JURNAL MULTIDISIPLIN MADANI (MUDIMA)

Homepage: https://journal.formosapublisher.org/index.php/mudima

ISSN: 2808-5639 (Online)

Research Article

Volume 3, No 9, September (2023)	DOI: https://doi.org/10.55927/mudima.v3i9.6092	Page: 1999-2010

Geometric Modeling of River Estuary to Support Normalization Program of Veteran River, Banjarmasin City

Ferry Sobatnu[1*], Nurul Inayah[2]

Politeknik Negeri Banjarmasin

Corresponding Author: Ferry Sobatnu sobatnu@poliban.ac.id

ARTICLE INFO

Keywords: Gridding Modeling, Veteran River, Pleiades Imagery

Received : *1 August*
Revised : *17 August*
Accepted : *20 September*

ABSTRACT

The city of Banjarmasin is in fact included in the tidal water zone. The Veteran River is one of the canals made by the Dutch to prevent flooding. This research applies geomatics and survey technology to show actual conditions at the mouth of the Veteran River by modeling geometric shapes, using terrestrial and bathymetric measurement data and corrected Pleiades satellite imagery. Modeling using the Gridding method can create geometric shapes of land surface appearances in 3 dimensions. The modeling results show that the condition of the Veteran river body is narrowing at a distance of 58 meters from the edge of the Martapura River with a width of up to 8 meters, and at a distance of 78 meters to 145 meters the width of the river body only reaches 3 meters. The shallowest point reaches (-) 0.074 meters at the mouth of the Veteran River, and the deepest point reaches (-) 13,311 meters in the Martapura River area. The basic condition of the cross section of the Veteran River estuary shows a relatively flat slope level. This shows a poor natural drainage system, where conditions like this can affect the volume of water flow in the Veteran River

INTRODUCTION

Veteran River is one of the canals created by the Dutch to prevent flooding in Banjarmasin City. Veteran River is a primary river with a vital function because it is located in the middle of the city and empties into the Martapura River. The river is about 2,087 meters long and serves as the main drainage channel for the riverbank and surrounding areas. The function of the river, which was previously a canal to cope with flooding, is not working as it should. This is due to the condition of the Veteran River, which can be said to be dead because it has experienced siltation and severe narrowing as a result of the construction of residential settlements on it. Muryanta (2016).

The flood disaster experienced by almost all areas of South Kalimantan in 2021 made us realize that it is very important to anticipate together in preventing flooding. One of the ways that can be done is normalizing rivers or canals. The flood management program in Banjarmasin city is included in the Indonesia: National Urban Flood Resilience Project (NUFReP), which is carried out by the Directorate General of Water Resources - Ministry of PUPR and assisted by the Directorate General of Regional Development - Ministry of Home Affairs (BWS Kalimantan III, 2022). Veteran River is included in the short-term program of river normalization and structuring out of 10 special programs in Banjarmasin city.

As you may already know, Banjarmasin is a city built on tidal marshland. Many rivers flow around the city, so the chance of flooding is very high. With the flood management program in Banjarmasin city, and the normalization of the Veteran River being one of the objects of the program, researchers see this as an urgent need that must be addressed by the government. The geometric model generated from the spatial analysis in this research is very useful and can be used as a reference in planning and designing river normalization projects, especially the Veteran River estuary, so that it is expected to restore the original function of the river, namely preventing flooding in the city of Banjarmasin.

METHODS

This modeling utilizes geomatics and survey technology to be able to show the actual geospatial conditions at the Veteran River estuary, by conducting a series of terrestrial and bathymetric measurement activities directly at the research site and digital mapping using corrected Pleiades satellite imagery as a spatial data source. Spatial analysis is a technique or process that involves a number of logical (mathematical) calculations and evaluations carried out in order to find or discover (potential) relationships that exist between geographic elements (Prahasta, 2009).

The series of survey activities produced data that can be processed into a 3-dimensional model that represents the shape of the relief or contour of the land, and the object of the appearance of the land surface or land indentation at the bottom of the waters of the Veteran River estuary as a whole.

