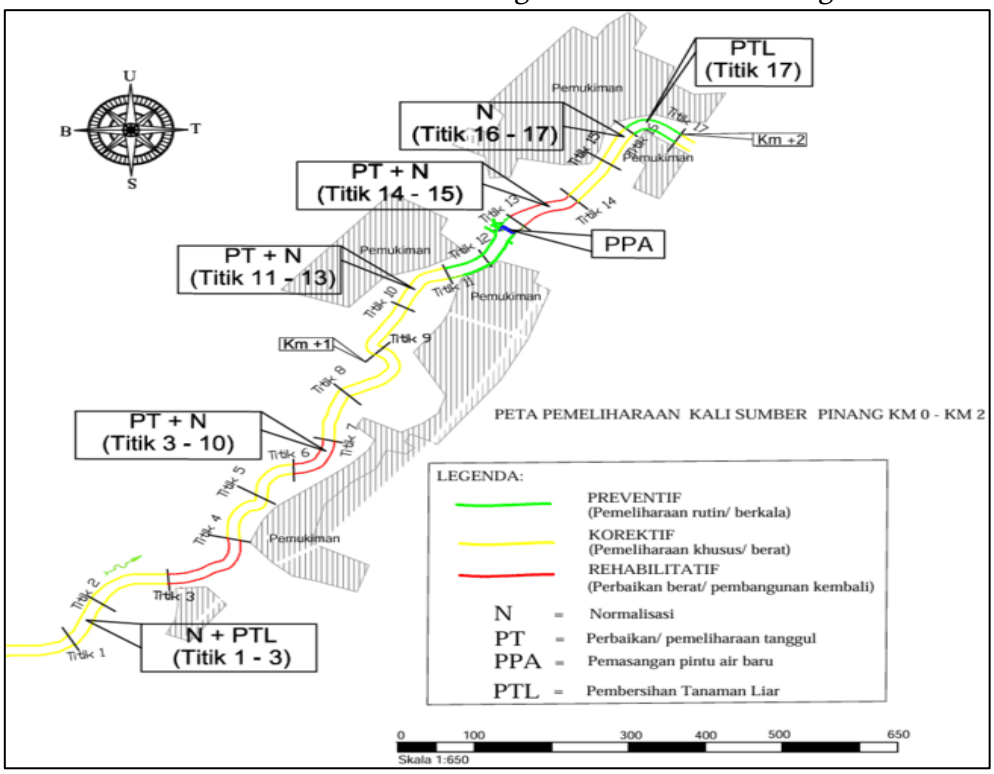
Review point	Performance Value			Action Maintenance
	River Morphology	River Infrastructure	Average	
Point 18	46,25	53,33	49,79	Rehabilitative
Point 19	46,25	50	48,13	Rehabilitative
Point 20	61,25	58,33	59,79	Corrective
Point 21	66,25	70	68,13	Corrective
Point 22	66,25	60	63,13	Corrective
Point 23	58,75	60	59,38	Corrective
Point 24	68,75	70	69,38	Corrective
Point 25	67,5	65	66,25	Corrective
Performance Value of kilometer 3			**61,74**	**CORRECTIVE**
Km 3 - 4				
Point 26	67,5	65	66,25	Corrective
Point 27	70	65	67,50	Corrective
Point 28	67,5	65	66,25	Corrective
Point 29	61,25	65	63,13	Corrective
Point 30	75	80	77,50	Preventive
Point 31	72,5	80	76,25	Preventive
Point 32	70	70	70	Preventive
Performance Value of kilometer 4			**69,55**	**CORRECTIVE**
Km 4 - 5				
Point 33	53,75	55	54,38	Corrective
Point 34	65	65	65	Corrective
Point 35	68,75	75	71,88	Preventive
Point 36	60	65	62,50	Corrective
Point 37	57,5	55	56,25	Corrective
Performance Value of kilometer 5			**62**	**Corrective**
Km 5 - 6				
Point 38	63,75	70	66,88	Corrective
Point 39	71,25	80	75,63	Preventive
Point 40	71,25	75	73,13	Preventive
Point 41	68,75	70	69,38	Corrective
Point 42	61,25	65	63,13	Corrective
Point 43	60	66,67	63,33	Corrective
Point 44	61,25	65	63,13	Corrective
Point 45	63,75	65	64,38	Corrective
Point 46	61,25	60	60,63	Corrective
Performance Value of kilometer 6			**66,62**	**Corrective**
Km 6 – 7				
Point 47	62,5	60,00	61,25	Corrective
Point 48	53,75	45,00	49,38	Corrective
Point 49	55	40,00	47,50	Corrective
Point 50	58,75	60,00	59,38	Rehabilitative
Point 51	63,75	56,67	60,21	Rehabilitative
Point 52	66,25	60,00	63,13	Corrective
Point 53	70	60,00	65,00	Corrective
Point 54	68,75	60,00	64,38	Corrective
Performance Value of kilometer 7			**58,78**	**Corrective**

