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MORPHOMETRIC ANALYSIS OF MARY'S RIVER BASIN USING DIGITAL ELEVATION MODELS (DEMs)

By

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Contents

Abstract

Morphometric analysis is an important tool for understanding the geomorphology and hydrology of landscapes. It involves the measurement and analysis of various properties of landforms and drainage systems, including stream networks, watersheds, and terrain characteristics. These properties can be used to better understand the dynamics of water flow, erosion, and sediment transport in a given landscape, and can inform decisions about land use, resource management, and environmental conservation. Morphometric analysis has applications in a variety of fields, including hydrology, geomorphology, ecology, and engineering. This abstract provides a brief overview of the importance and applications of morphometric analysis, highlighting its potential to improve our understanding of natural systems and inform sustainable land management practices. The USGS Digital Elevation Model (DEM) at 30m resolution has been used to delineate the basin and drainage network in the ArcGIS Pro software with the help of spatial analyst tools.

After carrying out the morphometric analysis of Mary's River, the drainage density of the river is 0.104 km/km2 and the average drainage density is 0.052 km/km2. The elongation ratio of the Mary's River is 0.64 which shows the Mary's River basin is elongated in shape with moderate relief. Mary's River has a stream order of nine (9) and the total number of streams is 325479. The total length in km is 40.818 km. The range of the bifurcation ratio for each stream order was calculated and the mean bifurcation ratio is 1.906. The higher the value of the bifurcation ratio, the higher the flood risk. From this analysis, it was proved that morphometric analysis is a competent analysis tool for analyzing hydrological studies and water properties. From these results, we have high stream frequency of 830.798 and form factor 0.328 which is low, this suggest that the landscape is highly dissected with many small streams, which could lead to flash floods and erosion. The resulting value for drainage texture indicates the degree of stream channel development in the watershed, with higher values indicating a denser network of streams.

Keywords: morphometric analysis, DEM, watershed, drainage basin and hydrologic terrain analysis.

Introduction

Morphometric analysis plays a significant role in understanding the geohydrological characteristics of a drainage in relation to the terrain features, soil physical properties, land processes and erosional features. Morphometric analysis is a quantitative description and mathematical analysis of the landforms that are applied to a drainage basin. (Clarke 1996; Agarwal 1998; Obi Reddy et al. 2002). Morphometric study of a basin provides valuable information about the drainage characteristics of a basin. We can also estimate the incidence of infiltration and runoff, hydrological character of a watershed like erosion and sediment transport that has a strong implication for natural resource conservation.

The morphometric analysis of the basin is achieved through linear computation, aerial relief and gradient of channel network and ground slope basin. DEMs (Digital Elevation Models) are the essential models used for in analyzing the watershed, landforms and drainage basin. The availability of a DEM-based surface hydrological model has provided an appropriate method for watershed and natural resource management. Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). GIS techniques are now a day used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information.

Problem statement and Aim of the Project

The aim of this project is to carry out morphometric analysis of Mary's River which is grouped into linear, areal and relief aspects in ArcGIS Pro. This project could provide a basis for those who want to do research on morphometric analysis of Mary's River. The analysis sought to:

1) Delineate the watershed of Mary's River and the stream gage.
2) To understand the hydrological and morphological characteristics of the region
3) To carry out morphometric analysis to reveal the linear, areal, and relief aspects of Mary's River.

Site description

As seen in figure 1, Mary's River arises in western Benton County at 659 feet (201 m) above sea level and falls 452 feet (138 m) between source and mouth to an elevation of 207 feet (63 m). The main stem, formed by the confluence of the East Fork Mary's River and the West Fork Mary's River, begins at about river mile 40 (RM 40) or river kilometer 64 (RK 64) north of Mary's Peak in the Central Oregon Coast Range. The West Fork Mary's River, which is 6 miles (9.7 km) long, rises at 44.733333°N 123.570833°W and flows south to join the East Fork.[3] The East Fork, which is 5 miles (8.0 km) long, rises at 44.7°N 123.5152778°W and flows southwest to join the West Fork.[10] Mary's Peak rises to 4,022 feet (1,226 m) above sea level at 44.5042870°N 123.5512165°W. Figure 1 shows the location of Mary's River and figure 2 shows the gage height in feet.

Study Area

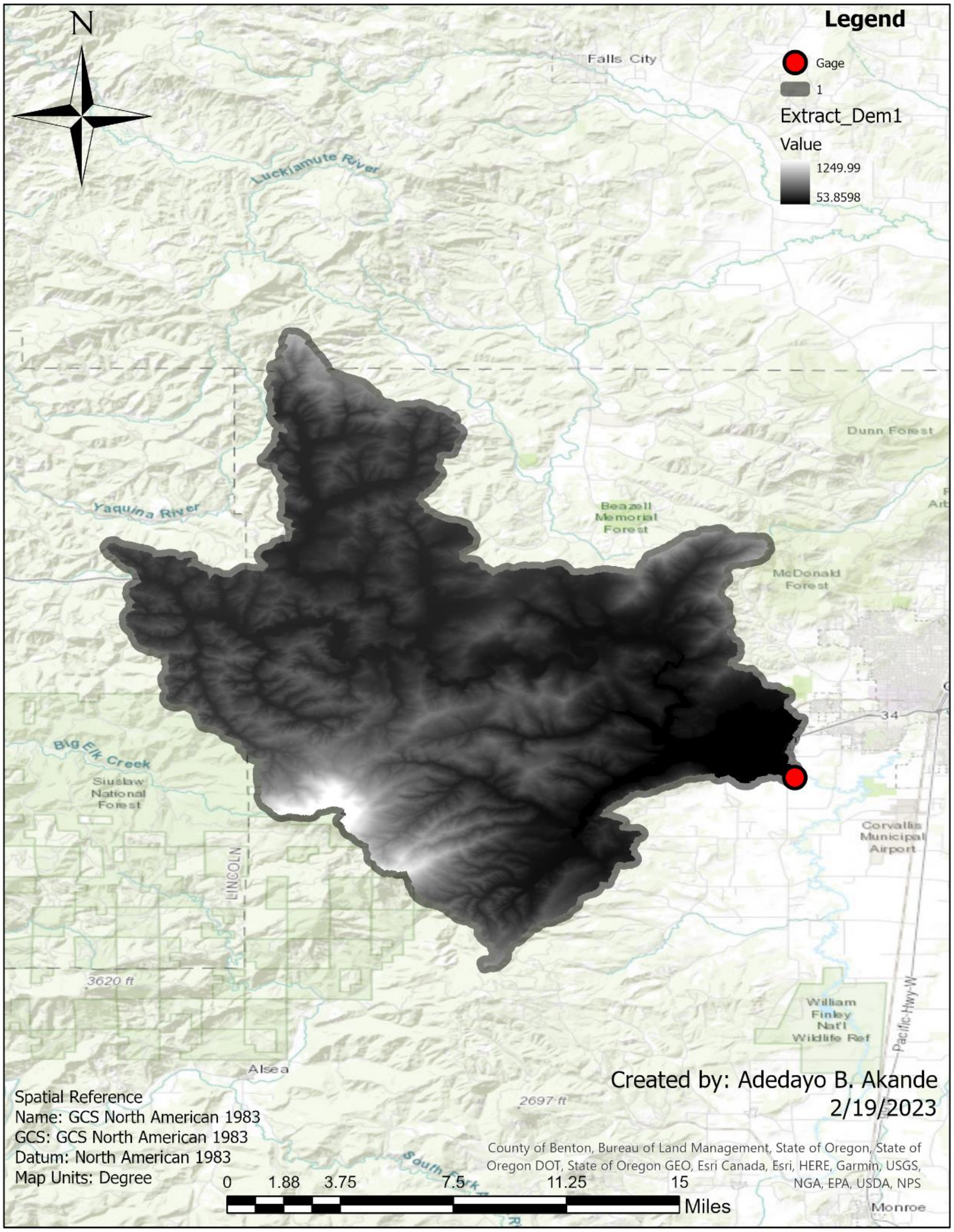


Figure 1: Mary’s River location.

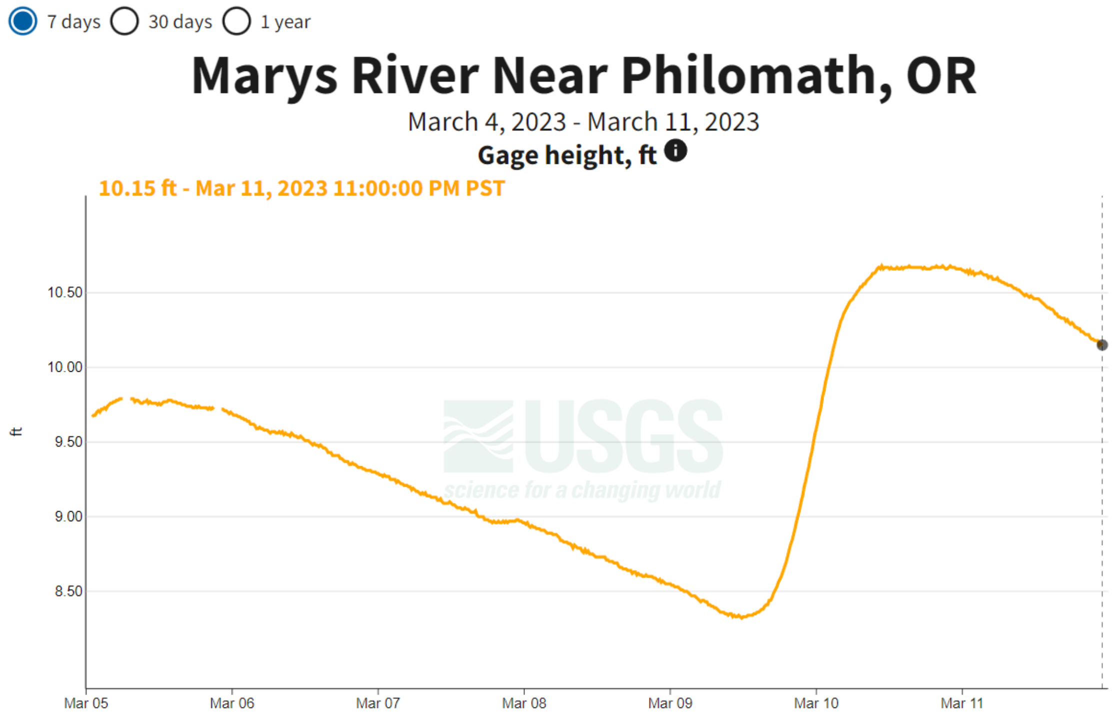


Figure 2: The gage height in feet.