The stages of model building can be explained as follows;

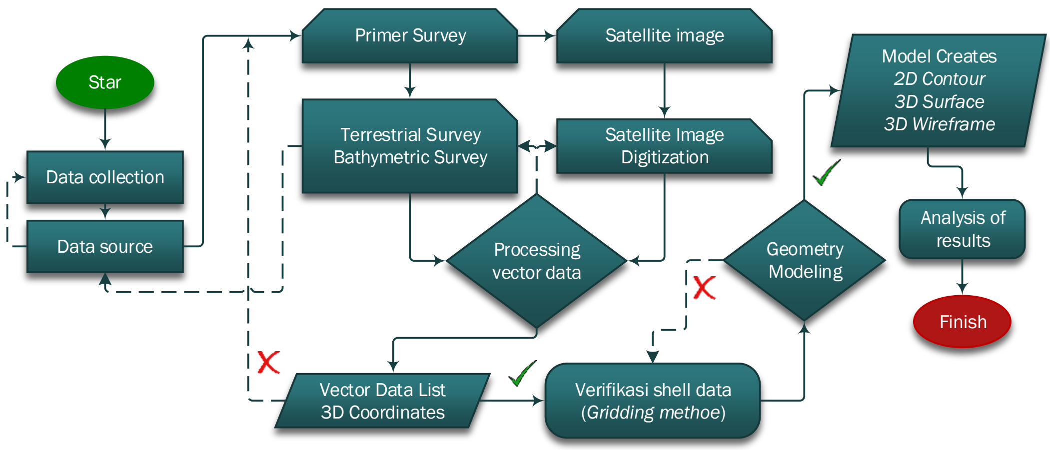

Figure 1. Modeling Flow Diagram

1. Data Collection

The thing to do is to collect and study literature studies, theoretical foundations relevant to this research. Inventory the surveying and mapping equipment that will be used. Ensure that all survey equipment is in good condition and calibrated. At this early stage, it is also ensured that all computers and data processing software have been tested and are ready for use.

2. Primary Survey

Primary Survey is a direct measurement activity at the research site. The data collected are the results of; terrestrial surveys in the form of land elevation data, Bathymetry surveys in the form of position data and riverbed depth, Banch Mark fixed point coordinate data and hydrometric surveys in the form of river current velocity data and water level elevation. The series of survey activities refer to Indonesian National Standards (SNI 19-6988-2024; SNI 19-6724-2002 and SNI 8283:2016).

3. Satellite Image Data

Corrected Pleiades satellite images are used as a source of spatial data in the form of a distribution of coordinate values (x,y) of the position of the distribution of objects at the research site which are interrelated to terrestrial survey data and bathymetry survey data. The process of taking coordinate values is done by digitizing. Accuracy of image geometric accuracy using geometric distortion correction that is not systematic using geographic positions (ground control points) that are evenly distributed throughout the image. Root Mean Square Error (RMSE) calculation is applied to determine the accuracy of Geometric correction. RMSE is the square root of the mean square of the difference between the data coordinate value and the coordinate value of the independent source with higher accuracy (FGDC, 1998). RMSE is the magnitude of the error rate of the prediction results, where the smaller (closer to 0) the RMSE value, the more accurate the prediction results will be, the terms of geometric accuracy of the image calculation of RMSE $\leq$ 1. (Purwadhi, F.S.H., 2001). The RMSE value can be calculated with the following equation;

$$RMSE = \sqrt{\frac{\Sigma(X-Y)^2}{n}} \quad (1)$$

when separated into horizontal and vertical plane tests it can be written as such;

$$RMSE_{Horizontal} = \sqrt{\frac{D^2}{n}} \quad \text{where,} \quad (2)$$

$$D^2 = \sqrt{(RMSE_x)^2 + (RMSE_y)^2}$$
$$= \sqrt{\frac{\Sigma(x_{data}-x_{cek})^2+(y_{data}-y_{cek})^2}{n}} \quad (3)$$

$$RMSE_{Vertical} = \sqrt{\frac{\Sigma(z_{data}-z_{cek})^2}{n}} \quad (4)$$

with:

n = Total number of data (checking sample)

D = Difference between the coordinates measured from the independent source and the coordinates on the reference map

x = x-axis coordinate value

y = y-axis coordinate value

z = z-axis coordinate value

the unit value in the RMSE calculation follows the unit value used in the cornerstone measurement.

4. Vector Data Processing

Data obtained from surveys and digitization are then processed using calculation methods in accordance with geomatics standards for vector data processing. The results of the calculation are then combined into a list of coordinates. This type of digital data is the vertex value of each metric dot, so it can be used as modeling metadata.

