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Sedimentation Analysis at Cariang Weir in Sumedang District using Mike 21 Software

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ABSTRACT

Sedimentation is the deposition of material carried by water media. The occurrence of sedimentation disrupts river flow, leading to increased susceptibility to flooding and drought during dry seasons. The impact of sedimentation causes riverbed siltation, reducing the river's capacity from its natural state. The Cariang Dam, located in Ujung Jaya Village, Ujung Jaya District, Sumedang Regency, is experiencing sedimentation issues. This has resulted in siltation and a decrease in the river's capacity at the dam site. In light of these issues, the researcher is interested in analyzing sedimentation at the Cariang Dam area. This analysis aims to determine the volume and height of sedimentation occurring annually. Based on the analysis conducted, the sedimentation height per day is found to be 0.7 centimeters, amounting to 23 centimeters per month and 276 centimeters annually.

Keywords: *Dam; Weir; River; Sedimen; Sedimentation; Capacity.*

INTRODUCTION

Indonesia is a country with a vast and diverse agricultural sector and many large and small rivers. This condition allows Indonesia to fulfill almost 80% of the living needs of its population, especially for farmers, making it the basis of an agrarian country. With a high water discharge capacity, Indonesia has many water structures, one of which is a weir. Weirs are construction structures made of river stones, gabions, or concrete, built in rivers to raise the water level and divert water flow. Problems that often occur with weirs include damage to the main structure, damage to ancillary buildings, and sedimentation.

Sedimentation is the deposition of material carried by water media, due to sedimentation, it disrupts river flow so that it can increase flow on the surface of the river and a decrease in groundwater levels, this results in when it rains, the river will easily experience flooding and during the dry season there will be drought. The impact of sedimentation causes siltation of the river so that the river's discharge capacity is reduced from what it should be. One of the existing weir buildings in the West Java region is the Cariang weir located in Ujung Jaya Village, Ujung Jaya District, Sumedang Regency. Cariang Dam was built in 1911 with the function as an irrigation area by local residents. The flow of this weir can irrigate up to an area of 1,603 hectares. This sedimentation problem also occurs in the Cariang Dam located in Ujung Jaya Village, Ujung Jaya District, Sumedang Regency.

Sedimentation that occurs is due to erosion caused by land subsidence from the side of the weir and channel. This land subsidence occurs due to the carrying of soil material by rainwater and the absence of a Retaining Wall (DPT) in the Cariang Dam side area. Based on previous

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research on sedimentation that occurred in an Awo weir located in Wajo Regency where this weir experienced siltation due to high sedimentation from the upstream river. [1].
Other research explains the occurrence of sedimentation in watersheds due to erosion which causes soil material to be carried downstream. So this researcher simulated the flow rate in the river using Mike 11 software. [2].

There is research that explains the carrying of sediment from upstream to the estuary, where this research compares the movement of sediment in the west and east seasons. So that the thickness at the bottom of the estuary experiences siltation and different sediment weights. [3]. The difference between the research conducted and the previous research is that in the previous research, the sedimentation analysis was carried out by manual calculation with the final goal being the volume in the weir area, while in this research the analysis was carried out using the help of Mike 21 software with the ultimate goal to be achieved is to know the volume of sedimentation and the height of sedimentation that occurs per year.

METHODS

Research Location
This research is located in Sumedang Regency Ujung Jaya Village, Cipelang River at Cariang Dam.

Data Collection Method
The data collected are primary data and secondary data. Primary data are water and sediment samples to determine the type and size of sediment grains, and current velocity using a current meter. While secondary data is data obtained from agencies or companies of Water Resources (SDA) in the form of topographic map data, hydrological analysis data, and hydraulic data of the Dam.

Data Analysis Method
Hydrological data was analyzed by analyzing rainfall, calculating river flow velocity/discharge, and calculating water level.

Topography and Bathymetry Data Processing
Topography and bathymetry data in this study are used as basic input data in the Mike 21 software, where the form of this data is in the form of autocad files which are converted or converted into dxf files. The topographic contour map used must be in accordance with the actual coordinates based on UTM coordinates, so that when inputting in the Mike 21 software this contour data is in accordance with the research location and reduces errors in the analysis. This data is used as meshing data.

