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Research Paper

Sedimentation and Erosion Control Efforts with the USLE Method in Oba River, North Oba Sub-District, North Maluku Province

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ABSTRACT
The existing condition that the Oba River located in Ampera Village, North Oba District has a River Length of 2,178 Km with a Watershed Area of 31.16 Km2 often experiences flooding during high rainfall, this is due to the amount of garbage and sedimentation in the Oba river. From the results of the analysis obtained by the Log Pearson III method design discharge produces 53.088 mm for a 100-year return period of 182.790 mm, the results of the analysis of the amount of sediment that occurs in the Oba watershed using the USLE method based on the sediment transport capacity of the river is 140.266 m3 / year. This is certainly the magnitude of sidementation resulting in erosion and flooding due to rising water levels. To overcome sedimentation and erosion control, a sedimentation retaining building or commonly called a check dam is needed, which is planned to have a height of 4.8 m which is used to retain sediment around 139,712 m3 / year with a plan life of 32.77 years and to control the level of erosion hazard, river conservation efforts are carried out vegetatively by changing the land cover of plantations planted with perennials and maintenance of the Oba river through community empowerment with the support of stakeholders.
Keywords: Sedimentation, Erosion, River Conservation

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I. INTRODUCTION

Oba River is located in the administrative area of North Oba District, Tidore Islands City, North Maluku Province. The Oba River has a length of 2,178 Km In the upstream part of the Oba River, it has a slope that is quite sloping so that when it rains, it has the potential to carry material into the river, this causes the sedimentation rate of the Oba River to be quite large so that it accumulates a thick layer of sediment that can block the flow of river water, and damage occurs in the Watershed (DAS) which certainly affects uncontrolled land change in the upper watershed. In addition, there are factors from the increase in high population activity and the increase in other developments so that land degradation due to soil erosion from the upper watershed area has an impact on the surrounding area and outside the location and soil erosion is a natural event that must occur on the earth's land surface and land cover change is one of the factors triggering the accumulation of sediment in the Oba River. Thus the reduction of forest land as infiltration, can affect the amount of surface erosion which can eventually cause flooding, and reduce soil fertility so that it can have a negative impact on community crop yields. In addition, there are also morphological changes in the Oba River that trigger high sediment accumulation downstream, and when there is high rainfall, it causes flooding which can be dangerous for the community as well. From these problems, it is necessary to build sedimentation barriers and check dams to minimize the problems that exist in the watershed with the aim of controlling sedimentation, erosion and flooding.

II. LITERATURE REVIEW

Sedimentation

Sediment is the process of deposition of a material associated with the flow from upstream due to erosion (Triadmodjo, 1999). Sedimentation can be in the form of a delta at the downstream end of the river, Soil and parts of the soil that are transported by water from a place that is eroded in a watershed (DAS) and into a body of water is generally called sediment. Sediment carried into the river is only part of the soil eroded from its place. Another portion of the soil carried by erosion will settle somewhereon the land at the bottom of the erosion site in the watershed (Sitanala, 2010). Sediment produced by the erosion process and carried by the flow of water will be deposited in a place where the water velocity slows or stops. This deposition event is known as the sedimentation event or process, which is the process responsible for the formation of extensive alluvial plains and many in the world, is an advantage because it can provide land for agricultural expansion or settlement (Sitanala, 2010).

Erosion

Definition and Impact of Erosion Erosion is the movement or transport of soil or soil parts from one place to another by natural media. In the event of erosion, soil or parts of soil in one place are eroded and transported which are then deposited elsewhere. The erosion and transportation of soil occurs by natural media, namely water and wind (Bisri, Muhamad. 2009). Erosion by wind is caused by the force of wind, while erosion by water is caused by the force of water. The process of soil erosion caused by water includes the breakdown of chunks or soil aggregates into small grains or soil particles at the bottom of the river.