5. Geometric Modeling

The modeling metadata is processed with a gridding-based method. Models are digitally created in 2-dimensional contour, 3-dimensional surface and 3-dimensional geometric views.

6. Spatial Analysis

Spatial analysis is conducted using the model that has been created. The model presents the appearance of the geomeric conditions of the land surface of the research object. The geometric dimensions of the Veteran River estuary can be measured on the model.

RESULTS AND DISCUSSION

The spatial data source used in this research is the 2016 Pleiades High Resolution Satellite Imagery (CSRT) of Banjarmasin City issued by the National Institute of Aviation and Space (LAPAN). The geometric correction process is carried out so that the image has map properties. In the process, geometric correction can be done with the help of Qgis software. The coordinates of the GCP (Ground Control Point) points needed in geometric correction can be obtained from the base map on the plugin that is already available in the software. Figures 2 and 3 show the distribution of GCP points on the image and the GCP table.

Figure 2. Distribution of GCP Points on the Image
Source: 2016 Pleiades Imagery of Banjarmasin City

Table 1. List of Coordinates and RMSE Value of GCP Points

Visible	ID	Source X	Source Y	Dest. X	Dest. Y	dX (pixels)	dY (pixels)	Residual (pixels)
✓	0	230844	9.63587e+06	230843	9.63587e+06	0.0216794	-0.0176865	0.0279788
✓	1	231006	9.63301e+06	231004	9.63301e+06	0.0199082	-0.00970988	0.0221499
✓	2	230995	9.63003e+06	230993	9.63002e+06	-0.00274306	-0.000575941	0.00280288
✓	3	231331	9.62667e+06	231332	9.62667e+06	9.85229e-05	0.00108746	0.00109192
✓	4	227932	9.63268e+06	227929	9.63267e+06	-0.0234599	0.0225872	0.0325661
✓	5	228090	9.63043e+06	228088	9.63042e+06	0.00804857	-0.0161326	0.0180289
✓	6	227914	9.62696e+06	227914	9.62696e+06	-0.0148216	0.0113964	0.0186964
✓	7	225263	9.62728e+06	225262	9.62728e+06	0.00921101	-0.00523055	0.0105925
✓	8	234015	9.62688e+06	234015	9.62688e+06	0.00632848	-0.00788621	0.0101115
✓	9	234071	9.62993e+06	234069	9.62993e+06	0.0106989	0.00452421	0.0116162
✓	10	233983	9.633e+06	233981	9.633e+06	-0.00224589	0.00271229	0.00352144
✓	11	233948	9.63608e+06	233947	9.63608e+06	-0.0377149	0.0229394	0.0441433
✓	12	236372	9.63626e+06	236372	9.63626e+06	0.0159004	-0.00613448	0.0170427
✓	13	236900	9.63308e+06	236899	9.63308e+06	0.00362396	-0.00990208	0.0105444
✓	14	237056	9.63009e+06	237054	9.63008e+06	-0.0183301	0.00735957	0.0197523
✓	15	239357	9.62995e+06	239352	9.62995e+06	0.00381796	0.000651738	0.00387319

Transform: Polynomial 3 Mean error: 0.0319761 331.578,9626674 EPSG:32750

Based on the distribution of 16 GCP points, the resulting RMSE (Root Mean Square Error) is 0.0319761. Tolerance of the RMSE value must be qualified $\leq$ 1 Pixel. This shows that the point distribution and RMSE values are qualified. As a validation of the geometric correction results, testing the size of several objects in the field was carried out directly. Table 2 shows the comparison of measurements on the image and direct measurements in the field.

Table 2. Results of Object Size Comparison Test

NO.	Image	Check	Dif.	Object location
1.	11,25	11,20	0,05	Bridge Width Kapten Piere Tendean Street
2.	11,71	11,60	0,11	The width of the Veteran River under the Captain Piere Tendean Street Bridge
3.	15,38	15,40	-0,02	Length of Siring Park Crossing Bridge Fence
4.	16,60	16,80	-0,20	The width of the river below the Siring park crossing bridge
5.	20,94	21,00	-0,06	Width of Siring Park Basketball Court
6.	33,74	34,00	-0,26	Length of Basekt Field in Siring Park

* Units are in Meters

From the measurement results, the average difference between direct measurement and measurement on the image is (±) 0.063 meters.