Hydraulic Data of the Dam
Weir hydraulic data is obtained from secondary data, where this data is used to determine the dimensions and shape of the weir body, where this data will be plotted in Mike 21 software as a weir body. Based on this data, the height of sedimentation that occurs from the results of the analysis can be known, and the area where sedimentation occurs can also be seen.

Analyzing Soil Content
This data is obtained from the results of tests conducted in the laboratory to determine the type and amount of sediment grains in the location of the Dam. In taking this data, measuring cups,

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water weight, sediment weight will be measured so that the final data that will be obtained is the amount of sediment content. From the results of this sedimentation data, data input will be carried out in the application used so that it can be seen what the distribution of sedimentation occurs.

Sedimentation Analysis

This analysis was conducted using Mike 21 software to determine the pattern of sedimentation distribution from upstream to downstream or the body of the Dam. The output generated from this analysis is the volume and height of sedimentation that occurs in the body of the Dam in a period of weeks, months and per year.

Flow Chart

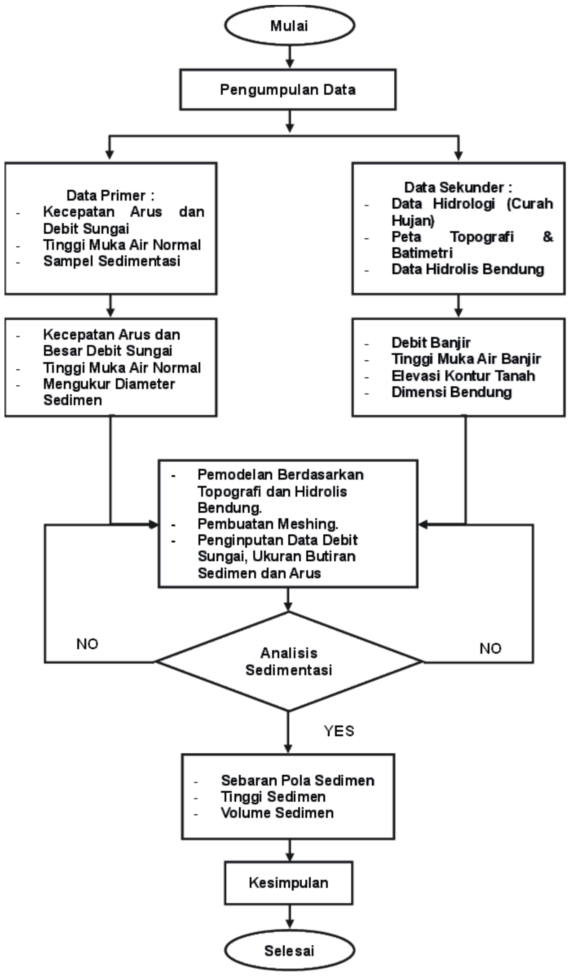

Figure 1. Flow Chart

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RESULTS AND DISCUSSION

Hydrological Data Analysis
Catchment Area of Cariang Weir.

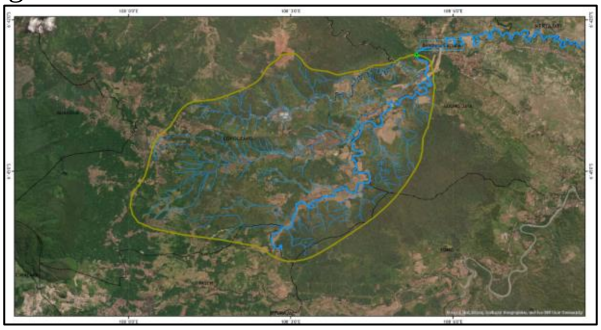

Figure 2: Map of Cariang Weir Catchment Area (DTA).

Flood Discharge
Frequency Distribution Analysis
This method used for the analysis of planned rainfall includes the Normal, Log Normal, Log Pearson III, and Gumbel distributions. The following is a summary of the distribution analysis results for the Cariang watershed.