Erosion Rate Analysis USLE method

While there are many methods to estimate the amount of surface erosion, the Universal Soil Loss Equation (USLE) method developed by Wischmeir and Smith (1978) is the most commonly used method to estimate the amount of erosion. USLE is an erosion model designed to predict the long-term average erosion of sheet or furrow erosion under certain circumstances. This method is also useful for building sites and non-agricultural uses, but it cannot predict deposition and does not take into accountthe sediment yield from erosion of ditches, riverbanks and riverbeds (Sitanala, 2010). The rate of erosion in the upper area of the Panasen sub-watershed was calculated using the USLEerosionpredictionmodel.

$$Ea = R.\ K_{ET}.\ L_{PL}.\ S_{KL}.\ C_{PT}.\ P_{PL}$$

Where:

Ea : Total erosion (tons/Ha/year)
R : Rainfall erosivity index (cm)
K_{et} : Soil erodibility factor
L_{pl} : Slope length factor (m)
S_{kl} : Slope slope factor
C_{PT} : Crop management factors
P_{Pl} : Crop management factors

In the USLE method, the estimated amount of erosion is annual and, thus, the average price of the R factor is calculated from as much annual rainfall data as possible (Asdak, 2010). Due to the limited distribution of automatic rain gauges, Lenvain (1975), in Bols, (1978) has tried and found another method to determine the value of rainfall erosivity using rainfall data that is generally available withthe following equation:

$$R = 2{,}23.P^{1.98}$$

Where:

P = monthly rainfall (cm)

The topographic index factors LPL and SKL, respectively, represent the influence of slope length and slope on the magnitude of erosion and surface flow. The length of the slope refers to the surface flow,
i.e. the location where erosion takes place from the possibility of sediment deposition, in general the slope is treated as a uniform factor (Asdak, 1995).

Sediment Retaining Structure (Check dam)

Sediment retaining dams are used to keep sediment from entering the reservoir too quickly. These sediment retaining weirs often fill up quickly, for example once during a rainy season. Fully filled sediment weirs are still considered to be functioning to control sediment entering the reservoir. Sediment upstream of the filled weir will form a new riverbed with a slope that is more gentle than the original riverbed slope. The slope will reduce the river sediment release ratio and will reduce the rate ofsediment heading to the reservoir (Gelagay, HS. and Minale, AS. 2016).

Checking the dam location determination

The layout design of check dams or sediment retaining buildings must meet the provisions (SNI 2851 of 2015):

1. The location was set on a straight section of the river and in good geological conditions.
2. If the sediment retaining structure is located on a bend in the river, a hydraulic review should be conducted on the possibility of runoff and scour on the outer bank of the bend both upstream and downstream of the structure.
3. The location of retaining structures is determined in areas with large storage volumes where there are no settlements and agricultural land.
4. There must be consolidation and protection of each other from the dangers of river degradation.
5. The axis of the sediment retaining structure should be perpendicular to the direction of flow downstream.

Conformance Test

Data checking is needed in research testing as validation of a series of existing data. One of the data checks is Inlier Outlier testing. Inlier Outlier testing is testing existing data to determine deviations that are outside the group trend limits. The existence of outliers can damage the use of distribution types in data samples, so these outliers are important to remove (Limantara 2010).

Frequency Distribution

In analyzing discharge with a certain return period, statistical methods such as normal distribution, log normal method, gumbel method, and log pearson III method are used (Triadmojo 2008).

Consistency Test

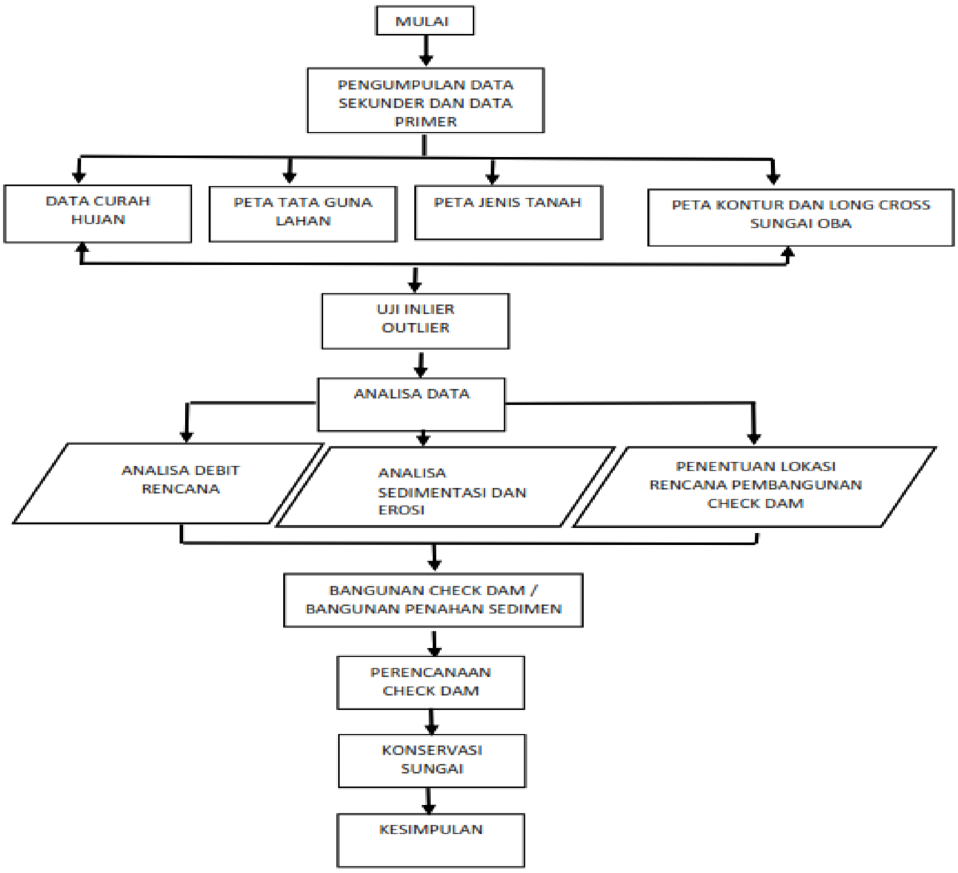
There are two ways to test whether the type of distribution chosen is consistent and suitable for the data, namely the Chi-square and Smirnov-Kolmogerov tests (Triadmojo 2008).

