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# Analysis of Flow Velocity in the Downstream of Palu River

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# ANALYSIS OF FLOW VELOCITY IN THE DOWNSTREAM OF PALU RIVER

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**Abstract**

The area downstream of the Palu River has great potential as a site for social and economic development that can contribute to the surrounding community. The characteristics of the river are influenced by the characteristics of the watershed in terms of land slope, topography, area and shape of the watershed, as well as the pattern of deposition and scouring that occurs along the river channel. Sediment transport analysis always requires flow velocity data, and any waterworks design will take into account the sediment transport problems that occur along with the current velocity in the stream. This study aims to analyze the flow velocity that occurs in the lower reaches of the Palu River. The research site is located in the downstream river of Palu City, Central Sulawesi Province, at UTM 50S coordinates. The data used in this study were flow velocity and discharge measurements. The measurement was made using ADCP RiverSurveyor SonTek M9 tool, using Eulerian method. The measurement results showed a normal discharge of 137.662 m³/s, a maximum discharge of 182.095 m³/s and a minimum discharge of 96.073 m³/s. The lower Palu River has a width ranging from 72 to 225 meters and a depth ranging from 1 to 3 meters in the gently sloping river area. The flow in the lower reaches of Palu River is more dominant in the left part of the river, and the flow velocity in the lower reaches of Palu River ranges from 0.04 - 2.88 m/s.

## Introduction

Rivers are open channels formed naturally on the earth's surface that not only collect water but also move it from upstream to downstream. The water area downstream of the Palu River has great

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potential as a site for social and economic development that can contribute to the surrounding community (Rahman A, 2017). When the tide enters the river, it behaves like a wave that rises upstream, is distorted, and eventually dissipates due to the friction of the river bed and flow (Thaha M. A, 2021). Flow conditions in open channels are complex, based on the fact that the position of the free surface tends to change with time and space (Triatmodjo B, 1996). The characteristics of the river are influenced by the characteristics of the watershed (DAS) in the form of land slope, topography, area and shape of the watershed, and the pattern of deposition and scour that occurs along the river channel (Marsudi, 2021). Aspects that are very influential on the processes that occur, especially flow depending on the shape and characteristics of the downstream rivers, are the hydrodynamic conditions (Hatta M.P, 2018). Siltation, narrowing or movement and closure of the river due to sedimentation has become a serious problem faced in several places in the world (Thaha M.A, 2006). One of the data needed in planning is river discharge, where the river discharge is obtained from field data processing in the form of flow cross-sectional width, depth and velocity distribution.

Sediment transport analysis always requires flow velocity data and any waterworks planning will take into account the sediment transport problems that occur, along with the current velocity in the flow. The combination of changes in each channel parameter will affect the velocity that occurs. On the other hand, the change in velocity will determine the state and type of flow.

In connection with this problem, a study was conducted to analyze the velocity of river flow in the downstream of Palu River which was influenced by the physical condition of the river flow in the form of width, depth and variation of flow velocity. The results of this study are expected to provide information to those interested in knowing the river flow velocity at the lower reaches of Palu River in review.

# Research Methods

The research location is in the downstream of Palu River, Palu City as the capital city of Central Sulawesi Province (Figure 1). Located at UTM coordinates 50 S.