Table 1. Distribution analysis with gumbel method

No	T (Year)	$\bar{X}$ (m^3/det)	S (m^3/det)	K	$X_T = \bar{X} + S \times K$ (m^3/det)
1	2	96.188	34.13	-0.14	91.563
2	5	96.188	34.13	1.06	132.297
3	10	96.188	34.13	1.85	159.267
4	25	96.188	34.13	2.85	193.343
5	50	96.188	34.13	3.59	218.623
6	100	96.188	34.13	4.32	243.716
7	200	96.188	34.13	5.05	268.718
8	500	96.188	34.13	6.02	301.703
9	1000	96.188	34.13	6.75	326.632

Table 2. Distribution Analysis with Normal Method

No	T (Year)	$\bar{X}$ (m^3/det)	S (m^3/det)	K	$X_T = \bar{X} + KT \times S$ (m^3/det)
1	2	96.188	34.13	0	96.19
2	5	96.188	34.13	0.84	124.86
3	10	96.188	34.13	1.28	139.88
4	25	96.188	34.13	1.71	154.55
5	50	96.188	34.13	2.05	166.16
6	100	96.188	34.13	2.33	175.71
7	200	96.188	34.13	2.58	184.25
8	500	96.188	34.13	2.88	194.49
9	1000	96.188	34.13	3.09	201.65

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Table 3. Distribution analysis with Log Normal method

No	T	$\overline{\text{Log X}}$	S Log x	K_T	$\text{Log } X_T = (3) + (4) \times (5)$	$X_T = \text{Log}^{-1} \times (\text{Log } X_T)$ (m^3/det)
1	2	1.96	0.14	0	1.961	91.4
2	5	1.96	0.14	0.84	2.078	119.7
3	10	1.96	0.14	1.28	2.140	137.9
4	25	1.96	0.14	1.71	2.200	158.3
5	50	1.96	0.14	2.05	2.247	176.6
6	100	1.96	0.14	2.33	2.286	193.2
7	200	1.96	0.14	2.58	2.321	209.4
8	500	1.96	0.14	2.88	2.363	230.6
9	1000	1.96	0.14	3.09	2.392	246.7

Table 4. Distribution analysis with Log Person III method

No	T	$\overline{\text{Log X}}$	S Log x	K_T	$\text{Log } X_T = (3) + (4) \times (5)$	$X_T = \text{Log}^{-1} \times (\text{Log } X_T)$ (m^3/det)
1	2	1.96	0.14	-0.1024	1.9466	88.433
2	5	1.96	0.14	0.798	2.0723	118.109
3	10	1.96	0.14	1.329	2.1464	140.085
4	25	1.96	0.14	1.9446	2.2323	170.730
5	50	1.96	0.14	2.3686	2.2915	195.653
6	100	1.96	0.14	2.769	2.3473	222.506
7	200	1.96	0.14	3.150	2.4006	251.520
8	500	1.96	0.14	3.462	2.4441	278.006
9	1000	1.96	0.14	3.981	2.5165	328.492

Repeat Priod	**Frequency Analysis of Plan Rainfall (mm/hr)**			
	Gumbel	**Normal**	**Log Normal**	**Log Person III**
TR02	91.563	96.19	91.4	88.433
TR05	132.297	124.86	119.7	118.109
TR10	159.267	139.88	137.9	140.085
TR25	193.343	154.55	158.3	170.730
TR50	218.623	166.16	176.6	195.653
TR100	243.716	175.71	193.2	222.506
TR500	268.718	184.25	209.4	251.520
TR200	301.703	194.49	230.6	278.006
TR1000	326.632	201.65	246.7	328.492

Frequency Distribution Fit Test

This distribution test is carried out using two methods, namely the Smirnov-Kolmogorov and Chi- Square tests, the results are as follows:

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Table 5. Frequency distribution fit test analysis