Review point	Performance Value			Action Maintenance
	River Morphology	River Infrastructure	Average	
Km 7 - 8				
Point 55	68,75	60,00	64,38	Corrective
Point 56	65	55,00	60,00	Corrective
Point 57	68,75	60,00	64,38	Corrective
Point 58	68,75	60,00	64,38	Corrective
Point 59	67,5	56,67	62,08	Corrective
Point 60	67,5	55,00	61,25	Corrective
Point 61	68,75	70,00	69,38	Corrective
Point 62	68,75	60,00	64,38	Corrective
Performance Value of kilometer 8			**63,78**	**Corrective**
Km 8 - 8,9				
Point 63	68,75	66,67	67,71	Corrective
Point 64	71,25	75,00	73,13	Preventive
Point 65	70	55,00	62,50	Corrective
Point 66	73,75	63,33	68,54	Corrective
Point 67	76,25	75,00	75,63	Preventive
Point 68	76,25	71,67	73,96	Preventive
Point 69	76,25	75,00	75,63	Preventive
Performance Value of kilometer 9			**69,47**	**Preventive**
Performance Value of Sumber Pinang River			**63,78**	**Corrective**

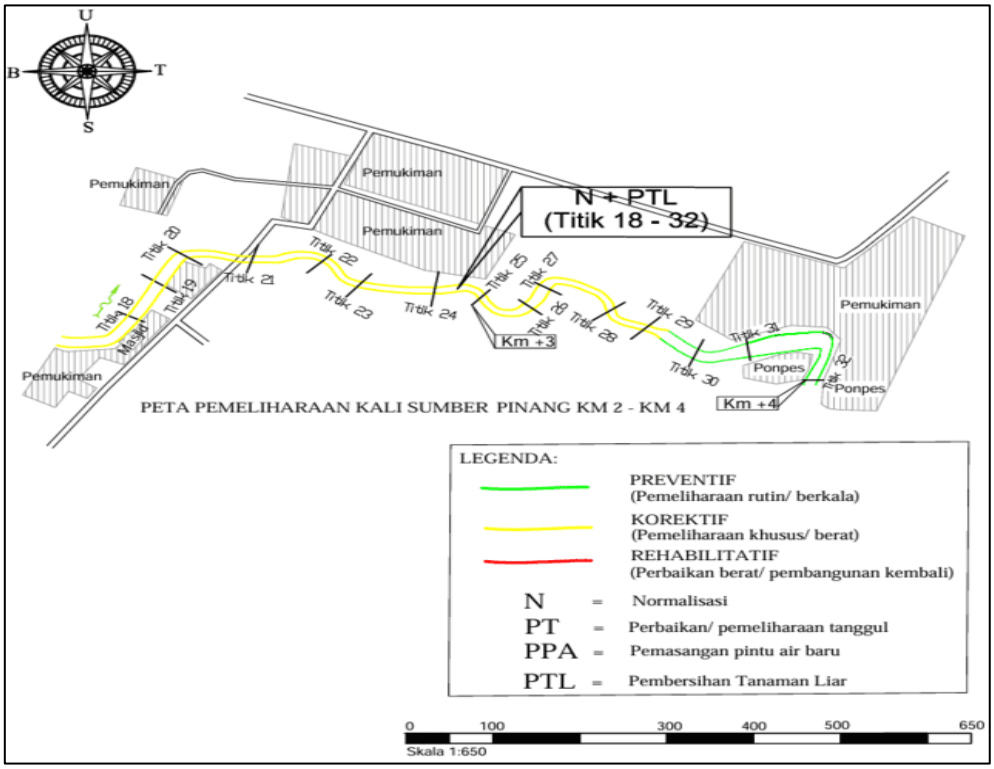
Based on Table 3, it can be seen that the Sumber Pinang River has a total performance value of 63.78. Kilometer 1 has the lowest performance value of 58.21, on this section there are many avalanches on the cliffs, sediment build-up in the river channel, as well as the ability to accommodate poor flood discharge which causes frequent runoff. The results of this river performance assessment are in line with Arif's (2024) research, where the results of hydrological and hydraulic analysis on the Sumber Pinang River using the HEC-RAS program with planned flood discharge at the 25-year re-enactment period (Q25) found that 85% of the STA stake was unable to accommodate the planned flood discharge with an average flood elevation of 1.5 meters.