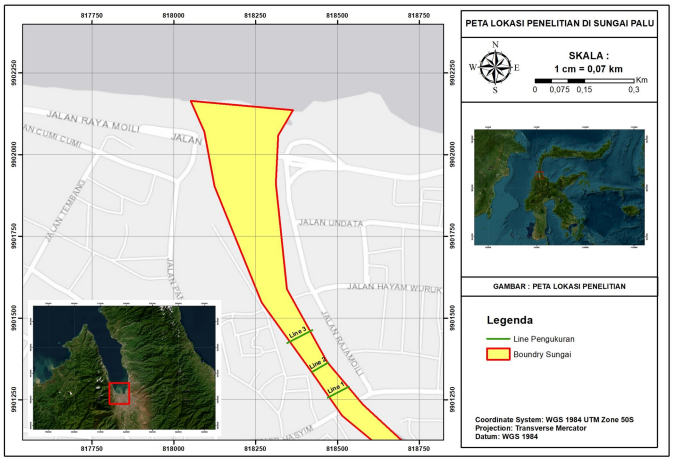


**Figure 1:** Map of Research Location

**Table 1.** Coordinates of the measurement location of flow velocity and discharge downstream of Palu River

| Observation | Left Side Coordinates | | Right Side Coordinates | |
|---|---|---|---|---|
| | Latitude | Longitude | Latitude | Longitude |
| Line S-1 | -0.892745° | 119.861595° | -0.892439° | 119.862175° |
| Line S-2 | -0.891524° | 119.860752° | -0.891264° | 119.861192° |
| Line S-3 | -0.889618° | 119.858082° | -0.889247° | 119.860077° |

The data used in this study consisted of flow velocity and discharge measurements. Data collection of flow velocity and discharge measurements with the eulerian / euler method. Measurements using the RiverSurveyor SonTek M9 ADCP tool. The euler method is the working principle of ADCP in measuring flow velocity and discharge with the concept of following the motion of water particles by shooting a single beam at a certain depth with layer division. The recording interval for river discharge measurements is 1 second, the river discharge used is the average discharge data.

The amount of water flow through a section and calculated from the average water velocity and cross-sectional area of the measurement section. The ADCP RiverSurveyor SonTek M9 is operated from a boat and connected directly to a computer so that the measurement results can be observed directly. For flow velocity and discharge measurements, a single moving boat can be broken down into three main components: Start Edge, Transect, and End Edge. These components are shown in Figure 2 below.

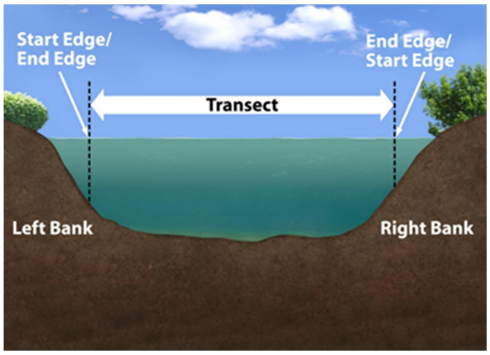


**Figure 2.** Measurement Section

The transect components can be further broken down into the highest estimate, middle or measured area and lower estimate as shown in Figure 3 below:

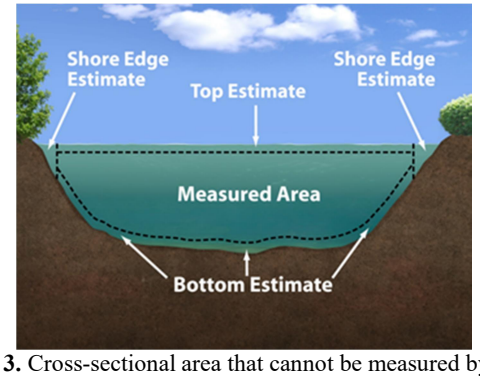


**Figure 3.** Cross-sectional area that cannot be measured by ADCP

Therefore, only the measured area is measured by the ADCP. The ADCP cannot measure the entire river cross section because the profiler has a minimum depth limit in operation. The installation depth plus a short distance (called emptying distance) from the profiler to the measured velocity leaves a section of water on the surface that is not measured. This area is referred to as the Top estimate. Contamination of potential data in the last cell, or disturbance at the end of the profile, leaves a section of water at the bottom unmeasured. This area is referred to as the Bottom Estimate.

**Figure 4.** Measurement of flow velocity and discharge at Palu river downstream

# Results and Discussion

Measurement of flow velocity and discharge in the downstream of Palu River was carried out using ADCP RiverSurveyor SonTek M9 where the results for flow velocity ranged from 0.04-2.88 m/s and can be seen in Table 2, Table 3, and Table 4. The discharge of Palu River was obtained from field measurements of normal discharge of 137.662 $m^3/s$ on October 17, 2022, maximum discharge of 182.095 $m^3/s$ on October 22, 2022, and minimum discharge of 96.073 $m^3/s$ on October 17, 2022 where there was an increase in discharge caused by tidal movements and accompanied by rain.