Data sources

From the USGS website I have downloaded two DEM datasets a raster data with a spatial resolution of 30m for the purpose of this project namely: USGS_13_n45w124_20220426.tif and USGS_13_n45w123_20220426.tif. The coordinate and other properties of the river were gotten from National hydrological Dataset (NHD). The coordinates were used to calculate the LongDD and LatDD for the stream gage (see figure 3). The DEM datasets and NHDPlus dataset required for ArcGIS Pro have been downloaded from the site named (TNM Download V2), which is also USGS linked. Figure 4 shows the USGS website and figure 5 shows the downloaded DEM. The coordinate system use for this project is **NAD 1983 UTM Zone 10N.**

SITEID	Lat	Long	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD
MARYS Riv	44 ˚ 31' 30	123 ˚ 20' 0	44	31	30	123	20	2.4	44.525	-123.334

Figure 3: Figure showing the coordinate of Mary's River.

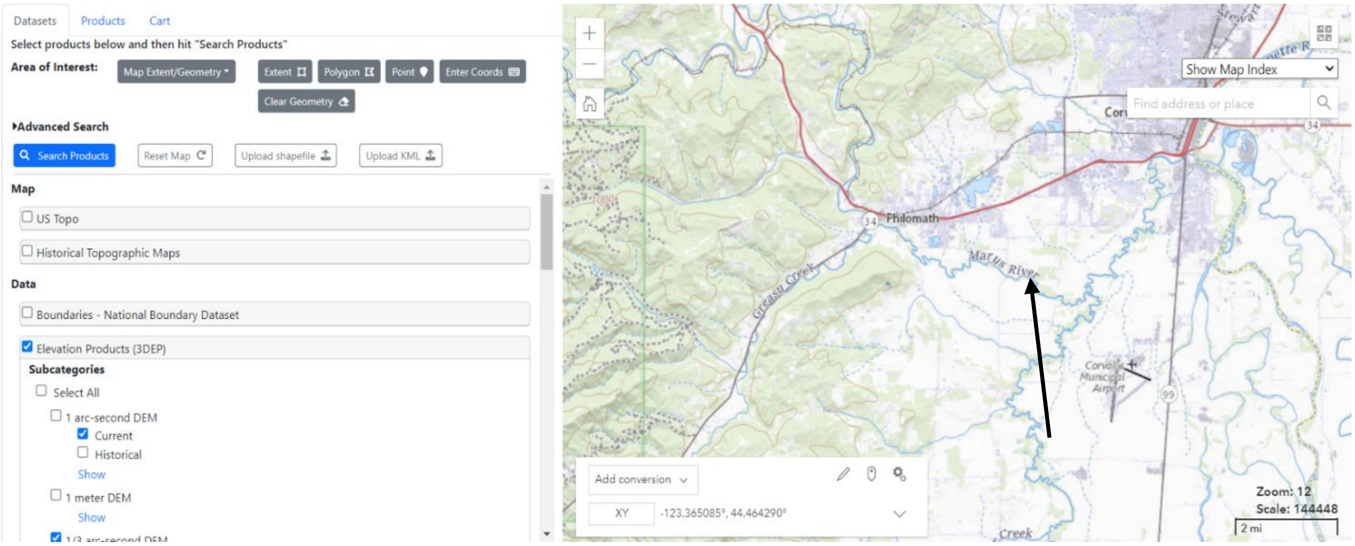


Figure 4: DEM and NHD Plus Data from USGS website.

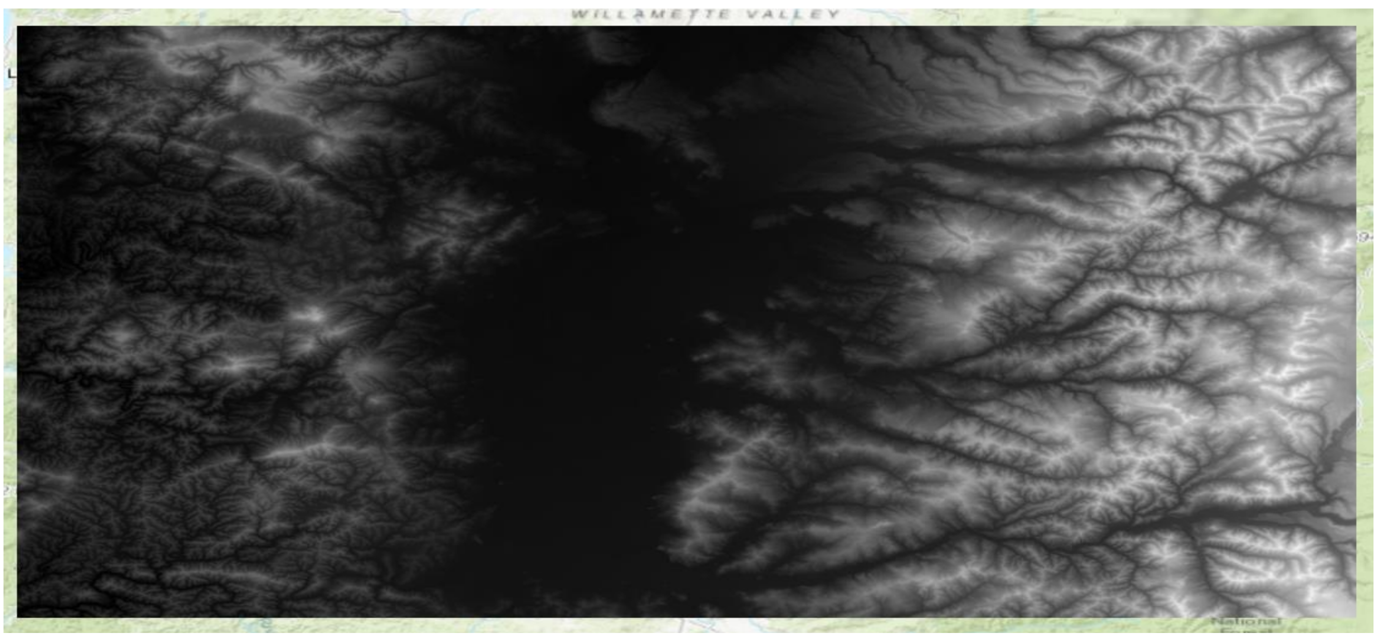


Figure 5: Digital Elevation Model (DEM) downloaded from USGS website.

GIS methods

Hydrologic Terrain Analysis and Morphometric analysis

Data Collection:

The first step in conducting hydrologic terrain analysis and morphometric analysis is collection of data, including digital elevation models (DEMs). Two DEMs with a spatial resolution of 30m were downloaded and the watershed was delineated (see figure 7).

DEM Pre-processing:

Once the data was collected, the DEMs were pre-processed to remove any artifacts or errors. This may involve filtering, smoothing to create a continuous surface. The two datasets were merged together using geoprocessing tool. The raster data was converted to vector data.

Hydrologic terrain analysis:

The merged DEM was used to model the flow of water through the river basin. This includes calculating the flow direction, flow accumulation, drainage area, fill, stream definition, stream links, catchments, CatchPoly and other relevant parameters.

Morphometric analysis:

The morphometric analysis involves calculating various parameters that describe the shape and size of the drainage basin. This includes calculating the basin area, perimeter, length, form factor, and other relevant parameters. This comprises of linear, Aerial and Relief analysis.

Stream Network:

Stream network analysis was carried out to identify the stream channels and to estimate their characteristics, such as length, slope, and drainage area. This information is used to model the flow of water through the stream channels and to predict flood events.

Interpretation of results:

The results of the analysis will be interpreted so as to understand the behavior of the water. The results can be used for decision making and strategies for water analysis and properties. Figure 6 shows the flowchart of hydrologic terrain analysis.