The results of the performance assessment showed that the Sumber Pinang River has an average Corrective maintenance category and requires special or heavy maintenance. There are four observation points that have a performance value of <50 so that they require the category of Rehabilitative maintenance in the form of heavy repairs or reconstruction, namely at Point 4, Point 7, Point 48, and Point 49. In the observation of morphodynamics on the Sumber Pinang River, changes have occurred in the form of narrowing and widening of the river channel which affects the reservoir capacity of the river and causes a decrease in river performance. The narrowing and widening of the river is influenced by sediment accumulation factors and stream erosion caused by changes in land use. Most of the areas around the border of the Sumber Pinang River are farming areas in the form of rice fields. The change in land use to rice fields causes an increase in surface runoff which causes an increase in the rate of erosion and brings sediment into the river. Changes in land use affect the increase in erosion and sedimentation rates, which are factors that support morphodynamic activities in rivers (Nasution & Sutriyono 2022). In the research of Aldi, et al. (2024), the Welang watershed has an Erosion Hazard Index (IBM) with a moderate criterion of 61.296% of the total area and a high criterion of 38.74% which has increased every time with an average erosion rate of 31,947 tons/ha/year which produces a sedimentation rate value of 27,560 tons/ha/year. This shows that the performance of the river is influenced by land use factors around the watershed which causes an increase in the value of erosion and sedimentation rates

This shows that the performance of Kal is influenced by land use factors around the watershed. The map of the maintenance of the Sumber Pinang River can be seen in Figure 4.



(a)