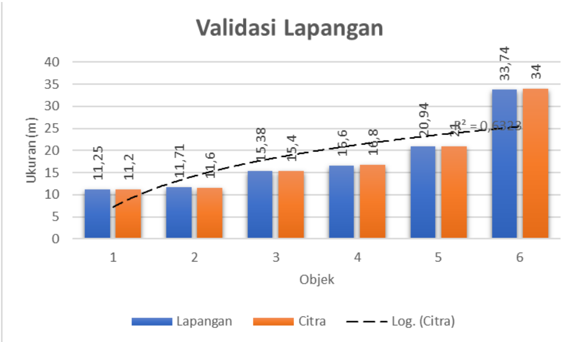

Figure 3. Object Size Comparison Test Graph

After the image validation stage is completed, the next step is the Cropping process on the image, this process is a technique of selecting, taking and cutting certain parts of the image overlaid on OpenStreetMap, in this case focusing on the Veteran river estuary.

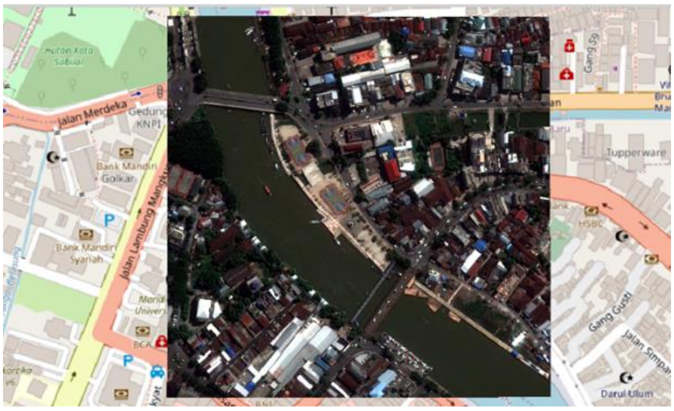

Figure 4. Cropping Satellite Imagery

The image that has been cropped is then digitized to change the raster data type of objects in the image into vector data type by drawing according to the shape of the object. This stage aims to make the information contained in the satellite image can be processed further as geospatial data that has coordinate values (x and y) land. This vector data shows position, shape, area and direction information on the ground so that it can be a source of spatial data.

The selection of objects digitized on the image was chosen to match the detailed objects measured terrestrially. The selected digitized objects are shown in Table 3.

Table 3. Image Digitization Objects

No.	Layer Name	*Geometry Type*	Amount
1.	Bridge	*Line* (Garis)	9
2.	Collector Street	*Line* (Garis)	4
3.	One Lane Arterial Road	*Line* (Garis)	2
4.	Two Lane Arterial Road	*Line* (Garis)	4
5.	River	*Line* (Garis)	20
6.	Local Roads	*Line* (Garis)	20
7.	Pedestrians	*Line* (Garis)	4
8.	Educational Facilities	*Polygon* (Area)	6
9.	Religious Facilities	*Polygon* (Area)	7
10.	Sports Facilities	*Polygon* (Area)	6
11.	Settlement	*Polygon* (Area)	122
12.	Place of Business	*Polygon* (Area)	121

To get the distribution of land elevation in the research object, geomatics engineering technology and surveys are applied in the form of terrestrial surveys and bathymetric surveys. Terrestrial survey is the collection of field data using the flat sipat method with an automatic level tool, the reference point used is the beanch mark (BM1), the data obtained is in the form of height data (Z) or elevation. The survey location is in the Bekantan Statue monument area and the Merdeka Bridge to Dewi Bridge siring path and at the mouth of the Veteran River. After conducting terrestrial survey measurements, the position of each elevation point is placed in the appropriate position on the Pleiades image map that has been processed previously, so that a combination of 3-dimensional coordinate values (x, y and z) can be obtained. The process of compiling and calculating land elevation data used Ms. Excel and QGIS software.

Banjarmasin's Veteran River empties into the Martapura River channel, so that land elevation collection is not only carried out in the plains, but also in the river area, both in the Veteran River and in the Martapura Sunagi, which are one unit of the river drainage area. Bathymetric surveys were conducted to obtain coordinates and elevations in this area. Figure 6 below shows the combined distribution of the calculated coordinate points.

Figure 5. Distribution of Terrestrial and Bathymetry Survey Elevation Points

The number of coordinate points that have been corrected reaches 1247 points, the coordinate list is shown in table 4.

