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Erosion hazard analysis using spatial modelling: A case study of the Tembesi watershed, Sarolangun Regency, Jambi Province

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Abstract

The formulation of the problem in this study is the characteristics of erosion, the level of erosion hazard, and the spatial model of erosion hazard in the Tembesi watershed, Sarolangun Regency, Jambi Province. Then the main purpose of this study is to determine the level of erosion hazard at the research location points which will then be spatialized using ArcGIS 10.4. In this study, the research method used is descriptive qualitative method. because seeing the information and description of the level of erosion hazard in the Tembesi watershed, Sarolangun Regency, Jambi Province. The data of this study include primary data, namely direct measurements and observations in the field and secondary data, namely data obtained through the relevant agencies. The results obtained in this study are: First, the erosion characteristics at the research location points have two dimensions, namely V and U-shaped dimensions with a depth of >30 cm and some <30cm. Second, the level of erosion hazard was calculated using the USLE method with the results at the research site points >2.00 tons/ha/year. Third, the spatial model used in this research is ArcGIS 10.4. With each level of erosion hazard are: 5.87 (very mild), 29.36 (mild), 2.94 (very light), 2.94 (very mild), 5.87 (very mild), 29, 36 (light), and 205.52 (heavy).

Keywords: *erosion hazard, spatial modelling*

A. Introduction

Watershed is one of the resources that exist on the surface of the earth, the flow of rivers needs to be corrected, both from the community and from the government. The management of water resources can be carried out by tracing environmental damage, especially regarding erosion. Environmental damage that occurs can be influenced by humans or caused by natural conditions itself, will be seen in the symptoms and phenomena of the behavior of the river flow from time to time. So far, the government and the public have not fully carried out the investigation regarding the level of environmental damage, especially river bank erosion and

flooding, which continue to be a concern for life in our country. So many of us think that the cause of this disaster arises as a result of an imbalance between the existing ecosystems (Juita et al., 2018).

Erosion that occurs in the watershed is mostly found due to the transfer of land use that does not observe what needs to be considered from the rules of soil and water conservation. Erosion that occurs in an area can cause the lifting of the top layer of fertile soil to restrain plant growth (Tan, 1991). Meanwhile, if erosion has occurred, land rehabilitation and conservation efforts are needed (Komaruddin, 2008).

Before discussing further what we need to know is the definition of erosion. Erosion is the carrying away of a layer of soil or sediment caused by friction from the movement of wind or water on the land surface or bottom of the waters (Poerbandono et al., 2006). The high rate of erosion around the watershed environment can be caused by parameters of water flow velocity and sediment properties. External factors that influence the occurrence of erosion are rainfall and water flow on the slopes of the watershed. High rainfall intensity and sloping watershed slopes are the main factors that increase the rate of erosion (Herawati, 2010).

The Tembesi watershed is the largest watershed in Sarolangun Regency, of course there will be some changes as a result of the land conversion. In the equatorial rain pattern, rainfall and humidity are high because the rain occurs throughout the year exceeding an average of 100 mm/month. With this high amount of rain, the destructive power will be higher than areas with monsoon rain patterns, especially coupled with the conversion of land from forest to cultivation (Ilfan & Prof. Dr. Ir. Arwin, n.d.).

Judging from the case that occurred as a result of erosion in the Tembesi watershed, Sarolangun Regency in April 2021, namely the occurrence of a landslide on the Jambi-Sarolangun highway in Batu Ampar Village, Pauh District, Sarolangun Regency. The author cites news from Tribunjambi.com which explains that judging from the observations of Tribunjambi.com in the field, the road is only halfway away, of course this is very dangerous for motorists because large-loaded tronton cars continue to pass in turns.

Based on the problems above, the researchers made observations on November 15, 2021 and directly observed the dangers caused by erosion that occurred in the Tembesi watershed, Sarolangun Regency. So, this is also one of the reasons for researchers to conduct research on erosion hazards in the Tembesi watershed, Sarolangun Regency. The formulation of the problem in this study are:

1. What are the characteristics of erosion in the Tembesi watershed, Sarolangun Regency, Jambi Province?
2. What is the level of erosion hazard in the Tembesi Watershed, Sarolangun Regency, Jambi Province?
3. What is the Spatial Model of Erosion Hazards in the Tembesi Watershed, Sarolangun Regency, Jambi Province?

B. Methodology

1. Research Design

In this study, the research method used is descriptive qualitative method. because the information sees and describes the erosion hazard in the Tembesi watershed, Sarolangun Regency, Jambi Province. The data of this study include primary data, namely direct measurements and observations in the field and secondary data, namely data obtained through the relevant agencies.