Repeat Priod	**Frequency Analysis of Plan Rainfall (mm/hr)**			
	Gumbel	**Normal**	**Log Normal**	**Log Person III**
TR02	91.563	96.19	91.4	88.433
TR05	132.297	124.86	119.7	118.109
TR10	159.267	139.88	137.9	140.085
TR25	193.343	154.55	158.3	170.730
TR50	218.623	166.16	176.6	195.653
TR100	243.716	175.71	193.2	222.506
TR200	268.718	184.25	209.4	251.520
TR1000	301.703	194.49	230.6	278.006
Kolmogorof Smirnov Test				
D Maximum	-0.079	0.898	0.898	-0.058
Significance Degree	5.000	5.000	5.000	5.000
D Critical	0.396	0.396	0.396	0.396
Hypothesis	Accepted	Not Accepted	Not Accepted	Accepted
Chi Square Test				
Chi-Square Count	1.79	2.99	2.99	3.48
Critical Chi-Square	3.84	3.84	3.84	3.84
Free Degree	2.00	2.00	2.00	2.00
Significance Degree	5.00	5.00	5.00	5.00
Hypothesis	Accepted	Accepted	Accepted	Accepted

Calculation of Norman Water Level and Flood Water Level

In the calculation of Normal and Flood Water Levels, the discharge used is based on the gumbel method. for the calculation of normal water levels, it uses a discharge value with a return period of 50 years and for flood water levels it uses a discharge value with a return period of 100 years.

River width (b) = 167 m
Riverbed slope (S) = 0.004
River wall slope (m) = 1
Wall roughness coefficient (n) = 0.03 (for earthen channel)

Table 6. Interpolation Results of Normal and Flood Water Levels

Description		**Q**	**H**
Normal water level	1	115.616	1.5
	X	**219**	**1.65**
	2	464.667	2
Flood water level	3	115.616	1.5
	Y	**244**	**1.68**
	4	464.667	2

Based on the table above, the normal water level is 1.65 m and the flood water level is 1.68 m.

Current Velocity and River Discharge

The current velocity and river discharge used are primary data from direct measurements using a current meter. Measurement of current velocity and river discharge was carried out by

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researchers in one day, namely on November 04, 2023 with different data collection times. Data sampling was carried out three times, namely in the morning at 10:30 with a discharge result of 1.59 m3 / s, the 2nd measurement at noon at 13.00 with a discharge result of 1.40 m3 / s and the 3rd measurement in the afternoon at 15:10 with a discharge result of 1.67 m3 / s. The three data obtained will be used for analysis of the three data obtained. The three data obtained will be used for sediment rate analysis.