Flowchart for Hydrologic Terrain analysis

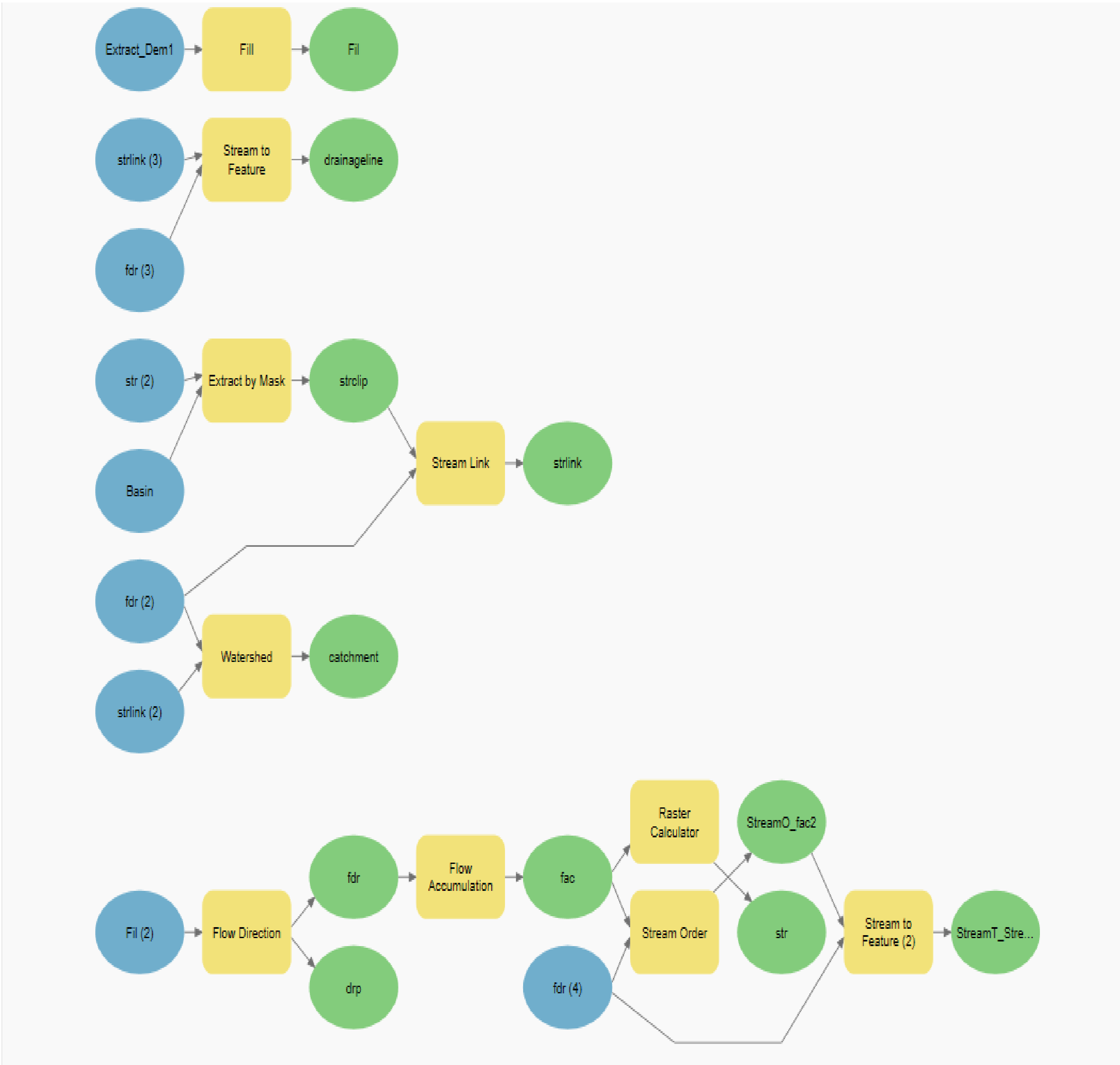


Figure 6: figure showing the flowchart of major processing steps.

Watershed Delineation of MARYS River Near philomath, OR.

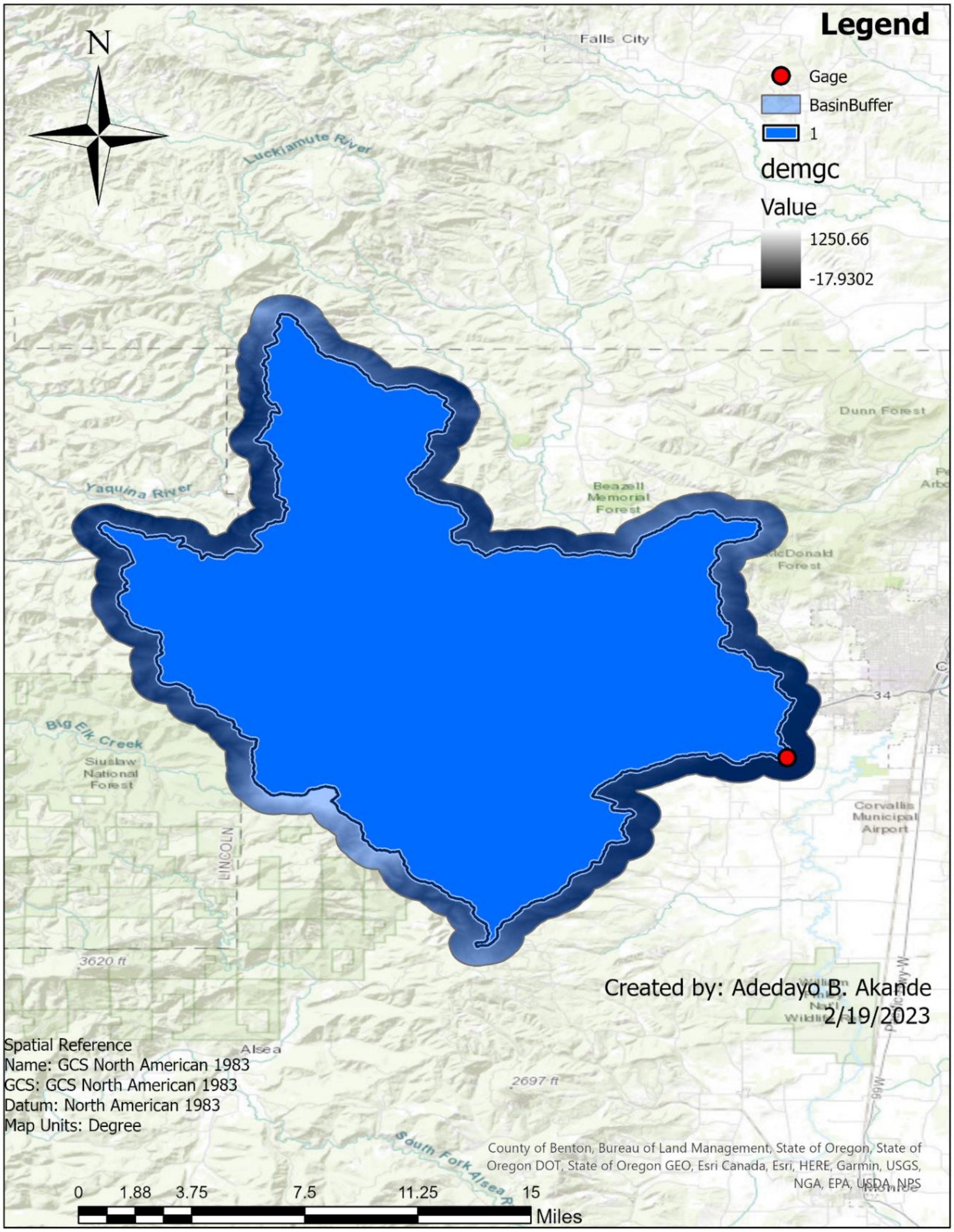


Figure 7: figure showing the watershed delineation of Mary's River.

Hydrologic Terrain Analysis

Hydrologic terrain analysis is a method of analyzing the topography of a terrain to understand how water moves through it. The process involves the use of digital elevation models (DEMs) to derive various terrain attributes that are essential for hydrological modelling. Some of the key terrain attributes derived in hydrologic terrain analysis include fill, flow direction, catchment, and flow accumulation.

The resulting flow accumulation raster then allows you to identify the contributing area at each grid cell in the domain, a very useful quantity fundamental to much hydrologic analysis. Next an outlet point was used to define a watershed as all points upstream of the outlet. The watershed streams were defined using a flow accumulation threshold within this watershed. Hydrology functions were used to define separate links (stream segments) and the catchments that drain to them. Next the streams were converted into a vector representation and more Hydrology toolbox functionality used to evaluate stream order and the subwatersheds draining directly to each of the eight stream gauges. The result is quite a comprehensive set of information about the hydrology of the watershed, all derived from the DEM.

<u>Fill</u>: The fill operation in hydrologic terrain analysis involves filling up any depressions or sinks in the DEM that might impede the flow of water. The depressions or sinks are usually filled with water until the lowest point of the depression overflows, creating a continuous flow of water across the terrain. This function fills the sinks in a grid. If cells with higher elevation surround a cell, the water is trapped in that cell and cannot flow. The Fill function modifies the elevation value to eliminate these problems. The Spatial Analyst Tools ⟹ Hydrology ⟹ Fill was used together with the DEM as the input and output surface raster as **fil.** Upon successful completion of the process, the "fil" layer was added to the map. The impact of Fill was examined on the DEM by Selecting Spatial Analyst Tools ⟹ Map Algebra ⟹ Raster Calculator and evaluate fil - dem. A contour of 2om interval was added to identify the deepest sink in Mary's River (as shown in figure 8).

Deepest sink in MARYS River Near philomath, OR.