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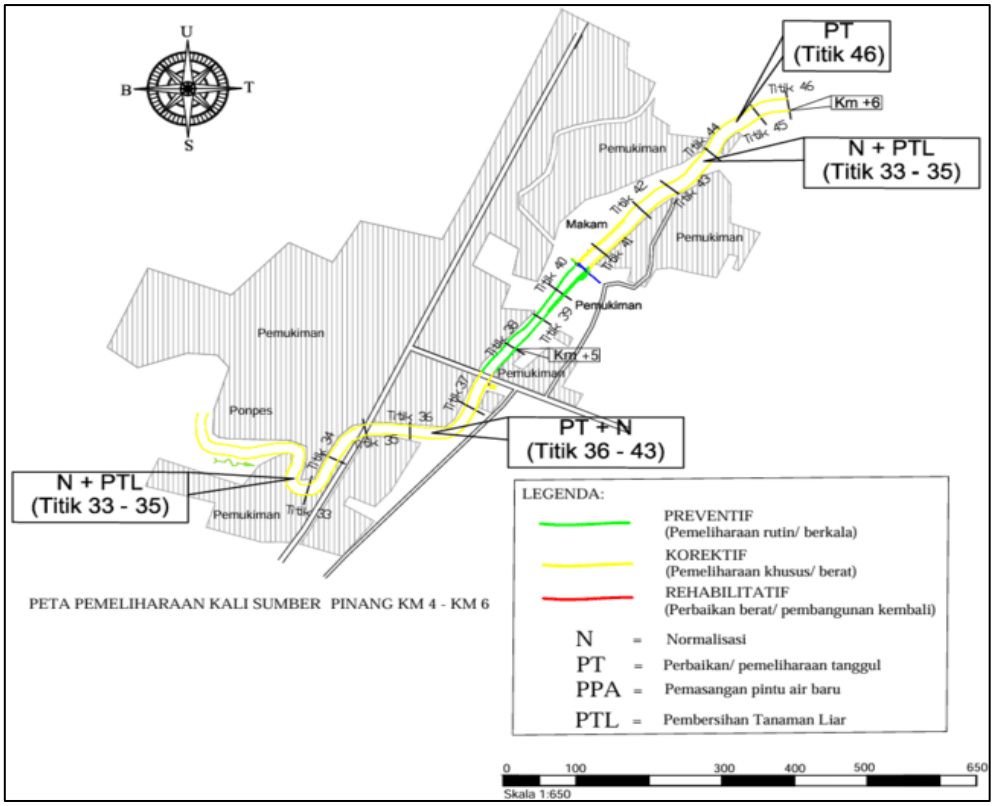

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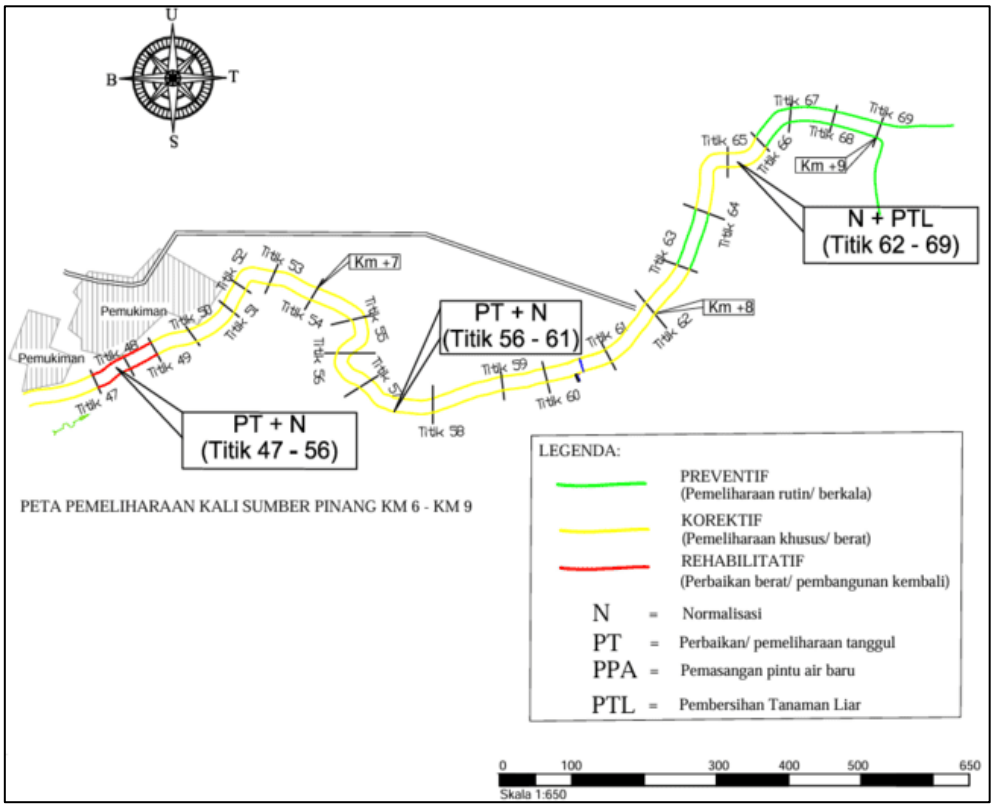