**Table 2.** Normal discharge flow velocity measurement results

| No | Time | Coordinates | | Depth (m) | Cells | Average Speed (m/s) | Direction |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | | | | |
| 1 | 5:18:05 PM | 0° 53' 28.02" | 119° 51' 39.85" | 1.06 | 10 | 1.06 | 312.70 |
| 2 | 5:18:06 PM | 0° 53' 28.02" | 119° 51' 39.84" | 1.06 | 10 | 1.04 | 306.30 |
| 3 | 5:18:07 PM | 0° 53' 28.02" | 119° 51' 39.84" | 1.07 | 11 | 1.02 | 314.20 |
| 4 | 5:18:08 PM | 0° 53' 28.03" | 119° 51' 39.83" | 1.07 | 10 | 0.99 | 316.40 |
| 5 | 5:18:09 PM | 0° 53' 28.03" | 119° 51' 39.82" | 1.06 | 10 | 1.00 | 315.10 |
| 6 | 5:18:10 PM | 0° 53' 28.03" | 119° 51' 39.81" | 1.06 | 9 | 0.97 | 314.80 |
| 7 | 5:18:11 PM | 0° 53' 28.04" | 119° 51' 39.81" | 1.08 | 9 | 0.87 | 323.60 |
| 8 | 5:18:12 PM | 0° 53' 28.05" | 119° 51' 39.80" | 1.00 | 8 | 1.12 | 321.10 |
| 9 | 5:18:13 PM | 0° 53' 28.05" | 119° 51' 39.79" | 0.94 | 7 | 1.11 | 332.20 |
| 10 | 5:18:14 PM | 0° 53' 28.05" | 119° 51' 39.78" | 0.86 | 6 | 1.43 | 325.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | 5:18:15 PM | 0° 53' 28.06" | 119° 51' 39.77" | 0.79 | 6 | 1.50 | 315.40 |
| 12 | 5:18:16 PM | 0° 53' 28.07" | 119° 51' 39.77" | 0.76 | 6 | 0.79 | 320.80 |
| 13 | 5:18:17 PM | 0° 53' 28.08" | 119° 51' 39.77" | 0.78 | 5 | 0.95 | 315.80 |
| 14 | 5:18:18 PM | 0° 53' 28.09" | 119° 51' 39.77" | 0.77 | 6 | 0.80 | 326.80 |
| 15 | 5:18:19 PM | 0° 53' 28.10" | 119° 51' 39.77" | 0.73 | 5 | 0.92 | 326.50 |
| 16 | 5:18:20 PM | 0° 53' 28.11" | 119° 51' 39.77" | 0.73 | 6 | 1.09 | 321.30 |
| 17 | 5:18:21 PM | 0° 53' 28.11" | 119° 51' 39.76" | 0.73 | 5 | 1.32 | 324.60 |
| 18 | 5:18:22 PM | 0° 53' 28.11" | 119° 51' 39.76" | 0.72 | 5 | 0.97 | 325.30 |
| 19 | 5:18:23 PM | 0° 53' 28.12" | 119° 51' 39.75" | 0.73 | 6 | 0.88 | 322.30 |
| 20 | 5:18:24 PM | 0° 53' 28.12" | 119° 51' 39.75" | 0.72 | 5 | 1.05 | 323.10 |