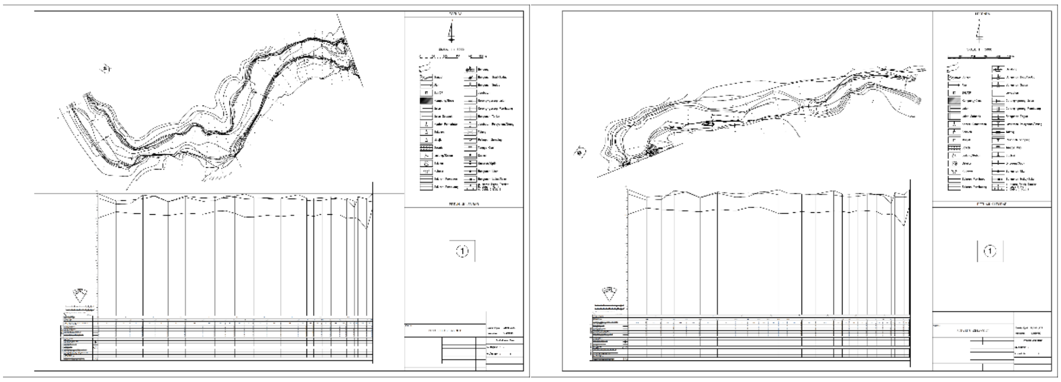
Water Level

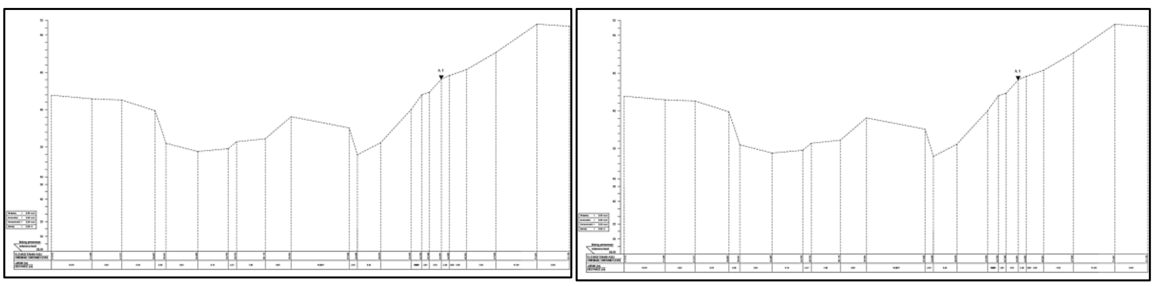
Based on the results of the survey that has been carried out, the Normal Water Level (MAN) is 0.80 to 1.20 meters. Meanwhile, based on the results of the analysis of secondary data using the HAC-RAS software, the height of the Flood Water Level (MAB), with a discharge of 255.42 m3 / sec, the height of the MAB obtained is 2.36 meters.

Topographic and Bathymetry Mapping Survey

Topographic and bathymetry measurement data used in the study were obtained from secondary data or agency data from Water Resources (SDA). The purpose of this survey is to obtain a description of the condition of the earth in the location of the surrounding area along with objects and important buildings in it in the form of a situation map and the height and position of the appearance.

Detailed situation measurements were carried out by means of tachymetry using the Theodolite Compass (TO) measuring instrument. The results of the measurement data are elevation data from the river situation map, river cross section and river longitudinal cross section.





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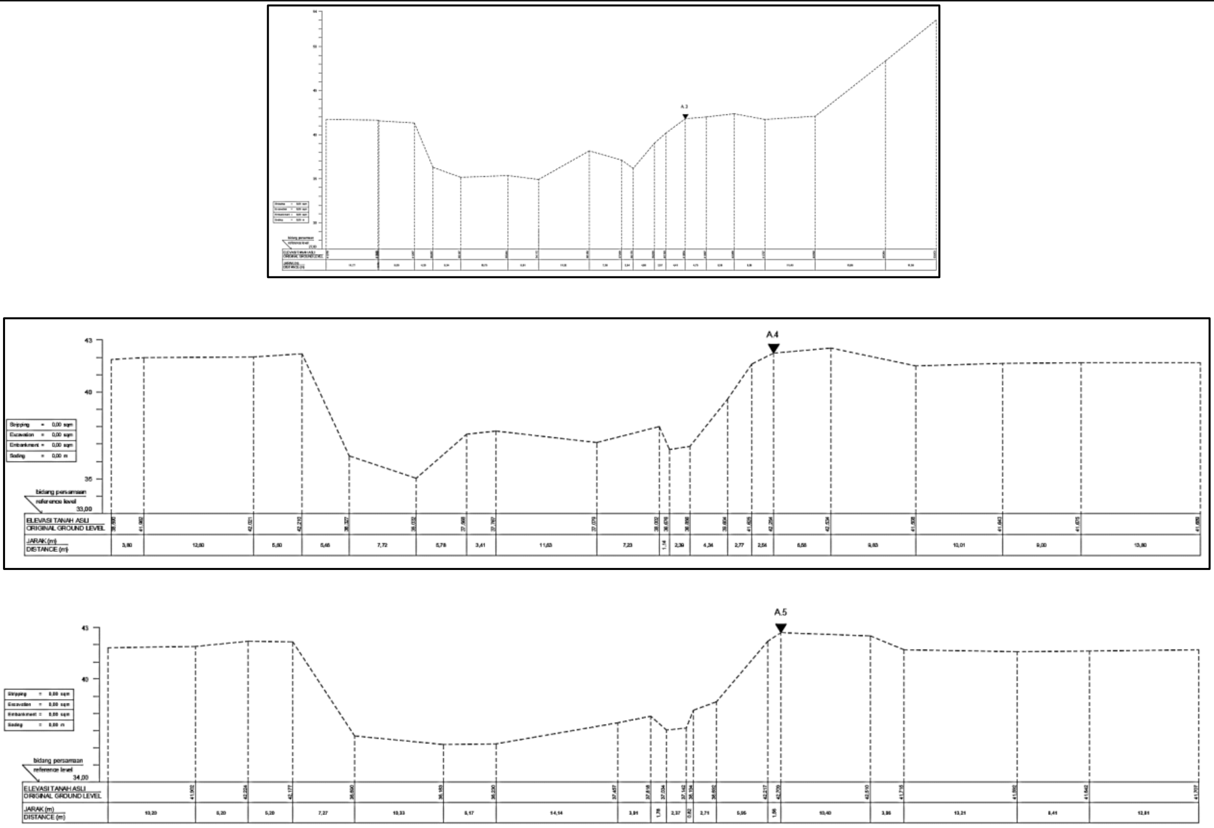