2. Instruments

The tools and materials used in this research are Camera, Laptop, ArcGIS, meter measuring device, Paper and pen and Sarolangun Regency Administration Map, Tembesi Watershed Map, Research Site Map.

3. Technique of Data Analysis

The data analysis technique used in this research is agency observation and survey, namely field observations, data collection from institutions and documentation. Observation, namely the collection of premiere data obtained from direct observations in the field at the research location points that have been determined. And secondary data is data collection from the agency, namely BMKG Jambi Province. The data analysis techniques used in this study are:

1. Erosion characteristics in the Tembesi watershed of Sarolangun Regency, using descriptive data analysis techniques, where to determine the characteristics of erosion that occur in the Tembesi watershed of Sarolangun Regency is to see how the land use in

the Tembesi watershed of Sarolangun Regency and determine the form of erosion in the Tembesi watershed of Sarolangun Regency.

2. Erosion hazard in the Tembesi watershed, Sarolangun Regency, analysis of erosion prediction data and the level of erosion hazard will be carried out using the Universal Soil Loss Equation (USLE) formula. The USLE formula equation that will be used is as follows:
   A = R.K.LS.C.P
   Where:
   A = Annual average actual erosion rate (tonnes/ha/year)
   R = Rainfall erosion power index (rain erosivity) 12
   K = Soil sensitivity index to erosion (soil erodibility)
   LS = Factor length (L) and steepness (S) of the slope
   C = Plant factor (vegetation)
   P = Factors of erosion prevention efforts
3. The spatial model of erosion hazard in the Tembesi watershed, Sarolangun district, the spatial model of the erosion hazard in the Tembesi watershed is a semi-detailed scale, built by analyzing rainfall data, slope slope and vegetation density/land cover factors. The results of land identification are analyzing maps using ArcGIS 10.4 which will show that the erosion hazard in the Tembesi watershed, Sarolangun Regency, Jambi Province is classified as light, very light, medium, heavy or very heavy.

C. Findings and Discussion

1. Findings

1) Erosion characteristics of the Tembesi watershed, Sarolangun Regency, Jambi Province can be seen in table 1 below:

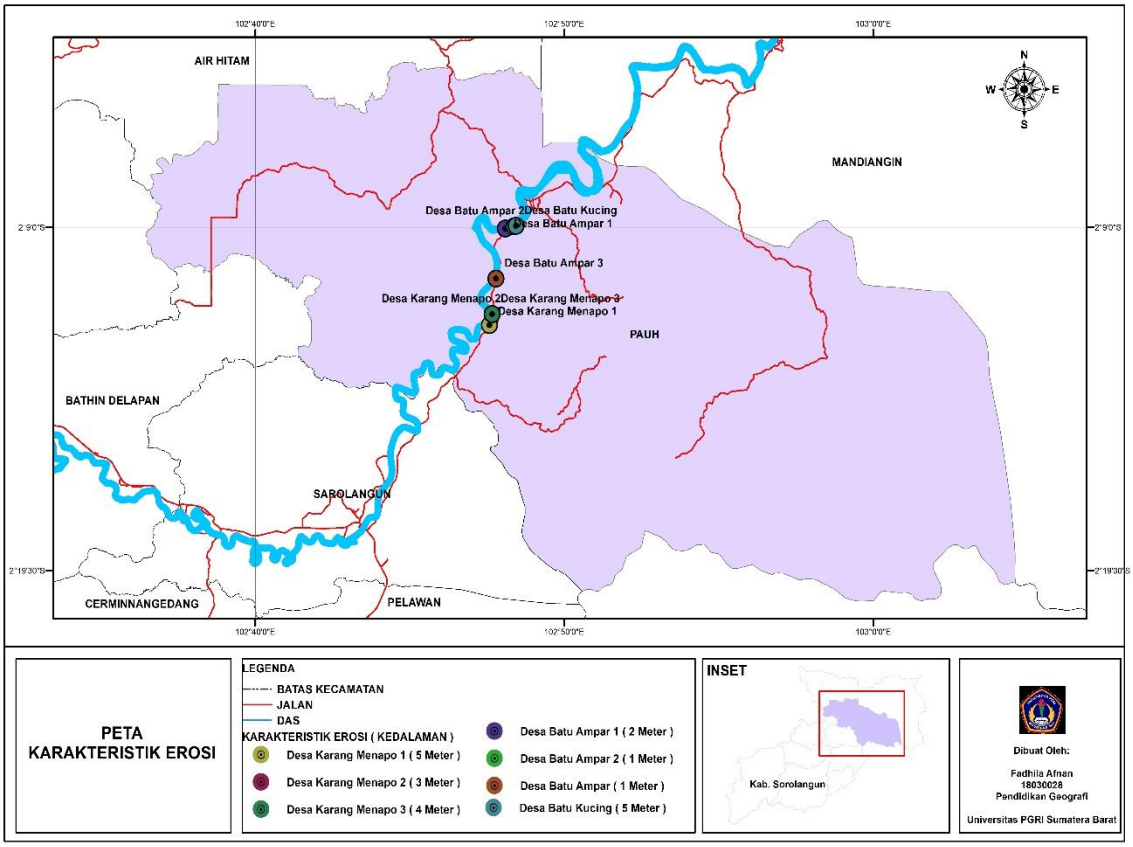
Table 1 Erosion Characteristics in the Tembesi Watershed