Table 4. Combined Coordinate List

X	Y	Z	NO TITIK	KETERANGAN
232658.860	9632588.910	2.058	BM 1	BM 1
232644.200	9632598.580	1.947	SI 1	SIMPANAN 1
232649.514	9632552.710	1.474	SI 2	SIMPANAN 2
232694.620	9632504.160	1.507	SI 3	SIMPANAN 3
232679.377	9632596.126	1.706	1	CROSS SUNGAI
232679.890	9632593.390	0.072	2	CROSS SUNGAI
232681.660	9632591.253	-0.286	3	AS SUNGAI
232683.624	9632588.035	0.079	4	CROSS SUNGAI
232685.071	9632586.321	2.056	5	CROSS SUNGAI
232688.588	9632580.499	1.807	6	CROSS SUNGAI
232660.269	9632596.620	1.918	7	CROSS SUNGAI
232664.974	9632592.584	1.932	8	CROSS SUNGAI
232668.297	9632589.125	0.476	9	CROSS SUNGAI
232671.585	9632584.502	-0.330	10	AS SUNGAI
232674.067	9632579.955	0.035	11	CROSS SUNGAI
232674.275	9632579.277	1.004	12	CROSS SUNGAI
232676.258	9632574.342	1.594	13	CROSS SUNGAI
232650.709	9632592.698	1.403	14	CROSS SUNGAI
232653.789	9632589.267	0.726	15	CROSS SUNGAI
232655.463	9632587.096	0.075	16	CROSS SUNGAI
232656.332	9632580.688	-0.346	17	AS SUNGAI
232659.432	9632575.438	-0.161	18	CROSS SUNGAI
232661.003	9632572.875	1.962	19	CROSS SUNGAI
232662.864	9632570.022	1.475	20	CROSS SUNGAI
232632.395	9632578.001	1.266	21	CROSS SUNGAI
232634.297	9632574.611	-0.096	22	CROSS SUNGAI
232637.935	9632569.733	-0.520	23	AS SUNGAI
232641.242	9632563.656	-0.108	24	CROSS SUNGAI
232642.648	9632561.837	1.396	25	CROSS SUNGAI
232645.087	9632558.612	1.376	26	CROSS SUNGAI

This data is then used for contour modeling and spatial analysis in the form of 3-dimensional terrain. The datum used for processing survey data and making contour maps and modeling is using the WGS'1984 ellipsoid and using the UTM (Universal Transverse Mercator) Zone 50S projection system for the coordinate units used using metric.

The purpose of this research is to conduct spatial analysis using spatial data from surveys at the mouth of the Veteran River. The results of spatial analysis can accurately show the geometric shape of the land surface in a 3-dimensional view. Geometric modeling uses the Gridding method.

Gridding is the process of coordinate data that is scattered irregularly and there is empty data to produce a grid file that contains organized data. Gridding determines how to interpolate or extrapolate data on each of the x, y, and z axes. In grid-based modeling, points are evenly and regularly distributed across the surface of a digital model (DTM) within a certain interval. DTM points can be sample points or interpolated points. The surface of the digital model is formed by a grid connecting the DTM points. This research utilizes Surfer software to perform the modeling. Surfer is a grid-based contouring and 3D surface plotting graphics program (Prahasta, E. 2008).

A. 2-Dimensional Model

The results of this spatial analysis show the actual geometric conditions of the Veteran River estuary. The results of the 2-dimensional model display the land using a density of 1 meter interval contour lines. This is made so that the contours are clearly visible and cover the entire research area. In the Martapura river section, the contours are aligned with the landward edge of the river and have the same distance from each other. The contours that have a fixed distance from each other indicate that the depth of the Martapura River waters has a regular slope. Figure 8 shows that the deeper the contour value is towards the center of the river body. At the mouth of the river the veteran contour display shows irregular contour lines, because in that area there are several building infrastructures that cannot be measured directly, due to being blocked by a pedestrian bridge.