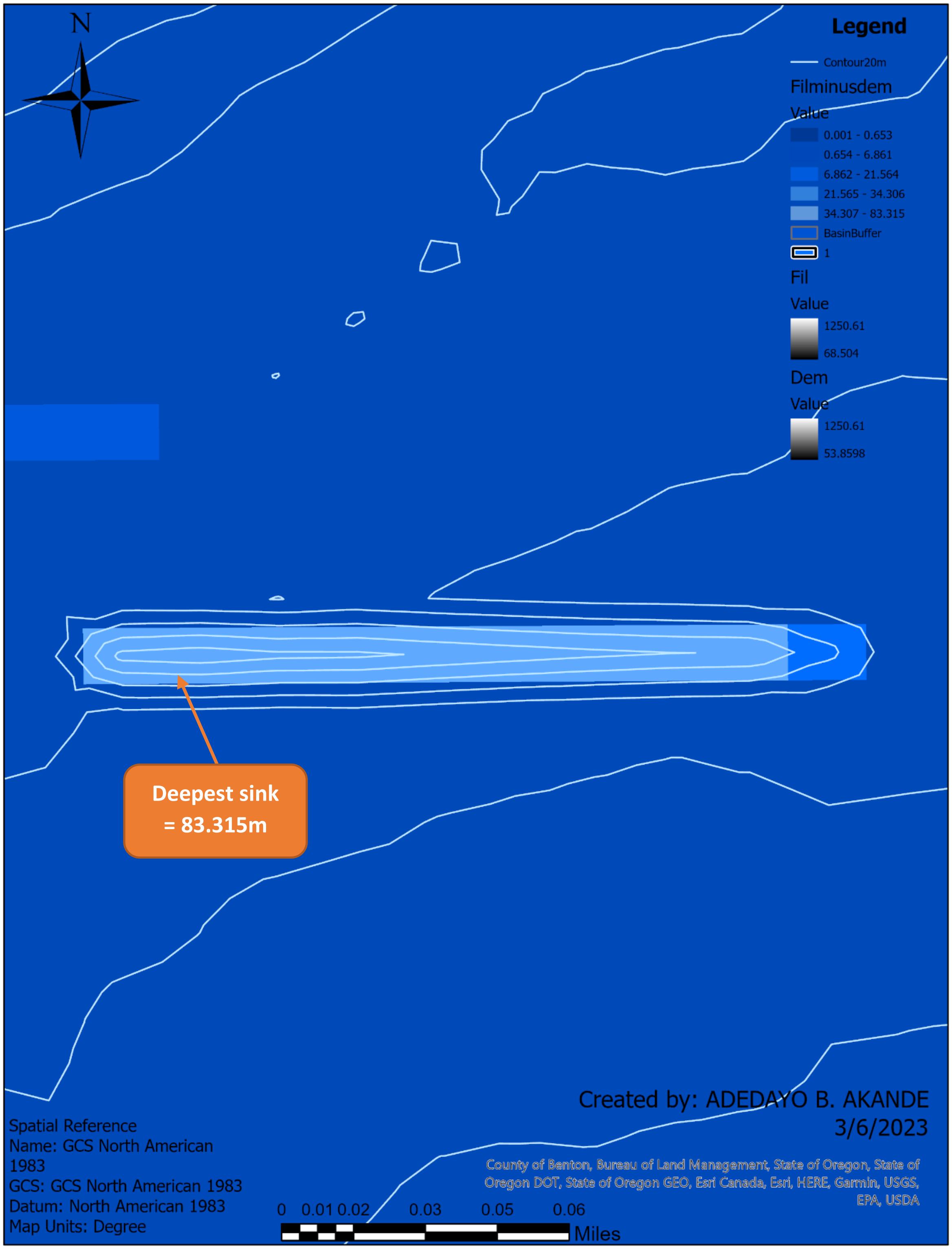
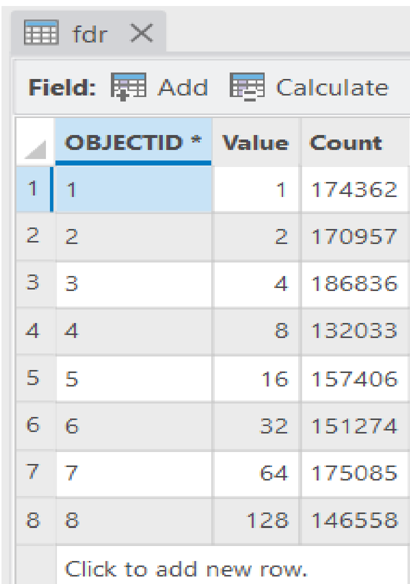


Figure 8: figure showing the deepest sink in Mary's River.

<u>Flow direction</u>: Flow direction analysis in hydrologic terrain analysis involves determining the direction of water flow across the terrain. This is done by identifying the steepest downward slope from each grid cell in the DEM and assigning a flow direction based on the direction of the steepest slope. The Spatial Analyst Tools⟹ Hydrology ⟹Flow Direction was used to compute the flow direction for given grids. The fill was used as input and output as fdr and drp. Figure 9 shows the flow direction value for each cell grid and figure 10 shows the flow direction encoded values. The encoded values explain the direction of flow of water.

The attribute table of Flow of direction



fdr

Field: Add Calculate

	OBJECTID *	Value	Count
1	1	1	174362
2	2	2	170957
3	3	4	186836
4	4	8	132033
5	5	16	157406
6	6	32	151274
7	7	64	175085
8	8	128	146558

Click to add new row.

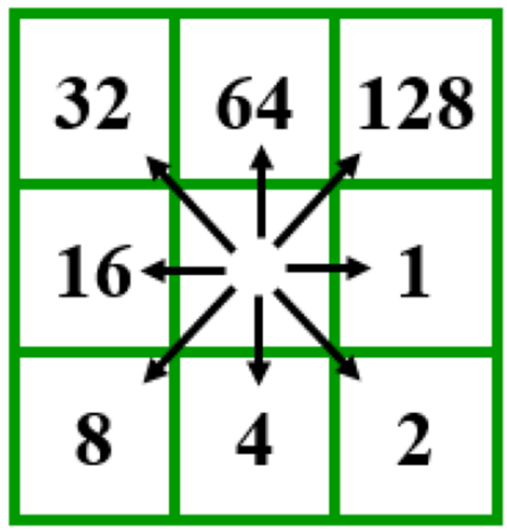


Figure 9: Flow direction of Mary's basin

Figure 10: Flow direction with encoded values

The table to the left shows the attribute table for flow direction and the figure to the right shows the interpretation for the values in the Value field. In the table to the left the objectID with value 1 has 174362 grid cells where the flow of the water moves to the east using the flow direction encoded value. The flow direction for this project is the value 8 (the smallest value) = **132033**

<u>Flow accumulation</u>: Flow accumulation is the sum of all contributing flow that passes through a particular grid cell in the DEM. It represents the total volume of water that would flow through a given point if it were to rain uniformly over the entire terrain. In hydrologic terrain analysis, flow accumulation is used to identify areas of high-water flow and potential flooding. The Spatial Analyst Tools ⟹Hydrology⟹ Flow accumulation was used to computes the flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid. The Integer output type was used because I didn't use a weight raster input and the result is a count (integer) of the number of upstream grid cells that drain into each grid cell.

Stream network: A stream is a type of feature that represents flowing water, such as a river, stream, or creek, within a geographic information system (GIS). The streams were defined based on a flow accumulation threshold within this watershed. The Spatial Analyst Tools⟹Map Algebra⟹ Raster Calculator. Figure 11 shows the stream network.