Figure 3. Cross Section of Cariang River and Cross Section of Cariang River.

The longitudinal section of the river with the elevation of the left side of the river, the riverbed and the right side of the river serves as a depiction of the depth of the river channel. The cross section or cross section of the river illustrates the situation on the river.

Soil Content Analysis Results

Lab sample testing was carried out at the Hydraulics and Geotechnical Engineering Center located in Dago. The purpose of this sampling was carried out to obtain the value of the amount of sedimentation grains that occurred in the Cariang Dam.

Table 7. Recapitulation of Test Results

No. Uji	Lokasi	Volume	Sampel			Kandungan Sedimen	
			Atas	Tengah	Bawah		
		ml	gr	gr	gr	gr/ltr	gr/m3
P1	Sungai Cipelang	830	1.07	1.05	1.03	1.026	1026.10
P2	Sungai Cipelang	640	1.05	1.04	1.02	1.011	1010.80
P3	Sungai Cipelang	710	1.08	1.05	1.02	1.026	1026.25

due to the amount of sediment carried from upstream to downstream, with the condition of the existing river channel is soil. In the input of sedimentation entered is the average value of 1021.05 gr/m3 and converted to 1.021 kg/m3.

Sedimentation Analysis Using Mike 21 Software

Meshing Creation

Inputting the boundary coordinates with xyz format, the river boundary will appear. After the boundary is successfully issued, it can be followed by inputting the bathymetry contour. Like

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the following picture:

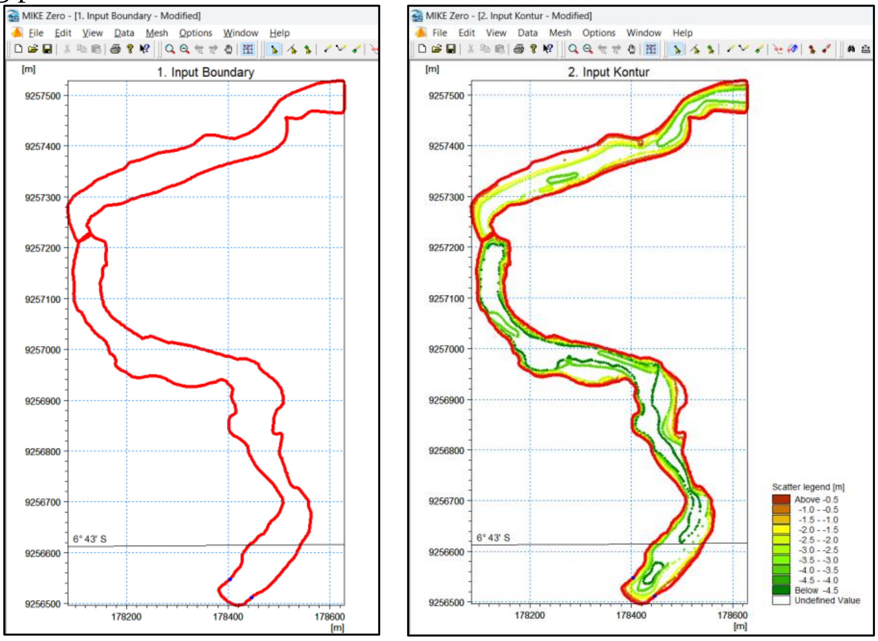

Figure 4. Boundary Point Data Input Results and Display After Point Bathymetry is Input.