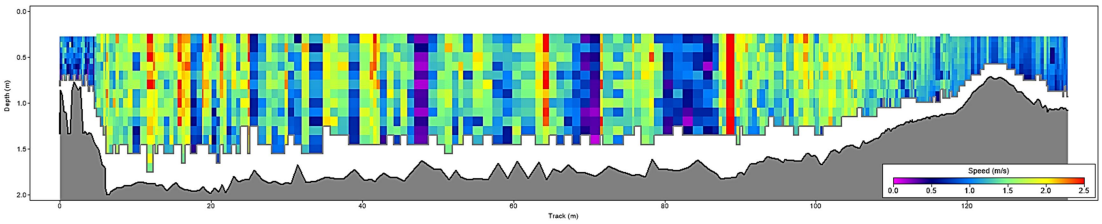


**Figure 5.** Normal Discharge Flow Velocity Cross-Sectional Profile

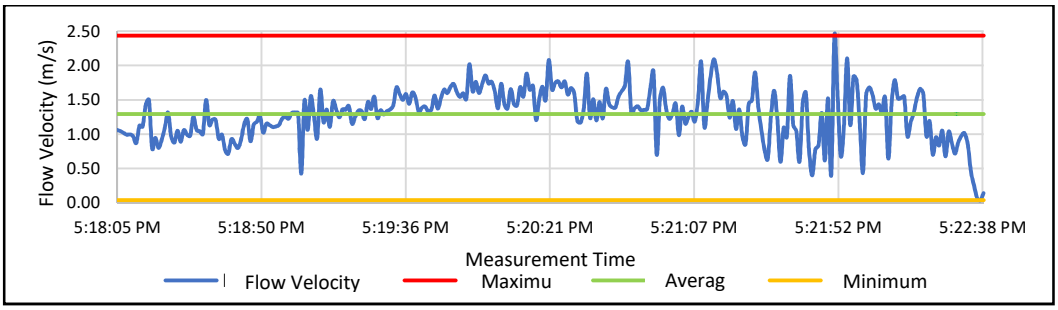


**Figure 6.** Normal Discharge Flow Velocity Graph

Measurement of normal discharge flow velocity at the downstream of Palu River is seen in Table 2, obtained data on velocity per second, coordinate points, cross-section depth, cells data per depth, average velocity and flow direction. The measurement results obtained maximum flow velocity of 2.44 m/s, minimum velocity of 0.04 m/s, and average velocity of 1.29 m/s.

In the middle and left side of the river, the flow velocity tends to be greater than the right side of the river. This is influenced by the cross-sectional shape of the right riverbed which tends to be shallower than the middle and left sides of the river. Silting on the right side of the river is caused by the lack of river flow velocity so that sedimentation occurs in the area. The velocity distribution depends on the channel shape and wall roughness. In Figure 5, the cross-sectional profile of normal discharge flow velocity shows uneven velocity distribution at each point in the cross section and also changes in velocity with depth from the water surface.