(d)

Figure 4. Map of the Source of Pinang River Infrastructure
Source: Field observation, 2025

Analysis of Maintenance Actions

Based on observations, analysis of existing conditions, and assessment of the performance of the Sumber Pinang River, the priority of improvement that must be carried out is in the form of river normalization and repair or maintenance of dikes. River normalization is carried out along the river flow by dredging sediments to increase the reservoir capacity of the river. River normalization aims to improve the function of rivers and areas around rivers as catchment and flood drainage areas (Solon, et al., 2023). The normalization of the Sumber Pinang River was carried out through modification of the transverse profile of the river and obtained a sediment volume of 7,121.04 m3. Planning for the repair and maintenance of the embankment is carried out on embankment infrastructure that is unable to accommodate water discharge or experiences landslides. Reconstruction efforts need to be carried out on rivers that have experienced avalanches to prevent the expansion of erosion areas and maintain river performance (Purnomo, 2020). Planning for the repair or maintenance of embankments in the form of earthen embankments with a volume of 37,965 m3 and parapets with a volume of 9,747 m3.

The recapitulation of the results of the analysis of the Sumber Pinang River AKNOP with the scope of river maintenance work and river infrastructure can be seen in Table 4 below.

Table 4. Recapitulation of the Results of the Analysis of the Source Pinang River AKNOP

No	Types of Maintenance Work	Price (Rp)	
1	River trough work	Rp	367.506.134
2	River embankment work	Rp	15.268.799.067
3	Stone parapet work	Rp	8.022.038.353
4	Gabion work	Rp	3.361.151
5	Sluice gate work	Rp	8.607.100
	Total Maintenance Costs	**Rp**	**23.670.546.185**

Based on Table 4, the value of AKNOP on the Sumber Pinang River in the scope of river maintenance activities and river infrastructure was obtained at a value of IDR 23,670,546,185. In the research of Dary, et al. (2022), the total value of the AKNOP of the Bajak River in Semarang City, which has a length of 3.4 km, is IDR 2,716,600,000 with the scope of river operation activities, river infrastructure maintenance activities, and river maintenance that are routine or periodic. The maintenance cost on the Sumber Pinang River has a greater value because the Sumber Pinang River has a longer flow and maintenance planning, in the form of normalization and embankment planning is carried out almost along the river channel.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Kali Sumber Pinang has a performance of 63.78 with Corrective maintenance measures. In a total of 4 observation point segments, it has a performance value of <50, namely at Point 4, Point 7, Point 14, Point 48, and requires the category of Rehabilitative maintenance actions. Maintenance actions that must be carried out in the form of cutting or cleaning wild shrubs and wild plants on the river embankment, installing sluice gates, and priority repairs in the form of river normalization and river embankment repair in the form of soil embankments and parapets with the total maintenance cost on the Sumber Pinang River obtained as much as Rp23.670.546.185

Recommendations

1. The results of this research on performance assessment and analysis of maintenance actions can be a reference document for the Pasuruan Regency government in determining maintenance actions and maintenance costs that must be carried out on the Sumber Pinang River

2. River maintenance must be carried out periodically through an inventory of river conditions and river infrastructure and through the cooperation of relevant stakeholders around the Sumber Pinang River to maintain the river service function.
3. In a similar study related to the analysis of river performance and ANKNOP on the Sumber Pinang River, other researchers are advised to analyze the scope of river infrastructure operation activities, river maintenance, and river infrastructure maintenance on a regular or periodic basis so that a detailed Operation and Maintenance Needs Score can be obtained.
4. In the repair of earthen embankments and parapets, it is necessary to precede DED first.

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