No	Research Location /Coordinate point	Region Name	Land Use	Erosion Form	Erosion Characteristics	Header Density	Slope
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	Meadow	Riverbank Erosion	The depth of river bank erosion at this location is 5 meters	Currently	4%
2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	Little Forest	Riverbank Erosion	The depth of river bank erosion at this location is 3 meters	close	15%
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	Little Forest	Riverbank Erosion	The depth of river bank erosion at this location is 4 meters	Close	5%

4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	Little Forest	Riverbank Erosion	The depth of river bank erosion at this location is 2 meters	Close	9%
5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	Forest Area	Riverbank Erosion	The depth of river bank erosion at this location is 1 meter	Close	4%
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	Agriculture	Riverbank Erosion	The depth of river bank erosion at this location is 1 meter	Seldom	8%
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	Settlement	Riverbank Erosion	The depth of river bank erosion at this location is 5 meters	Currently	3%

Source: Field Observation Results

The map of the erosion characteristics in the Tembesi watershed, Sarolangun Regency, Jambi Province can be seen below:



Picture 1 Erosion Characteristic Map

2) Erosion Hazard Level of Tembesi Watershed, Sarolangun Regency, Jambi Province. To determine the amount of soil loss or erosion of the Tembesi watershed in this study using the general soil loss equation Universal Soil Loss Equation (USLE). Where the USLE model looks at several factors in erosion studies such as rain erosivity factors, soil erodibility factors, slope length and slope factors, land cover factors and soil conservation (Arsyad, 2010).

1. Factors that affect the level of erosion hazard
   a. Determining the Value of Rain Erosivity Factor (R), To calculate E130, rainfall data is needed from the relevant agencies, namely BMKG Jambi Climatology Station. The value of rain erosivity is processed using the formula E130 -8.79 + (7.01×R), to determine the value of rain erosivity (R) is as follows:
   E130 $_{=}$ -8,79 + (7,01×R)
   R = Average monthly rain (cm)
   Given: R = 303.41 mm/month = 30.34 cm/month
   E13 = -8,79 + (7,01×30,34)
   =-8,79 + 212,68
   =203,89 cm
   =2.038,9 mm
   So, the value of rain erosivity in the study area in the year the erosion occurred and caused land damage in 2021 was 203.89 cm/month.
   b. Determining the Value of Soil Erodibility Factor (K), There are two types of soil at the research site, namely latosol yellowish brown with a value of 0.36 and regosol with a value of 0.40, which was obtained based on field observations on June 13, 2022 – June 18, 2022. Soil erodibility factors can be seen in table 2 below. :

Table 2 Soil Erodibility Factor Value

No	Research Location/Coordinate point	Region Name	Type of soil	K . value
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	Latosol Yellowish Brown	0,36

2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	Latosol Yellowish Brown	0,36
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	Latosol Yellowish Brown	0,36
4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	Latosol Yellowish Brown	0,36
5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	Regosol	0,40
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	Regosol	0,40
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	Latosol Yellowish Brown	0,36

Source: Field Observation Results

c. Determining the LS . Factor Value, Observations in the research area are generally relatively flat and sloping areas. The areas that are most prone to erosion are relatively sloping areas with wild grass land cover with small trees. For more details, it can be seen in this table which is the result of observations in the field. The value of the LS factor can be seen in table 3 below:

Table 3 LS Factor Value

No	Research Location/Coordinate point	Region Name	Slope (%)	Classification	LS value
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	6	Flat	0,40
2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	3	Flat	0,40
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	2	Flat	0,40
4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	3	Flat	0,40
5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	4	Flat	0,40
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	5	Flat	0,40
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	10	Sloping	1,40