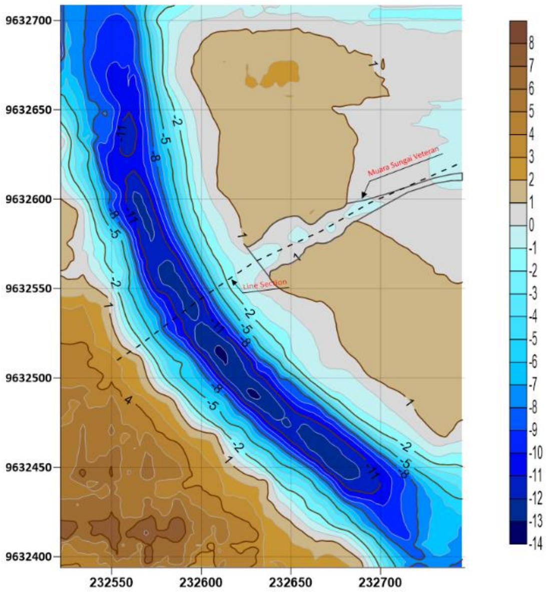

Figure 5. Land Contour Condition of the Veteran River Estuary

Figure 5 also shows the condition of the narrowing of the Veteran River body at a distance of 58 meters from the Martapura river bank with a width of up to 8 meters and at a distance of 78 meters to 145 meters the width of the river body only reaches 3 meters. Figure 9 shows the basic condition of the Veteran River estuary cross section showing a relatively flat slope.

This condition can affect the volume of water flowing from the Veteran River to the Martapura River, becoming one of the contributing factors to flooding in Banjarmasin city in general and in Central Banjarmasin Sub-district in particular. This indicates a poor natural drainage system, as the city is still in the tidal water zone.

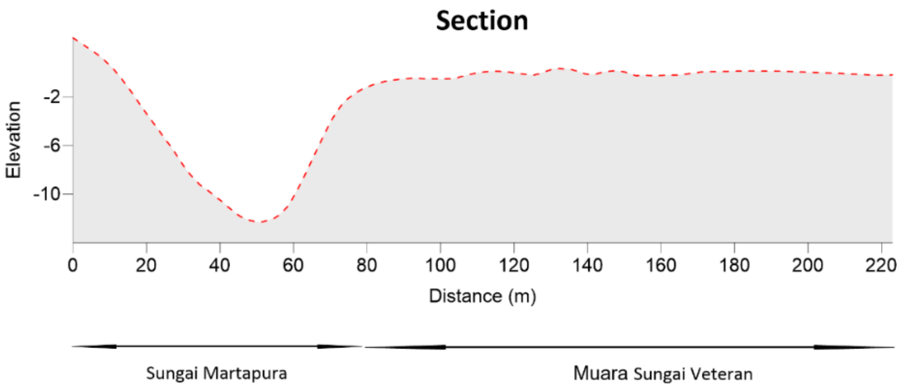

Figure 6. Cross-sectional Condition of the Bed of the Veteran River Estuary

This condition can affect the volume of water flowing from the Veteran River to the Martapura River, becoming one of the contributing factors to flooding in Banjarmasin city in general and in Central Banjarmasin Sub-district in particular. This indicates a poor natural drainage system, as the city is still in the tidal water zone.

B. 3-Dimensional Model

The results of spatial analysis can also be presented with 3 (three) dimensional modeling to show the actual shape of the ground relief. This information can be utilized for further analysis in simulating the overflow zone that may occur at the mouth of the Veteran River. Figure 10 below shows the ground relief in the perspective form of a 3-dimensional Wireframe model.

For the next stage, the ground relief is visualized with color gradation based on the contour index depicting the river depth condition. Figure 11 shows the contours that have some areas deeper than their surroundings. The dark blue area is indicative of the deepest area, and the peach-colored area is indicative of the shallowest area, while the dark brown area is higher than the light brown area. The result of the shallowest point reading scale is (-)0.074 meters at the mouth of the Veteran River, and the result of the deepest point is (-)13.311 meters in the Martapura River area.