Plan Flood Discharge

Nakayasu synthetic unit hydrograph is one of the synthetic unit hydrographs that has been developed. This HSS is generated based on empirical observations in Japan (Triadmojo 2008).

III. RESEARCH METHODS

The implementation of research for sedimentation and erosion control efforts using USLE in Oba River includes several activities and stages that can be systematically seen in the following figure.



Flowchart of Sedimentation and Erosion Control Efforts using USSLE in Oba River, North ObaDistrict, North Maluku

Existing Condition of Oba River

Oba River which has a length of 2,178 Km and has silted up due to sedimentation carried from the upstream of the Oba River The sedimentation carried away also has an impact on the Sofifi reservoir building. The silting of the reservoir capacity and the erosion of the embankment's complementary buildings, namely the *spillway* and the eroded dodger channel, are also the result of the large sedimentation of the Oba River. In the upstream part of the Oba River, it has aslope that is quite sloping so that when rain falls, it has the potential to carry material into the river. This causes a large sedimentation rate of the Oba River, while in the downstream part of the Oba River, some river slopes are eroding, causing large river flows during flood conditions and also changes in river morphology.

Figure 2. Downstream condition of Oba River and Upstream condition of Sofifi Embung

IV. RESULTS AND DISCUSSION

Plan Discharge Analysis

Table 1. Log Pearson III Method Design Rainfall

No	Tr (Tahun)	Peluang (%)	K	Curah Hujan Rancangan (Xtr) Log	mm
1	1,01	99	-2.107	1.7250	53.088
2	2	50	-0.040	1.9648	92.207
3	5	20	0.716	2.0525	112.856
4	10	10	1.178	2.1061	127.677
5	20	5	1.548	2.1491	140.964
6	25	4	1.734	2.1706	148.117
7	50	2	2.134	2.2170	164.833
8	100	1	2.521	2.2620	182.790

Source: Analysis Result,

Design rainfall from the *log Pearson III* method yields 53,088 mm for a 1.01-year return period and 182,790 mm for a 100-year return period.

Table 2. *Chi-square* Test Class Grouping

No.	Pr	K	Log X	X	Batas Kelas	Oi	Ei	$(Oi-Ei)^2/Ei$
1	80	-1.009	1.852	71.171	X ≤ 71.171	3	3.60	0.10
2	60	-0.185	1.948	88.719	71.171 < X < 88.719	5	3.60	0.54
3	40	0.640	2.044	110.593	88.719 < X < 110.593	6	3.60	1.60
4	20	1.465	2.139	137.860	110.593 < X < 137.860	1	3.60	1.88
5					X ≥ 137.860	3	3.60	0.10
					Jumlah	18	18	4.22