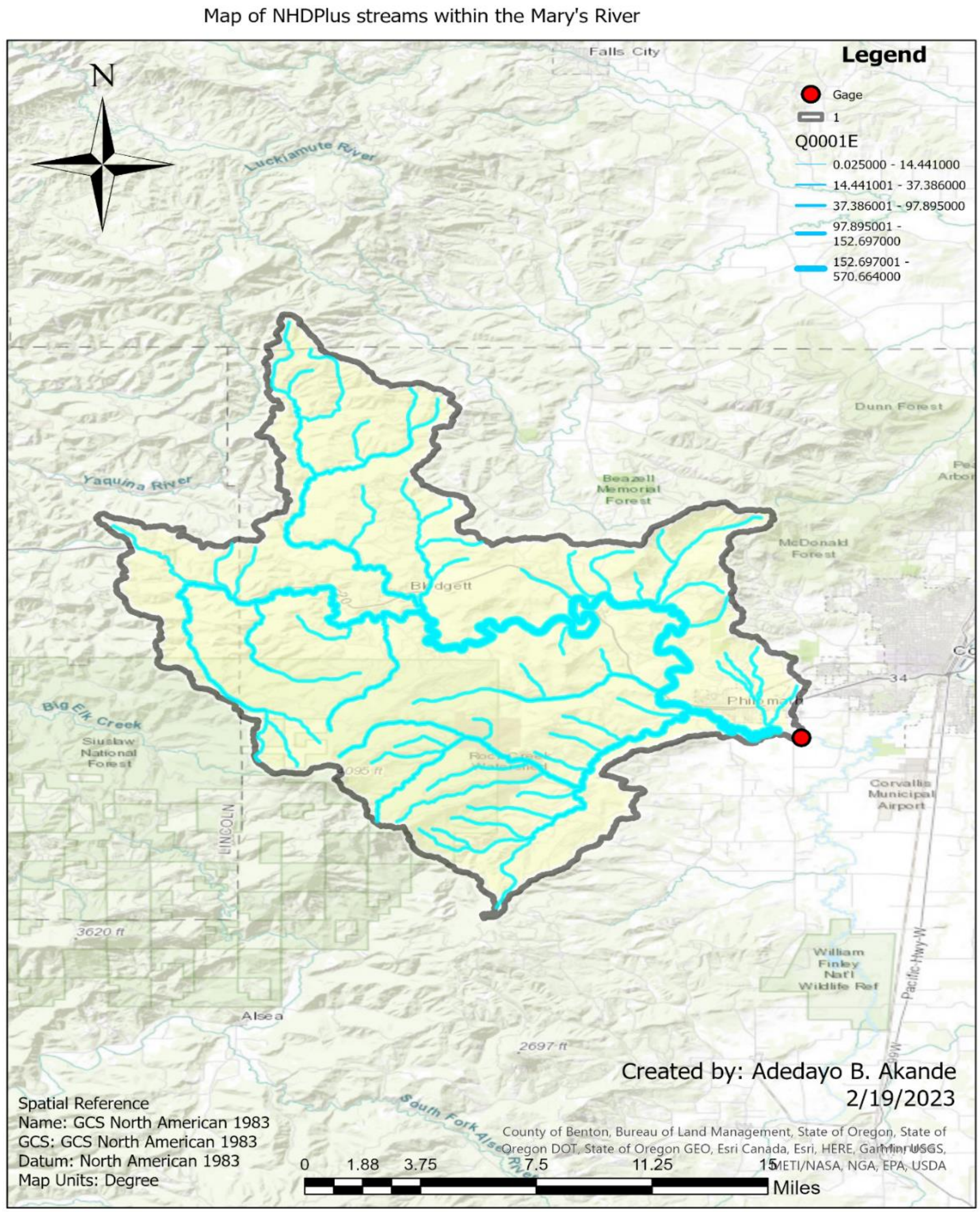


Figure 11: A layout showing the NHDPlus stream network.

Catchment: Catchment is the area of land that drains into a particular watercourse, such as a river or stream. In hydrologic terrain analysis, catchment is determined by tracing the path of water flow from each grid cell in the DEM upstream until the watercourse is reached. The Watershed function provides the capability to delineate catchments upstream of discrete links in the stream network. The result is a catchment grid where the grid cells in the area draining directly to each link are assigned a unique value the same as the link it drains to. This allows a relational association between lines in the strlink grid and areas in the catchment grid. Figure 12 shows the stream network and catchments of Mary's River. Figure 13 shows the hillshade map.

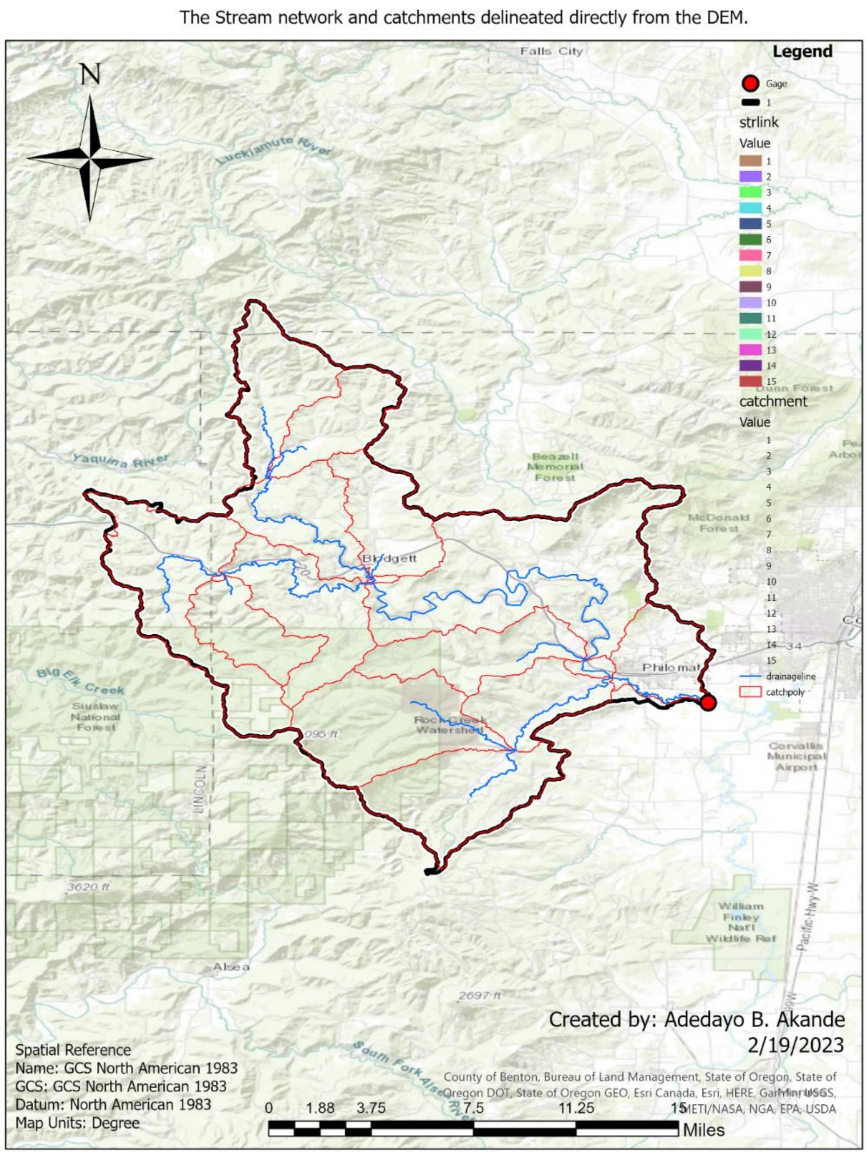


Figure 12: A layout showing the stream network and catchments in Mary's River.

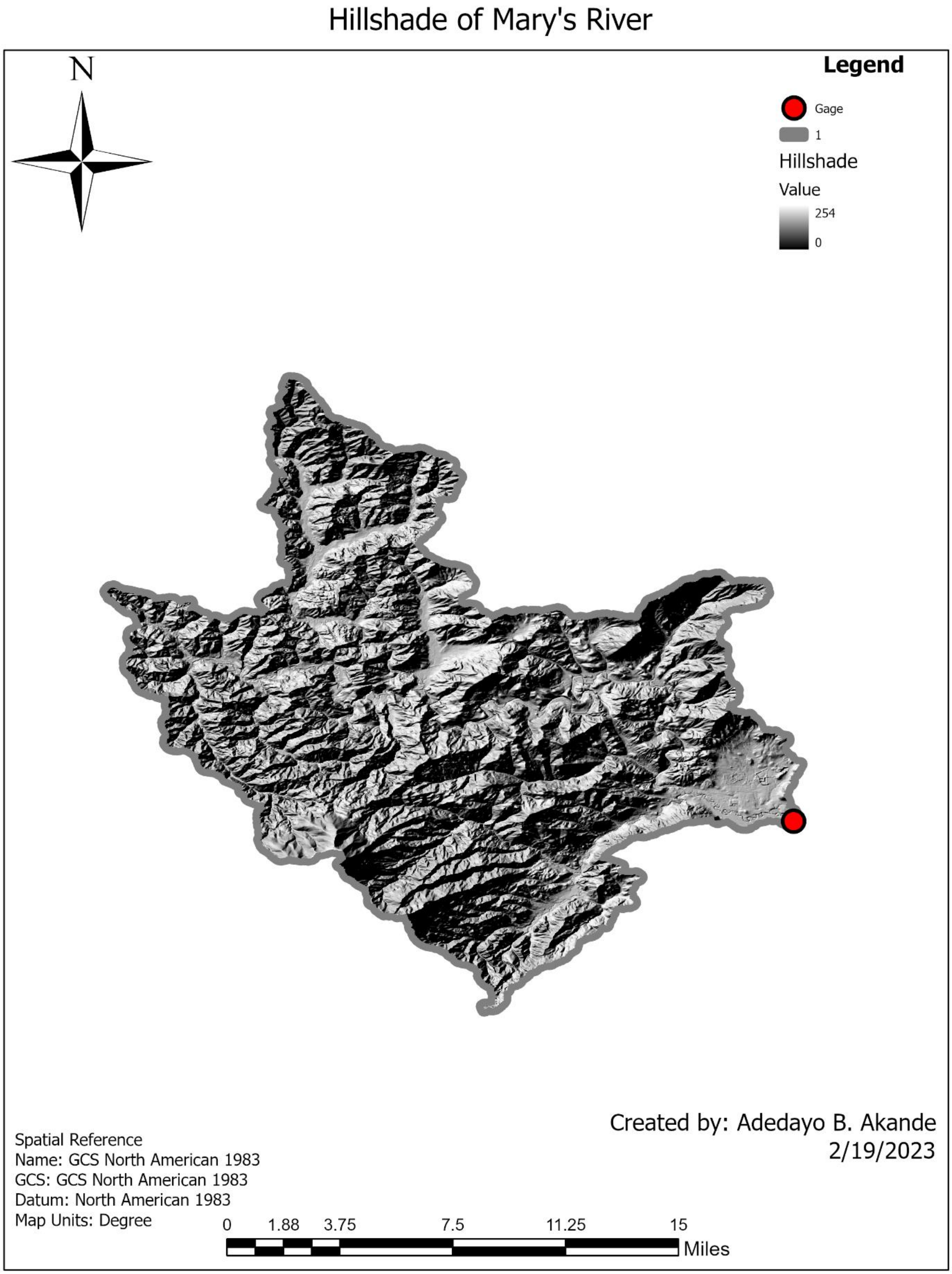


Figure 13: Hillshade map of Mary’s River.