**Table 3.** Flow Velocity Measurement Results at Minimum Discharge

| No | Time | Coordinates | | Depth (m) | Cells | Average Speed (m/s) | Direction |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | | | | |
| 1 | 3:06:05 PM | 0° 53' 32.27" | 119° 51' 43.69" | 0.50 | 3 | 1.39 | 303.70 |
| 2 | 3:06:06 PM | 0° 53' 32.26" | 119° 51' 43.68" | 0.51 | 12 | 1.52 | 305.10 |
| 3 | 3:06:07 PM | 0° 53' 32.25" | 119° 51' 43.66" | 0.54 | 12 | 1.61 | 304.20 |
| 4 | 3:06:08 PM | 0° 53' 32.24" | 119° 51' 43.65" | 0.57 | 11 | 1.49 | 306.10 |
| 5 | 3:06:09 PM | 0° 53' 32.24" | 119° 51' 43.65" | 0.65 | 11 | 1.03 | 297.30 |
| 6 | 3:06:10 PM | 0° 53' 32.24" | 119° 51' 43.64" | 0.83 | 15 | 1.02 | 300.40 |
| 7 | 3:06:11 PM | 0° 53' 32.26" | 119° 51' 43.63" | 0.84 | 6 | 1.07 | 280.10 |
| 8 | 3:06:12 PM | 0° 53' 32.27" | 119° 51' 43.62" | 0.84 | 7 | 1.10 | 312.70 |
| 9 | 3:06:13 PM | 0° 53' 32.29" | 119° 51' 43.61" | 0.89 | 7 | 0.79 | 299.70 |
| 10 | 3:06:14 PM | 0° 53' 32.35" | 119° 51' 43.60" | 0.95 | 8 | 1.13 | 196.90 |
| 11 | 3:06:15 PM | 0° 53' 32.40" | 119° 51' 43.57" | 0.94 | 5 | 1.28 | 269.20 |
| 12 | 3:06:16 PM | 0° 53' 32.44" | 119° 51' 43.54" | 0.93 | 5 | 1.41 | 287.80 |
| 13 | 3:06:17 PM | 0° 53' 32.47" | 119° 51' 43.52" | 0.90 | 4 | 1.57 | 281.70 |
| 14 | 3:06:18 PM | 0° 53' 32.51" | 119° 51' 43.50" | 0.89 | 4 | 1.30 | 276.40 |
| 15 | 3:06:19 PM | 0° 53' 32.57" | 119° 51' 43.49" | 0.91 | 4 | 1.04 | 277.10 |
| 16 | 3:06:20 PM | 0° 53' 32.62" | 119° 51' 43.48" | 0.88 | 4 | 0.99 | 252.60 |
| 17 | 3:06:21 PM | 0° 53' 32.67" | 119° 51' 43.45" | 0.89 | 4 | 1.49 | 276.50 |
| 18 | 3:06:22 PM | 0° 53' 32.71" | 119° 51' 43.43" | 0.89 | 4 | 1.38 | 280.20 |
| 19 | 3:06:23 PM | 0° 53' 32.73" | 119° 51' 43.40" | 0.86 | 4 | 1.43 | 286.50 |
| 20 | 3:06:24 PM | 0° 53' 32.75" | 119° 51' 43.42" | 0.90 | 5 | 1.14 | 293.10 |