Source: Analysis Results

Table 3. Hourly Effective Rainfall Distribution

Jam ke (t)	Tahun	Distribusi Curah Hujan Efektif							
		1.01	2	5	10	20	25	50	100
1.0	0.55	6.56	20.89	29.08	35.13	40.66	43.67	50.79	58.56
2.0	0.35	4.13	13.16	18.32	22.13	25.61	27.51	32.00	36.89
3.0	0.26	3.15	10.04	13.98	16.89	19.55	20.99	24.42	28.15
4.0	0.22	2.60	8.29	11.54	13.94	16.14	17.33	20.16	23.24
5.0	0.19	2.24	7.14	9.94	12.01	13.91	14.94	17.37	20.03
6.0	0.17	1.99	6.33	8.81	10.64	12.31	13.23	15.38	17.73

Source: Analysis Results,

Table 4. Results of Plan Discharge Analysis

No	Periode (Tr)	Qmaks (m^3/det)
1	1.01	7.882
2	2	22.410
3	5	30.715
4	10	36.855
5	20	42.463
6	25	45.517
7	50	52.738
8	100	60.612

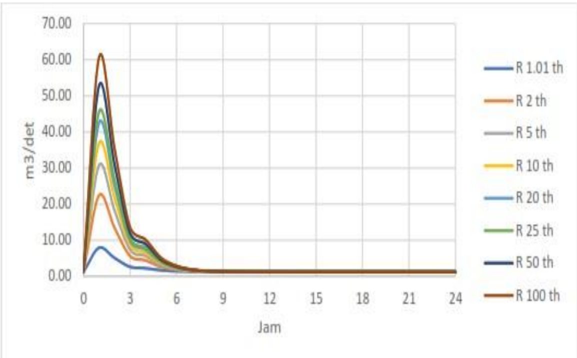


Figure 3: Plan Flood Discharge Distribution Chart

From the results of the graph, the comparison value of the planned flood discharge for each period in the calculation of check dam planning will be used the value of the planned flood discharge for the 50- year period, namely 52.74 m^3 /det.

Sedimentation and Erosion Analysis

The results of the amount of erosion that occurs upstream of the *check dam* with the *USLE* method, namely:

$A = R * K * LS * CP$

By

A : estimated annual soil erosion rate (tons/ha/year)

R : rainfall erosivity index

K : soil erodibility factor

LS : length and slope factor

CP : ground cover vegetation and soil conservation factors

Erosion can be expressed as a double result between the factors of rainfall, soil erodibility and topography (slope and slope length). Estimation of potential erosion can be calculated with the USLE formula approach (Asdak 2010).

Rain Erosivity Value

$Pb = 2164.7\ mm$

Pb = 216.47 cm
R = 2,21$P^{1,36}$
R = 2,21 * 216.47^{1,36}
R = 3315.38 cm

Soil Erodibility Factor Value

Table 5. Distribution of Slope

Luas ((km²)	Jenis Tanah	K	K Total
9.279	Tanah Liat Lempung	0.26	0.07
15.209	Lempung	0.2321	0.11
6.674	Lempung Berpasir	0.2504	0.05
Jumlah			0.24

Source: Analysis Results, Slope factor and slope length

The slope and length factors are obtained from the slope sourced from the Geospatial Information Agency data in the form of the National Digital Elevation Model in tiff format. To obtain the data, contour analysis and distance between contours are needed to obtain the slope and length of the slope.

Table 6. Distribution of Slope

Kemiringan	Keterangan	Luas (km²)	LS	LS total (%)
8-15 %	Landai	3.989	1.4	0.17
15-25 %	Agak Curam	8.088	3.1	0.80
25-40%	Curam	10.765	6.8	2.34
>40 %	Sangat Curam	8.320	9.5	2.53
Jumlah				5.87

Source: Analysis Results

From the analysis, the total LS value is 5.87% with the most slope in the steep category with a slopeof 25-40%.
Land use factors
Land use factors greatly affect the amount of erosion so it is necessary to analyze the distribution ofland use. As in the following table.

Table 7. Land Use Distribution

Legenda	Luas (km2)	CP	CP Total
Hutan Sekunder	27.61	0.005	0.0044
Belukar	3.54	0.3	0.0341
Jumlah			0.0385

Source: Analysis Result,

From the results of the distribution of land use, the CP price is 0.038 with the most land area is secondary forest, so that the results of the analysis of the total amount of erosion of the upstream *checkdam* watershed are :
$A = R * K * LS * CP$
A = 3315,38 * 0,244 * 0,0587 * 0,038
A = 1,83 $ton/ha/year$

Total Erosion for the year
$Atotal$ = 1,83 * 3116,18
$Atotal$ = 5709,881 $ton/year$

The total erosion that occurs in the Oba watershed is 5709.881 tons / year, which then obtained theresults of the *Sediment Delivery Ratio* (SDR) analysis, it is :