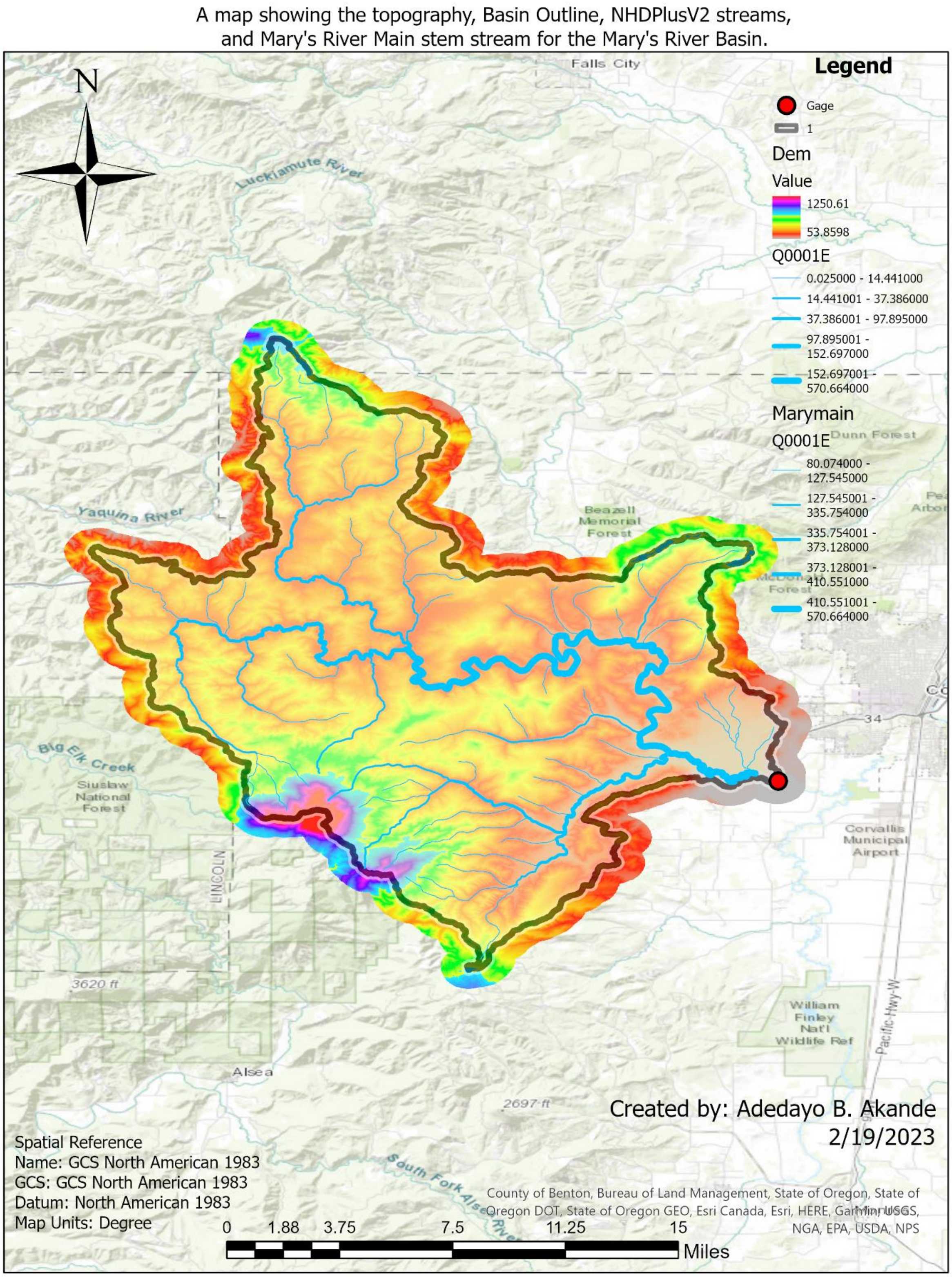


Figure 14: Topography map of Mary's River

Stream Order: Stream order is a way to classify and describe the hierarchy of streams and rivers within a watershed based on their relative position and size. The concept of stream order was developed by Robert Horton in the 1940s and has since become an important tool in hydrology, ecology, and geomorphology. A numerical value was assigned to each segment of the stream with the first-order streams having a value of 1 and the highest-order streams having the highest value as shown in figure 16. Streams of the same order are those that are formed by the confluence of two or more streams of the next lower order. Stream order is important because it provides a way to describe the structure and function of river networks, as well as the movement of water, sediment, and nutrients within a watershed. It can also be used to identify areas of a watershed that are more vulnerable to pollution or other disturbances. Figure 17 shows the Layout of the basin outline, stream links and stream orders of Mary's River.

The Mary's River has a stream order of nine (9) as shown in figure 15.

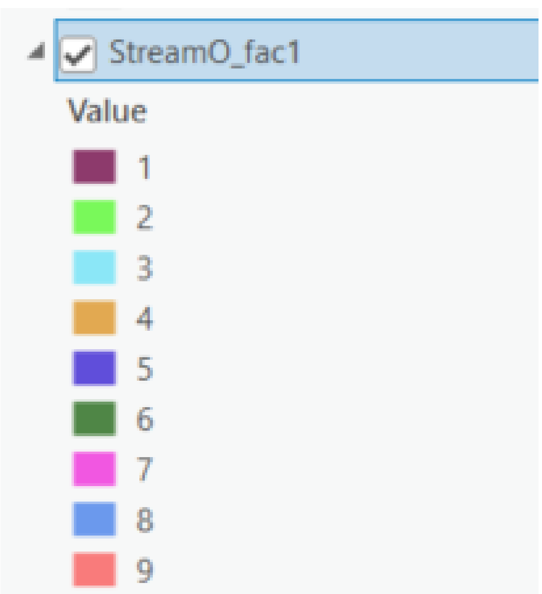


Figure 15: figure showing the stream order from order highest to lowest

StreamO_fac1

Field: Add Calculate

	OBJECTID *	Value	Count
1	1	1	467067
2	2	2	125102
3	3	3	55421
4	4	4	22628
5	5	5	10454
6	6	6	5159
7	7	7	2995
8	8	8	1778
9	9	9	1726
	Click to add new row.		

Figure 16: figure showing the stream attribute table.

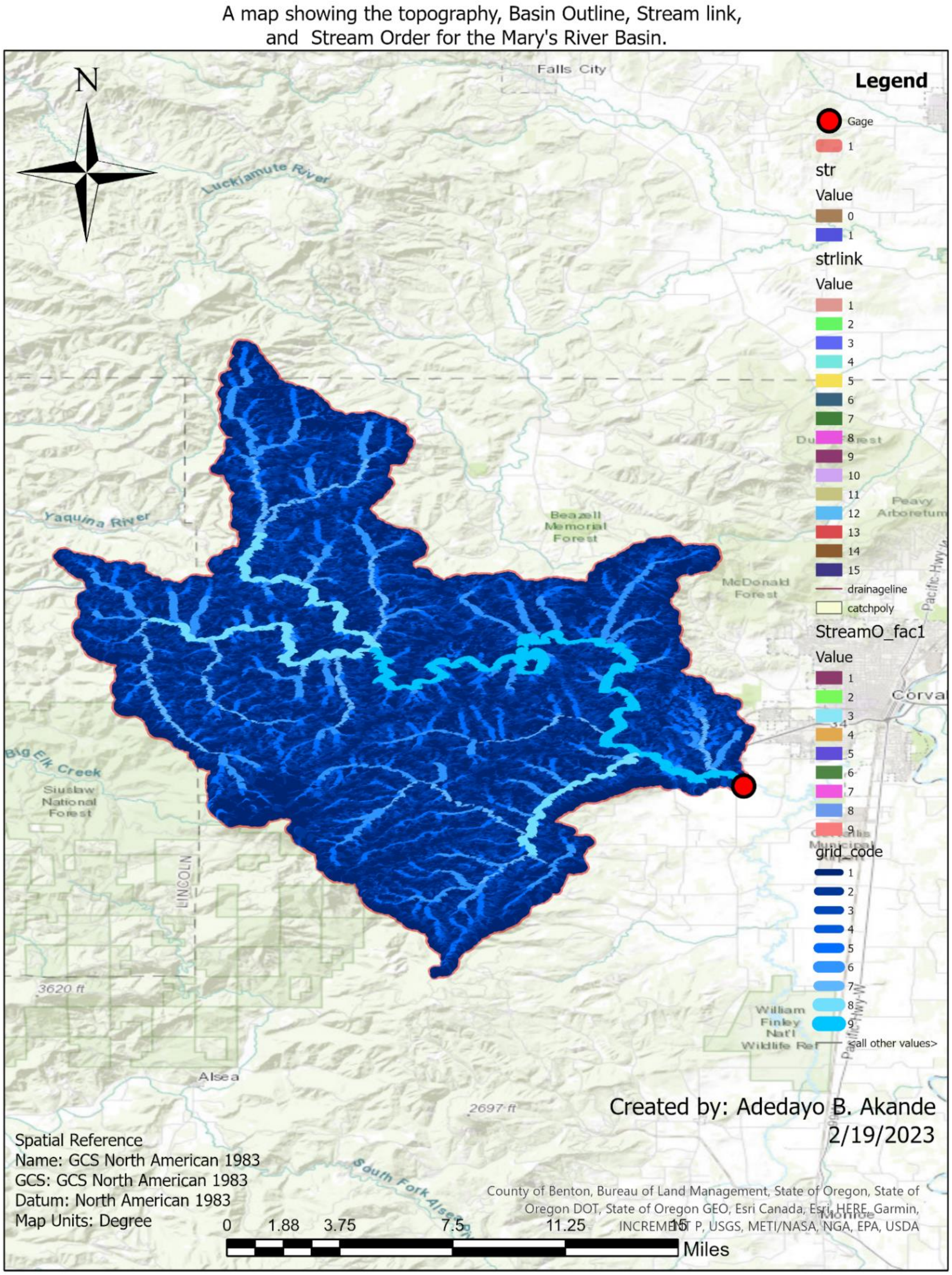


Figure 17: Layout showing the basin outline, stream links and stream orders of Mary’s River.