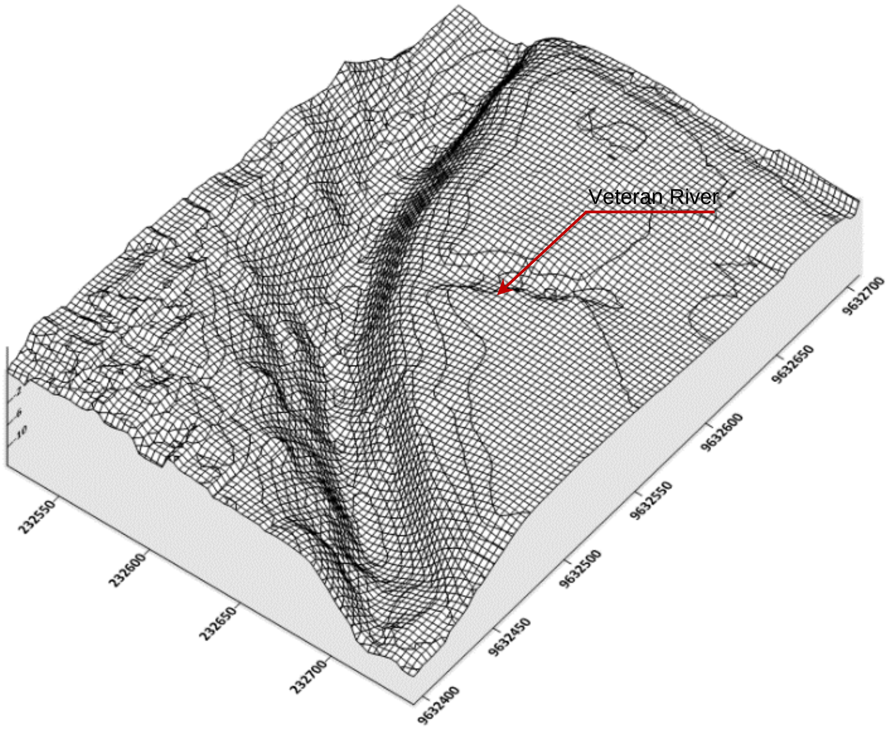

Figure 7. 3-Dimensional Wireframe Model

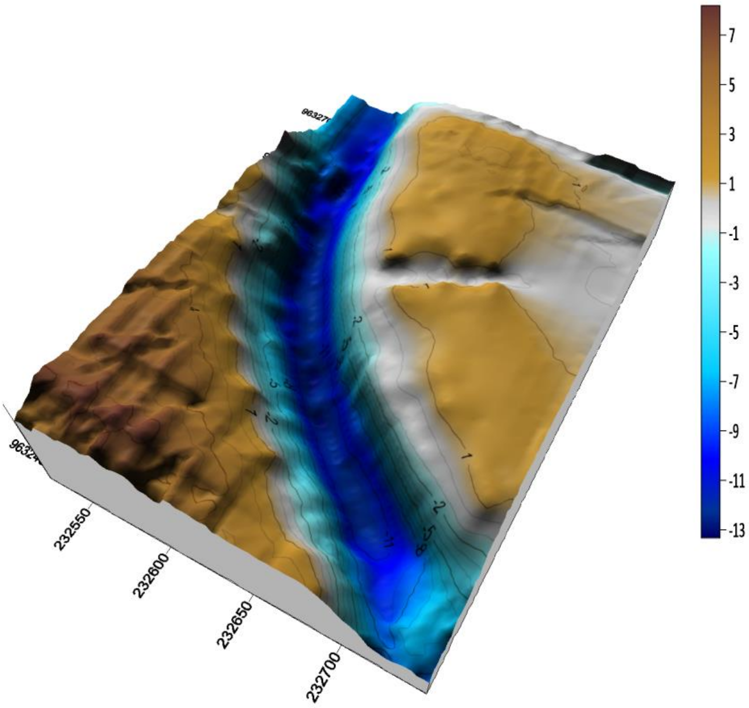

Figure 8. 3-Dimensional Surface Model

CONCLUSION

1. This research utilizes geomatics and survey technology to be able to show the actual geospatial conditions at the Veteran River estuary, by conducting a series of terrestrial and bathymetric measurement activities directly at the research site and utilizing corrected Pleiades satellite images as a source of spatial data.
2. Modeling using Gridding-based methods creates a geometric shape of the land surface in a 3-dimensional view.
3. The results of spatial analysis show the condition of the narrowing of the Veteran River body at a distance of 58 meters from the edge of the Martapura River with a width of up to 8 meters and at a distance of 78 meters to 145 meters the width of the river body only reaches 3 meters.
4. The modeling results show that the shallowest point reading scale is (-) 0.074 meters at the mouth of the Veteran River, and the deepest point result is (-)13.311 meters in the Martapura River area.
5. The basic condition of the Veteran River estuary cross section shows a relatively flat slope. This indicates a poor natural drainage system. This condition can affect the volume of water flow in the Veteran River, where in fact the city of Banjarmasin is still included in the tidal water zone.
6. The resulting geometric model is very useful and can be used as a reference in planning and designing river normalization projects, especially at the mouth of the Veteran River, so that it is expected to restore the original function of the river, namely preventing flooding in the city of Banjarmasin.

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