Next, the meshing that has been done is smooth. Contour depth can be seen with color gradation according to its depth.

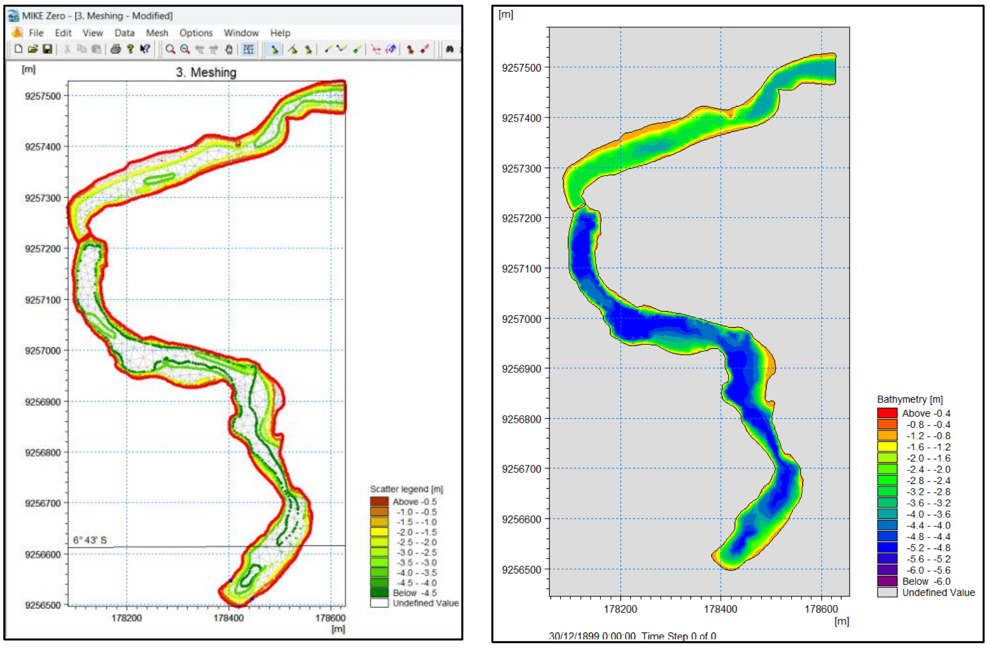

Figure 5. Smooth Meshing and Interpolation Results of Bathymetry Depth Contour.

Flow Modeling Results

This modeling is done to get an overview of current patterns in the Cipelang River. The simulation results in this modeling in the form of contours and large vectors of current direction and velocity.

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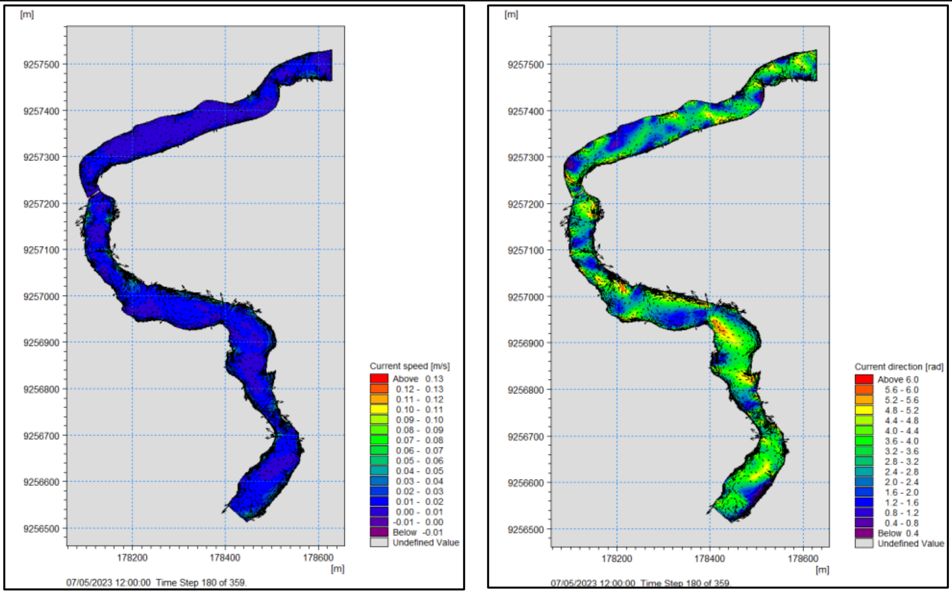

Figure 6. Simulated Cipelang River Flow Pattern (Current Speed) and Simulated Cipelang River Flow Pattern (Current Direction).