Source: Field Observation Results

d. Determining the CP Factor Value, The factor value is determined based on land use and land management at each point of the research location in the Tembesi watershed, Sarolangun Regency, Jambi Province. The value of the CP factor can be seen in table 4 below:

Table 4 CP Factor Value

No	Research Location/Coordinate point	Region Name	Land Cover	CP value
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	Grazing (partial ground cover, overgrown with weeds)	0,02
2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	Forest (undisturbed)	0,1
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	Forest (undisturbed)	0,01
4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	Forest (undisturbed)	0,01
5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	Garden (talun garden)	0,02
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	Shrub (some grassy)	0,1
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	Garden (yard garden)	0,2

Source: Field Observation Results

2. Erosion Hazard Level

From the above factors, the erosion rate will be analyzed and calculated at each research location point in the Tembesi Watershed, Sarolangun Regency, Jambi Province in 2021 using the USLE method. The calculation of the erosion rate value of the research site uses the formula:

$A = R \times K \times LS \times CP$

Table 5 Results of Eros Rate Values at Research Location Points

No	Research Location/Coordinate point	Region Name	R value	K . value	LS value	CP value	A value
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	2.038,9	0,36	0,40	0,02	5,87
2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	2.038,9	0,36	0,40	0,1	29,36
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	2.038,9	0,36	0,40	0,01	2,94
4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	2.038,9	0,36	0,40	0,01	2,94

5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	2.038,9	0,40	0,40	0,02	5,87
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	2.038,9	0,40	0,40	0,1	29,36
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	2.038,9	0,36	1,40	0,2	205,52

Source: Calculation Results From Field Observations

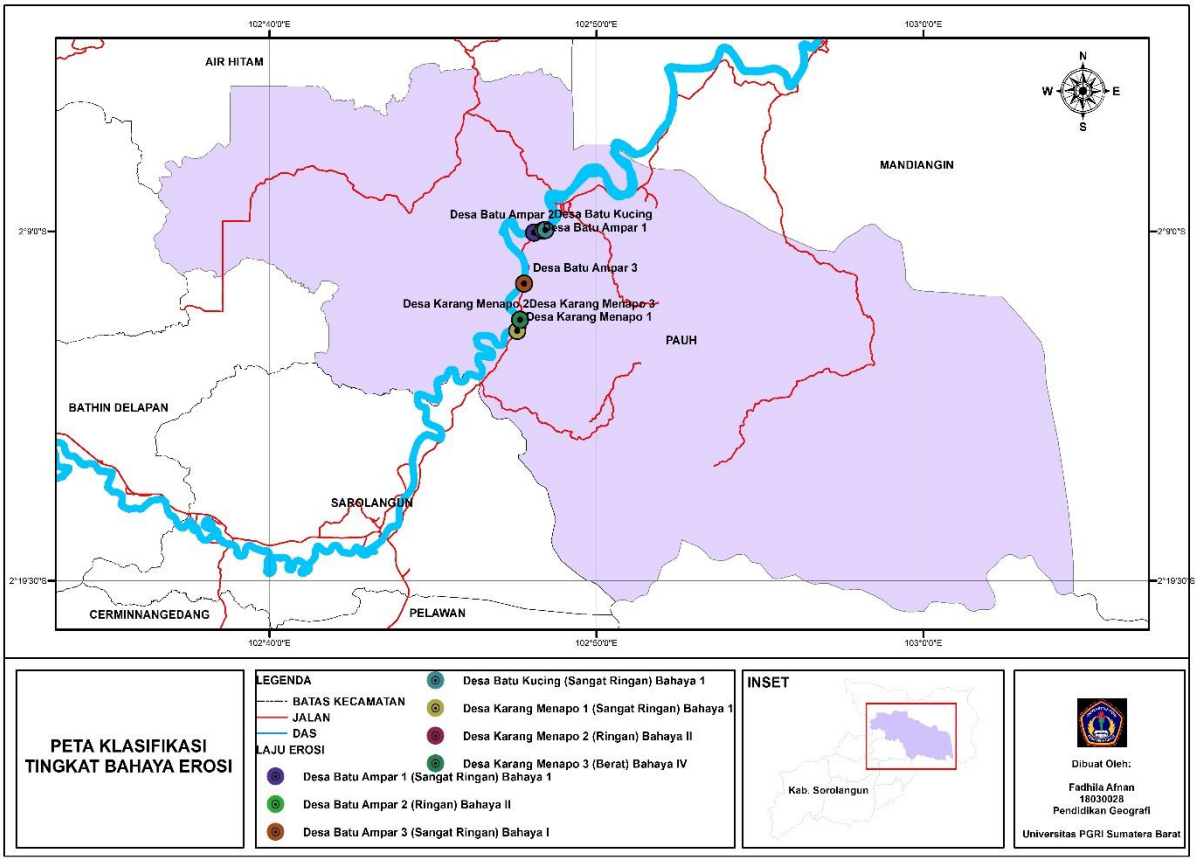
Then it can be seen in table 6 below, the classification of erosion hazard in the Tembesi watershed, Sarolangun Regency, Jambi Province.