Morphometric Analysis

Parameters for computation for morphometric analysis. Table 1 shows the morphometric analysis and their formulas.

1. Stream order (Su)

Stream order is one of the primary steps in drainage basin analysis. It is important to designate order as the number of streams decreases with increase in stream order. Two principal stream order schemes are in use today. The Strahler Order system designates 1st order streams as those that lack a tributary. The second order streams are formed at the junction of 1st order streams. Third order streams are formed at the junction of 2nd order streams, fourth at the junction of 3rd order streams, and so on. Stream order increases when two streams of the same order join. Therefore, where a 2nd order stream joins a 3rd stream there is no change in stream order; the 3rd order stream remains 3rd order. Streams are categorized according to their position, order or magnitude within a drainage network. Stream order is used to describe a stream and to divide a stream network into component parts that may be quantified and compared.

2. Stream number (Nu)

Stream order describes the count of stream channel in a given order. According to Horton's law states that "the number of streams of different orders in a given basin tends closely to approximate as inverse geometric series of which the first term is unity and the ratio is the bifurcation ratio". Also, the stream frequency is inversely proportional to stream order and stream number is directly proportional to size of contributing basin and to the channel dimension.

3. Stream length (Lu)

Stream length is the total length of stream segment of each of the consecutive order in the basin. Horton (1945) states that the numbers of stream segments of each order form an inverse geometric sequence with order number.

4. Mean Stream Length (Lum)

Mean stream length shows the size of component of drainage network and it contributing watershed surface. It's directly proportional to the size and topography of drainage basin. It is calculated by dividing the total length of stream of an order by total number of segments in the order.

5. Stream Length Ratio (Lurm)

Horton (1945, p.291) states that the length ratio is the ratio of the mean (Lu) of segments of order (So) to mean length of segments of the next lower order (Lu-1), which tends to be constant throughout the successive orders of a basin. The stream length ratio has important relevance with surface flow and discharge and erosion stage of the basic.

6. Bifurcation Ratio (Rb)

Horton (1945) described bifurcation ratio as an index of relief and dissection. Strahler (1957), described bifurcation ratio exhibits subtle fluctuation for different region with varied environment except where powerful geological control dominates. According to Schumm (1956), bifurcation ration is the ration of number of stream segment of given order to the number of segments in the next order. Low bifurcation indicates high possibilities of flooding as water will get trapped instead of spreading out or flowing. Human activities also have impact on bifurcation ratio which leads to flooding within the basin.

7. Drainage density (Dd)

The computation of the total stream length in a given basin area to the drainage area is called drainage density. This is really important for numerical measurement of landscape direction and runoff potential. A high drainage density indicates weak basin and impermeable subsurface material with sparse vegetation and high relief. According to Strahler (1964), drainage density is directly proportional to basin relief.

8. Elongation ratio (Re)

The ratio of a diameter of a circle having the same area as of the basin and maximum basin length is called Elongation ratio. Elongation plays a vital role in getting the notion of the hydrological character of drainage basin for computation of basin shape. The value ranges from zero which indicates unity and 1 indicates circular shape of the drainage basin. Value of elongation ratio generally varies from 0.6 to 1.0 over a wide range of climatic and geologic types. Values close to 1.0 are typical of regions of very low relief, whereas that of 0.6 to 0.8 are usually associated with high relief and steep ground slope.

9. Circulatory ratio (Rc)

Circularity ratio is the ratio of an area of basin to an area of circle having same circumference as the perimeter of basin According to Miller (1953), it's significant ratio that exhibits dendritic stage of drainage due to variation in the slope and relief pattern of the basin. It's used as quantitative measure for the shape of the basin. This ratio is prominently relevance to the length and frequency of streams, geological structures, land use/ land cover, climate, relief, and slope of the basin.

10. Form factor (Ff)

According to Horton (1932), form factor may be defined as the ratio of basin area to square of the basin length. The value of form factor would always be less than 0.754 (for a perfectly circular watershed). Smaller the value of form factor, more elongated will be the watershed. The watershed with high form factors has high peak flows of shorter duration, whereas elongated watershed with low form factor ranges from 0.42 indicating them to be elongated in shape and flow for longer duration.

Table 1: Formulas and Parameters for computation of morphometric analysis

S/N	Morphometric Parameters	Formulas	Unit	Results (km)
1	Basin Area (A)	The area enclosed by the watershed	km	391.788
2	Basin Perimeter (P)	Perimeter of the watershed	km	167.8659
3	Basin Length (Lb)	This is the distance from outlet to the farthest point on basin boundary	km	34.53
4	Stream order (U)	Hierarchical order		9
5	Total Stream length (Lu)	Length of the stream	km	40.818
	Total number of stream (Nu)			325497
6	Mean stream length (Lsm)	Lsm = Lu / Nu		0.00012540
7	Stream length ratio (RL)	RL = Lu/ (Lu - 1)	km	
8	Bifurcation ratio (Rb)	(Rb) = Nu / (Nu + 1) Rb= Bifurcation ratio, Nu = Total no of stream segments, Nu + 1 = Number of segments of the next higher order		2.57 0.19 2.19 1.99 1.99 1.85 1.70 0.92
9	Mean bifurcation ratio (Rbm)	Rbm = average of bifurcation ratios of all order		1.906
10	Drainage density (Dd)	Dd = Lu / A Where D= Drainage density, Lu = Total stream length of all orders, A= Basin area	(km^2)	0.1041
11	Stream frequency (Fs)	Fs = Nu / A Where Fs = stream frequency, Nu = Total no of streams of all orders, A = basin area.		830.7987
12	Elongation ratio (Re)	Re = 2 / Lb sqrt (A / π) A = Basin area, π = pi (3.14), Lb = Basin length		0.64698
13	Circularity ratio (Rc)	Rc = 4 x π x A /P^2 π = pi (3.14), A = Basin area, P = Basin perimeter.		0.17462
14	Form factor (Ff)	Ff = A /Lb^2		0.32859
15	Drainage texture (Dt)	Dt = Nu / P where Nu = total no of streams of all orders, P =Basin Perimeter (km)		1939.0299
16	Relief	R = H - h		1196.14
17	Relief Ratio	R_r = R / Lb		34.53

Results and Discussion:

This study shows the morphometric analysis of the Mary's River basin in three different aspects (Linear, Areal, and Relief). The slope, aspect, and drainage density of the basin are also evaluated.

a) <u>Linear Aspect:</u>

The linear aspect represents all the linear features in the basin. Linear Aspect such as stream order(w), stream Number (Nu), Bifurcation ratio (Rb), stream length and their mean. The number of streams in each segment as shown in **figure 16**. There is a total of nine (9) stream orders in the basin as shown in figure 15. The total number of streams in the Mary's River basin is 325,479 and the total length is 40818.47255 m^2 (40. 818472 km) **(Table 2).** The range of bifurcation ratio is between 0.92:2.57. Which means there is minimum structure disturbance the mean bifurcation ratio is 1.906. The bifurcation ratio is important in drainage basin examination as it helps in interpreting the basin shape and the runoff behavior. The higher the values of the bifurcation ratio, the higher the flood risk. **Figure 18** shows the first law of Horton for Mary's River.