Based on the simulation results above, it can be concluded that the current velocity in the Cipelang River is at a speed of 0.01 m / s to 0.09 m / s with a current radius of 1.2 meters to 5.6 meters. The direction of the vector in the simulation is irregular due to the natural meander of the river, so that in the simulation there is a vector direction that decreases following the elevation and rotates due to river bends.

Sedimentation Modeling Results

The results that will be released from the sedimentation modeling simulation are in the form of sediment distribution direction vectors and suspended sedimentation concentrations. The following are the results of sedimentation modeling simulations that have been carried out.

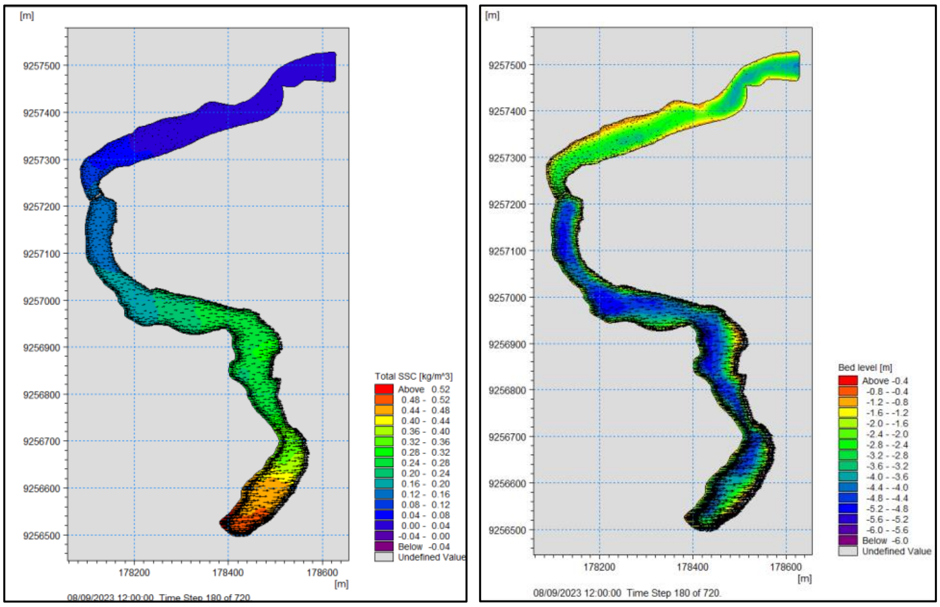

Figure 7. Distribution pattern of suspended sedimentation concentration and sedimentation bed level.

Figure 7 The simulation results above show the distribution of suspended sedimentation concentration or total SSC from upstream to the weir is at 0.12 kg/m3 to >0.44 kg/m3 with the direction of the vector pointing to the right, which means that the dominant sediment carried from the upstream river is carried by the current to the right side of the river. And the figure ... The above simulation shows that the bed level sediment that occurs in the weir is at an elevation of -2.80 meters to -2.40 meters, which means that with a weir height of 3.00 meters, the sedimentation that occurs in a month is as high as 20 centimeters.

CONCLUSIONS

Based on the analysis that has been done, then

- The current velocity that occurs in the Cipelang River is 0.01 m/s to 0.09 m/s with a current radius of 1.20 meters to 5.60 meters. The direction of the vector in the simulation is irregular because it is influenced by the river meander.
- Sedimentation that occurs in the weir has a total SSC of 0.12 kg/m3 to >0.20 kg/m3.
- Simulation results, the average sedimentation per day is 0.7 centimeters or 7 mm.
- If in a month the height of sedimentation reaches a height of 23 centimeters, and in a year the sedimentation reaches a height of 276 centimeters.

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