Table 6 Classification of Erosion Hazard Levels at Research Site Points

No	Research Location/Coordinate point	Region Name	Erosion Hazard Class	Erosion Rate, A (tonnes/ha/year)	Information
1	2°11'59.2"S 102°47'34.9"E	Mendapo Karang Village	I	5,87	Very Light
2	2°11'39.0"S 102°47'40.2"E	Mendapo Karang Village	II	29,36	Light
3	2°11'42.0"S 102°47'40.2"E	Mendapo Karang Village	I	2,94	Very Light
4	2°09'02.0"S 102°48'05.7"E	Batu Ampar Village	I	2,94	Very Light
5	2°08'58.0"S 102°48'22.6"E	Batu Ampar Village	I	5,87	Very Light
6	2°08'57.0"S 102°48'26.7"E	Batu Ampar Village	II	29,36	Light
7	2°10'34.0"S 102°47'47.5"E	Batu Kucing Village	IV	205,52	Heavy

Source: Calculation Results from Field Observations

3) Spatial Model of Erosion Hazards in the Tembesi Watershed, Sarolangun Regency, Jambi Province. The spatial model of erosion hazard in this study uses ArcGIS 10.4, to see the classification of erosion hazard at the research location points that have been calculated previously through field observations. It can be seen on the map below:



Picture 2 Erosion Hazard Classification Map

2. Discussion

First, the characteristics of the erosion hazard at the research site in the Tembesi watershed, Sarolangun Regency, Jambi province, have several characteristics with a width of 3.3 meters to 12.4 meters, a length of 4.2 to 6.5 meters and various erosion depths, starting from depth of 1 meter to 5 meters. According to Arsyad (2012), the meaning of erosion is the process of losing or eroding part of the soil from one place that is transported by water or wind to another place.

Second, the magnitude of the Erosion Hazard Level at the research location points in the Tembesi Watershed, Sarolangun Regency, has erosion hazard classes I, II, and IV. With an erosion rate of 2.94 tons/ha/year up to 205.52 tons/ha/year. With slopes ranging from 6-10% at the research location points in the Tembesi watershed, Sarolangun Regency, Jambi Province, the land uses are Perumutan (partial soil cover, overgrown with weeds), Forest (undisturbed), Shrub (undisturbed), Shrub (partially covered with grass), Forest (undisturbed), Shrub (undisturbed), Bush grass), and Kebun (yard garden). The method used in calculating the classification of the erosion hazard level in the Tembesi watershed, Sarolangun Regency is using the USLE method (A = R.K.LS.C.P) (Arsyad, 2010).

Third, the spatial model of the erosion hazard level at the research location points in the Tembesi watershed, Sarolangun Regency, Jambi Province using ArcGIS 10.4. Then the results of the identification of the level of erosion hazard can be seen in the form of a map to make it easier to find out the location of the occurrence of erosion in the Tembesi watershed, Sarolangun Regency, Jambi Province. Based on the notion of spatial model, in general, spatial modelling is an activity which makes a spatial model of a phenomenon. In Longley's book, spatial modelling can be done using Geographic Information Systems (GIS), either analogously or digitally. Geographic Information System is a computer-based system that is used to store and manipulate geographic information. GIS 19 is designed to collect, store, and analyze objects and phenomena in which geographic areas are important or critical characteristics to be analyzed (Juita et al., 2020).

D. Conclusion

Based on the results of research and discussion, it can be concluded:

1. Erosion Characteristics at the research location points in the Tembesi watershed, Sarolangun Regency, Jambi Province, of the seven research locations, the erosion characteristics had the widest erosion of 12.4 meters and the narrowest 3.3 meters, also

the longest erosion of 6.5 meters and the shortest 4.2 meters, and has the deepest erosion of 5 meters and the shallowest of 1 meter.

2. The level of erosion hazard at the research location points in the Tembesi watershed, Sarolangun Regency, Jambi Province, from the seven research location points, it was found that the erosion hazard class I to IV, with the lowest rate of 2.94 tons/ha/year and the fastest 205 tons/ha/year with descriptions from very light to heavy.
3. The spatial model used to analyze in this research is to use ArcGIS 10.4.

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