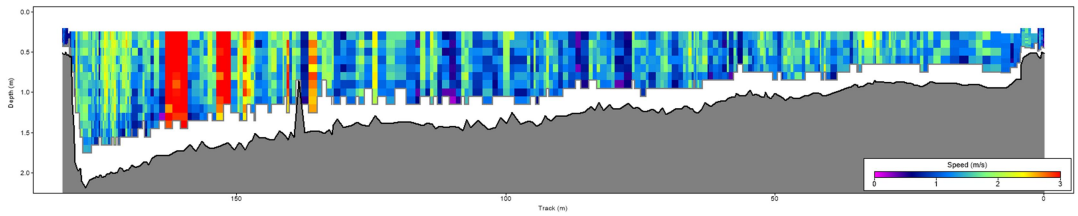


**Figure 7.** Minimum Discharge Flow Velocity Cross-Sectional Profile

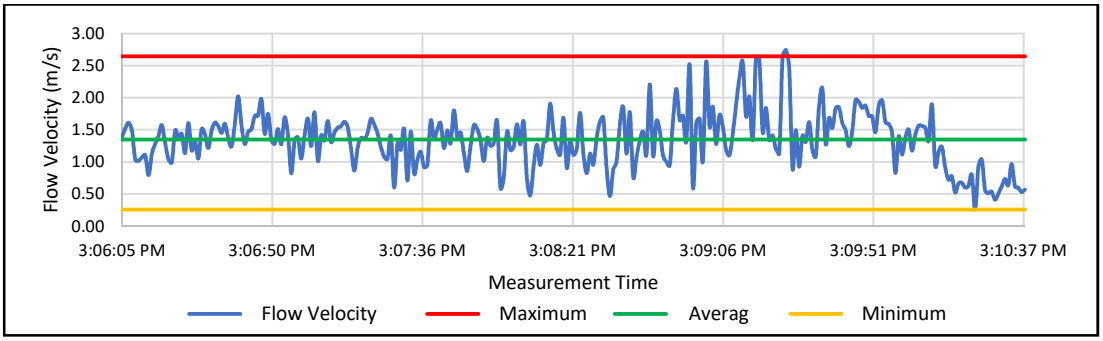


**Figure 8.** Flow Velocity Graph Of Minimum Discharge

Measurement of minimum discharge flow velocity at the downstream of Palu River is seen in Table 3, measurement of flow velocity obtained velocity data per second, coordinate points, cross section depth, cells data per depth, average velocity and flow direction. The measurement results obtained the maximum average flow velocity of 2.74 m/s, the minimum velocity of 0.26 m/s, and the average velocity of 1.34 m/s. The left side of the river, the flow velocity tends to be greater than the middle and right side of the river. This is influenced by the shape of the riverbed cross section on the right side tends to be shallower than the left side of the river. Silting on the right and middle sides of the river is caused by the lack of river flow velocity so that sedimentation occurs in the area. The distribution of flow velocity also depends on the shape of the channel. In Figure 7, the cross-sectional profile of the minimum discharge flow velocity downstream of Palu River shows an uneven velocity distribution at each point in the cross section and also a change in velocity with depth from the water surface.

**Table 4.** Flow Velocity Measurement Results at Maximum Discharge

| No | Time | Coordinates | | Depth (m) | Cells | Average Speed (m/s) | Direction |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | | | | |
| 1 | 15:08:20 | 0° 53' 27.99" | 119° 51' 40.06" | 1.06 | 28 | 0.29 | 355.30 |
| 2 | 15:08:21 | 0° 53' 27.99" | 119° 51' 40.06" | 1.05 | 32 | 0.38 | 319.50 |
| 3 | 15:08:22 | 0° 53' 27.99" | 119° 51' 40.06" | 1.07 | 32 | 0.23 | 330.30 |
| 4 | 15:08:23 | 0° 53' 28.00" | 119° 51' 40.06" | 1.07 | 31 | 0.22 | 327.20 |
| 5 | 15:08:24 | 0° 53' 27.99" | 119° 51' 40.06" | 1.09 | 27 | 0.32 | 320.50 |
| 6 | 15:08:25 | 0° 53' 27.99" | 119° 51' 40.06" | 1.07 | 29 | 0.17 | 337.20 |
| 7 | 15:08:26 | 0° 53' 27.99" | 119° 51' 40.06" | 1.07 | 28 | 0.34 | 332.30 |
| 8 | 15:08:27 | 0° 53' 27.99" | 119° 51' 40.06" | 1.08 | 30 | 0.27 | 276.70 |
| 9 | 15:08:28 | 0° 53' 27.99" | 119° 51' 40.05" | 1.07 | 29 | 0.37 | 298.90 |
| 10 | 15:08:29 | 0° 53' 28.00" | 119° 51' 40.06" | 1.06 | 31 | 0.17 | 274.60 |
| 11 | 15:08:30 | 0° 53' 28.01" | 119° 51' 40.06" | 1.06 | 28 | 0.14 | 253.70 |
| 12 | 15:08:31 | 0° 53' 28.02" | 119° 51' 40.06" | 1.07 | 28 | 0.12 | 182.20 |
| 13 | 15:08:32 | 0° 53' 28.02" | 119° 51' 40.06" | 1.06 | 26 | 0.28 | 269.60 |
| 14 | 15:08:33 | 0° 53' 28.03" | 119° 51' 40.06" | 1.08 | 28 | 0.22 | 301.70 |
| 15 | 15:08:34 | 0° 53' 28.04" | 119° 51' 40.06" | 1.06 | 30 | 0.25 | 302.30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | 15:08:35 | 0° 53' 28.04" | 119° 51' 40.06" | 1.07 | 31 | 0.18 | 290.20 |
| 17 | 15:08:36 | 0° 53' 28.05" | 119° 51' 40.06" | 1.07 | 30 | 0.20 | 284.90 |
| 18 | 15:08:37 | 0° 53' 28.04" | 119° 51' 40.07" | 1.07 | 30 | 0.58 | 43.30 |
| 19 | 15:08:38 | 0° 53' 28.04" | 119° 51' 40.09" | 1.07 | 27 | 0.46 | 42.10 |
| 20 | 15:08:39 | 0° 53' 28.04" | 119° 51' 40.11" | 1.07 | 29 | 0.38 | 49.40 |