$SDR = 0{,}41 * (3116{,}18)^{-0.3}$
$SDR = 0{,}0367$

The relationship between land erosion (EA), sediment transport (SY) and *sediment delivery ratio* (SDR) can be obtained through the formula (Suripin 2002)
$SY = SDR * Atotal$
$SY = 0{,}0367 * 5709{,}881$
$SY = 209{,}56\ ton/year$

To determine the volume of sediment that will fall, it can be converted to a value of m^3 . The conversion uses the SY value divided by the specific gravity of the sediment, using a value range of 1.5 tons/m^3 .
$SY = 209{,}56/1.5$
$SY = 139{,}712\ m^3/year$

The total volume of sediment per year was estimated at 139.712 m^3 /year. With the results of sediment transport, an estimate for the amount of sediment per year is 209.56 tons/year.

Building Sediment Retention Building / *Check dam*
Initial dimensions of the plan site
Watershed area : 31.16 Km^2
River Length : 2,178 Km
Base Elevation : 81,9
Left Cliff Elevation : 90,2
Right Cliff Elevation : 92,8
As for the plan discharge analysis, the influence of the sediment concentration factor is obtained as follows:
Plan Discharge (Q)=52.74
Low sediment concentration ratio (a)=6%
Qd=Q*(1+a) Qd=52.74*(1+0.06)
Qd=55.90 m^3/det

Capacity Sediment Retaining Devices / *Check dams*
The storage volume was assessed from the area of each elevation by adjusting the contour map of the Oba River. The area of each elevation is calculated using the *AutoCAD* application.

Table 8. Volume Capacity of Sediment Building / Check *Dam*

Elevasi Embung (m)	Luas Permukaan (m^2)	Jumlah Luas Permukaan (m^2)	Beda Tinggi (m)	Volume Embung (m^3)	Volume Komulatif (m^3)
82.00	0.00				0.00
		571.65	1.00	198.52	
83.00	571.65				198.52
		3626.36	1.00	1228.86	
84.00	3054.71				1427.38
		9355.27	1.00	3150.66	
85.00	6300.55				4578.04
		18609.56	1.00	6248.66	
86.00	12309.01				10826.70
		29665.01	1.00	9945.75	
87.00	17356.00				20772.45

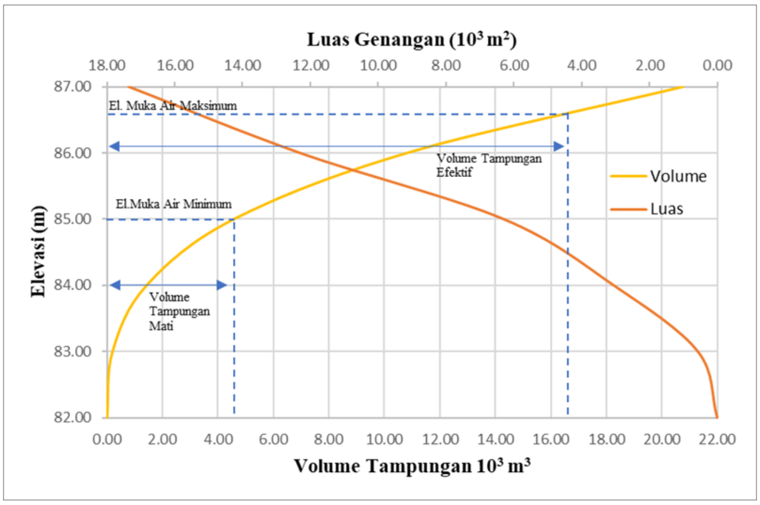
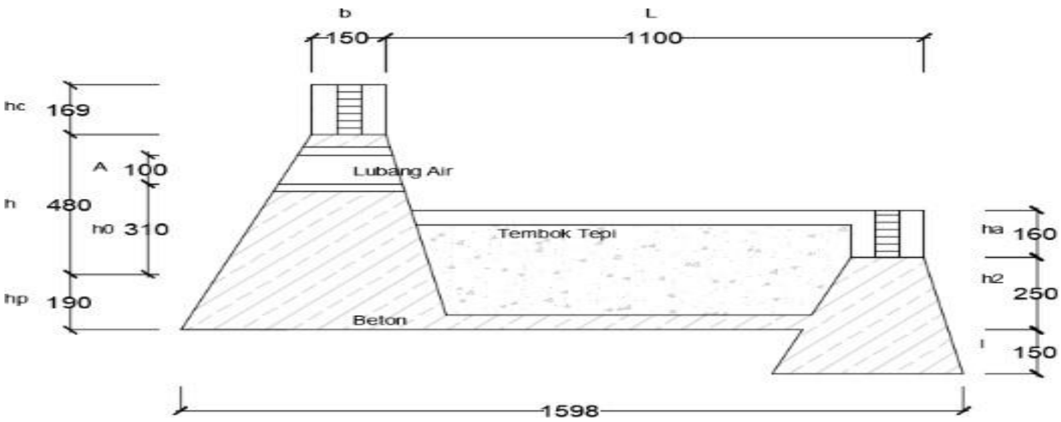


Figure 4: Graph of the Relationship between Storage Volume and Inundation Area



Dimensions Check Dam Oba River

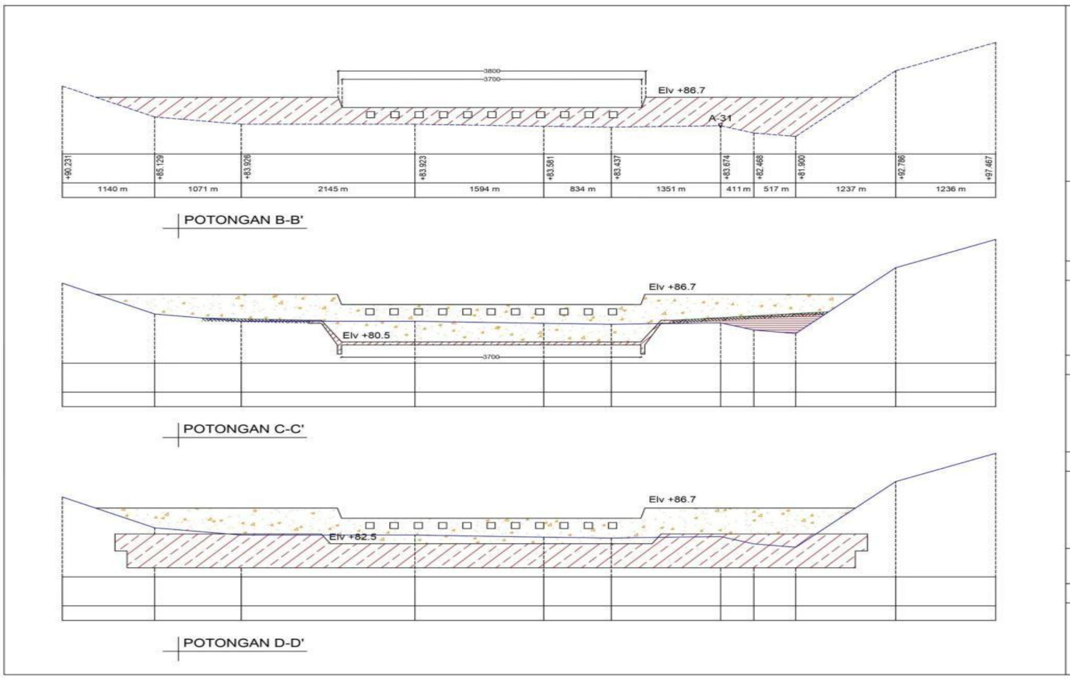


Figure 6. Sedimentation Retaining Structure / Check Dam Planning

River Conservation

The decline in the function of the watershed (DAS) in the Oba river began to decline due to the influence of sedimentation, and erosion. This is of course when it has a major effect on high rainfall which causes flooding and can also decrease the quality of surface water to be utilized as a source of supplying clean water needs. On the other hand, the decline in watershed functions due to sedimentation and erosion in the Oba River also has a negative impact on many damaged community agricultural lands. Therefore, from the results of the analysis of plan discharge, sedimentation and erosion, the efforts made to conserve the Oba River are vegetative treatments carried out by planting hard plants such as pine, teak and mahogany trees at moderate, heavy and very heavy erosion hazard levels, while efforts to overcome sedimentation are with sedimentation retaining buildings (*Check Dam*) which function to inhibit the speed of surface flow and at the same time capture sediment carried by water flow so that the depth and slope of the river decreases. The location of the sedimentation retaining building was built in the upper reaches of the Oba river with the results of the analysis of sedimentation retaining / *check dam* as high as 4.8 M, capacity 139,712 m^3 / year with a plan life of 32.77 years.

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