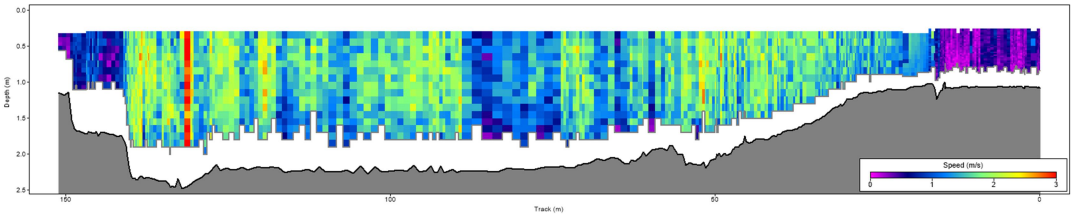


**Figure 9.** Cross-sectional profile of maximum discharge flow velocity

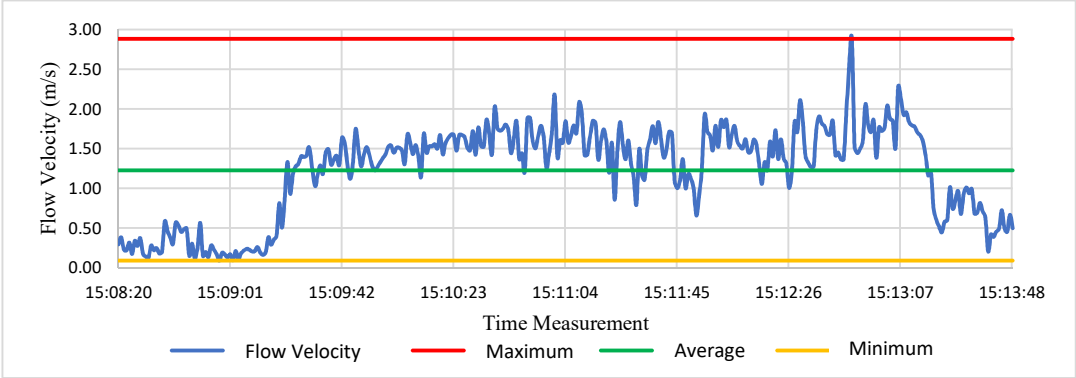


**Figure 10.** Maximum Discharge Flow Velocity Graph

Measurement of the maximum flow velocity of the downstream discharge of Palu River can be seen in Table 4, the measurement of flow velocity obtained speed data per second, coordinate points, cross-sectional depth, cells data per depth, average velocity and flow direction. The results of the flow velocity measurement obtained the maximum average flow velocity of 2.88 m/s, the minimum velocity of 0.09 m/s, and the average velocity of 1.22 m/s. On the left and center of the river, the flow velocity tends to be greater than on the right side of the river. This is influenced by the shape of the riverbed cross section on the right side tends to be shallower than the left and center of the river. Silting on the right side of the river is caused by the lack of river flow velocity so that sedimentation occurs in the area. The distribution of flow velocity also depends on the shape of the channel. In Figure 9, the cross-sectional profile of the maximum discharge flow velocity shows an uneven velocity distribution at each point in the cross section and there is also a change in velocity with depth from the water surface.

# Conclusion

The lower Palu River has a river width ranging from 72 - 225 meters and has a depth ranging from 1 - 3 meters in the river area with a gentle slope. Measurements obtained a normal discharge of 137.662 $m^3/s$, a maximum discharge of 182.095 $m^3/s$, and a minimum discharge of 96.073 $m^3/s$ The

flow in the lower reaches of the Palu River speed is more dominant on the left side of the river, and the flow velocity in the lower reaches of the Palu River ranges from 0.04 - 2.88 m/s.

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