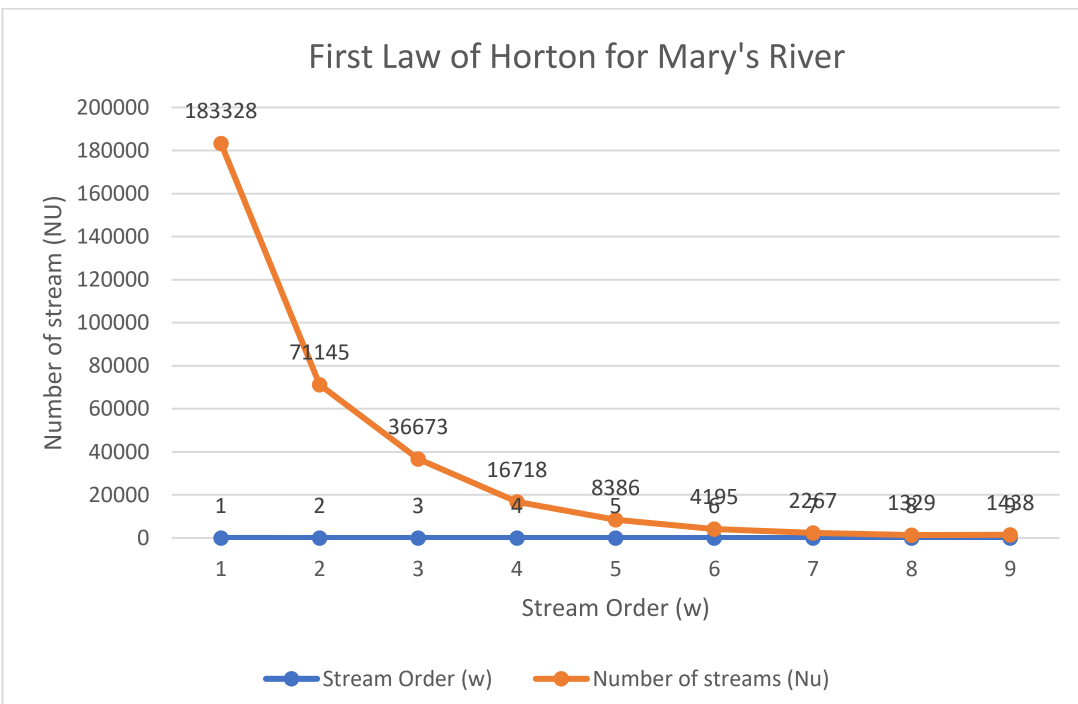


Figure 18: First Law of Horton for Mary's River.

Table 2: **Linear Aspects of Mary's River Basin.**

Stream Order (w)	Number of streams (Nu)	bifurcation ratio (Rb)	Mean of bifurcation ratio	Total length of stream (Lu)	mean of the stream (km)
1	183328			70.71	
2	71145	2.57		20	
3	36673	0.19		98.99	
4	16718	2.19		20	
5	8386	1.99	1.906	127.27	0.000125
6	4195	1.99		20	
7	2267	1.85		70	
8	1329	1.7		28.28	
9	1438	0.92		98.99	
	325479			Total = 40818.472555 m2 (40.818 km2)	

Note: for the length I didn't put everything in the table because of the length (325479 length).

- The first value of 2.57 is the bifurcation ratio for 2nd order streams, indicating that there are approximately 2.57 streams of 3rd order for every 2nd order stream in the network.
- The second value of 0.19 is the bifurcation ratio for 3rd order streams, indicating that there are approximately 0.19 streams of 4th order for every 3rd order stream in the network.
- The third value of 2.19 is the bifurcation ratio for 4th order streams, indicating that there are approximately 2.19 streams of 5th order for every 4th order stream in the network.
- The fourth and fifth values of 1.99 are the bifurcation ratios for 5th and 6th order streams, respectively, indicating that there are approximately 1.99 streams of the next higher order for every stream of that order in the network.
- The sixth value of 1.85 is the bifurcation ratio for 7th order streams, indicating that there are approximately 1.85 streams of 8th order for every 7th order stream in the network.
- The seventh value of 1.7 is the bifurcation ratio for 8th order streams, indicating that there are approximately 1.7 streams of 9th order for every 8th order stream in the network.
- The last value of 0.92 is the bifurcation ratio for 9th order streams, indicating that there are approximately 0.92 streams of 10th order for every 9th order stream in the network.

b) <u>Areal Aspects:</u>

Areal Aspects of watershed comprises of Basin Area (km2), perimeter (km), Elongation Ratio (Re), Drainage density (Dd), Drainage texture (T), stream frequency (Fs), Form factor (Ff) and circulatory ratio (Rc). The total area of Mary's River is **391.788 km2** and the perimeter is **167. 865 km (see table 3).** The elongation value for Mary's River is **0.64** which means that the basin is elongated in shape with moderate relief. The circulatory ratio is **0.17** which explains that the basin is less circular or more elongated in shape. The form factor shows the flow intensity of the basin. Here, the form factor value is **0.32** which indicates that flow intensity is very low. The value of stream frequency is **830.79** and drainage density **0.104 km/km2.** Which implies that both are directly related to each other.

The drainage texture value is 1939.029, which implies that the drainage texture is not coarse.

Table 3: **Areal Aspects of Mary's River Basin.**

Basin Area (km2)	Perimeter (km)	Length (km)	Form Factor (Ff)	Elongation Ratio (Re)	Circularity Ratio (Rc)	Drainage Density (km/km2)	Stream Frequency (Fs)	Drainage Texture (T)
391.788	167.865	40.818	0.328	0.646	0.174	0.104	830.798	1939.029

c) <u>Relief Aspects:</u>

These are the 3-dimensional properties of the drainage basin. It shows the difference in elevation between reference points in the basin. The relief ratio is the ratio of basin relief and basin length. Here, the total basin relief is **1873** m and the relief ratio is **46.25** (Table 4), which indicates that the basin has moderate relief, some areas have a steep slope and most of the region has a gentle slope.

Table 4: Relief Aspect for Mary's River.

Maximum height (m)	1249.99	
Minimum height (m)	53.85	
Relief (R)	1196.14	
Basin length	34.53 km	
Relief (R)	H-h	1196.14
Relief ratio	R / Lb	34.640

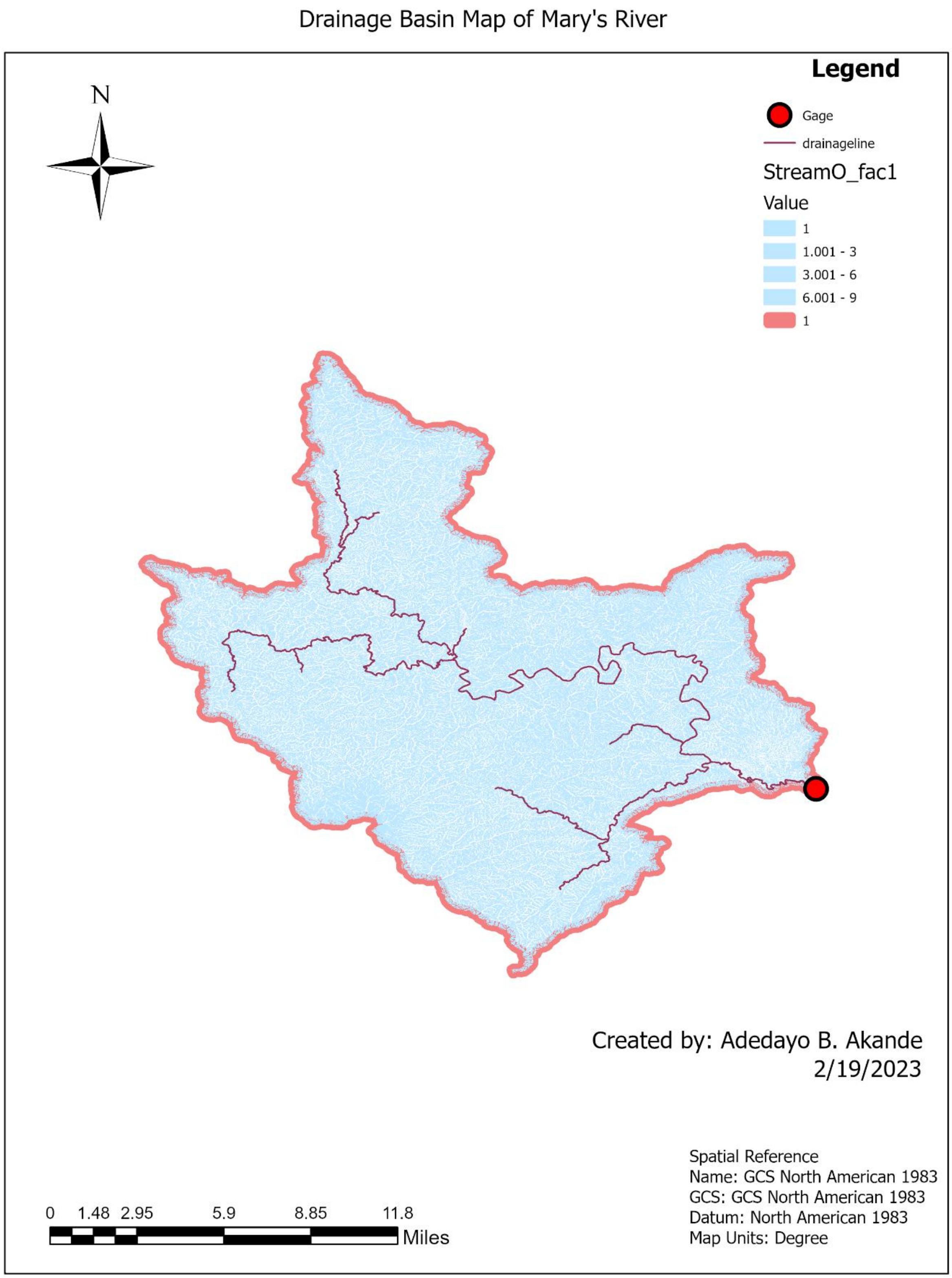
d) <u>Slope:</u>

Slope defines the steepness of an area. In the Mary's River basin, the maximum height is 1249.99m, whereas the minimum height is 53.85m. It is visible from the map that most of the basin area has very gentle to moderate slopes. A gentle slope is good for groundwater infiltration having less runoff, whereas a steep slope or higher slope category has bad groundwater infiltration with more runoff.

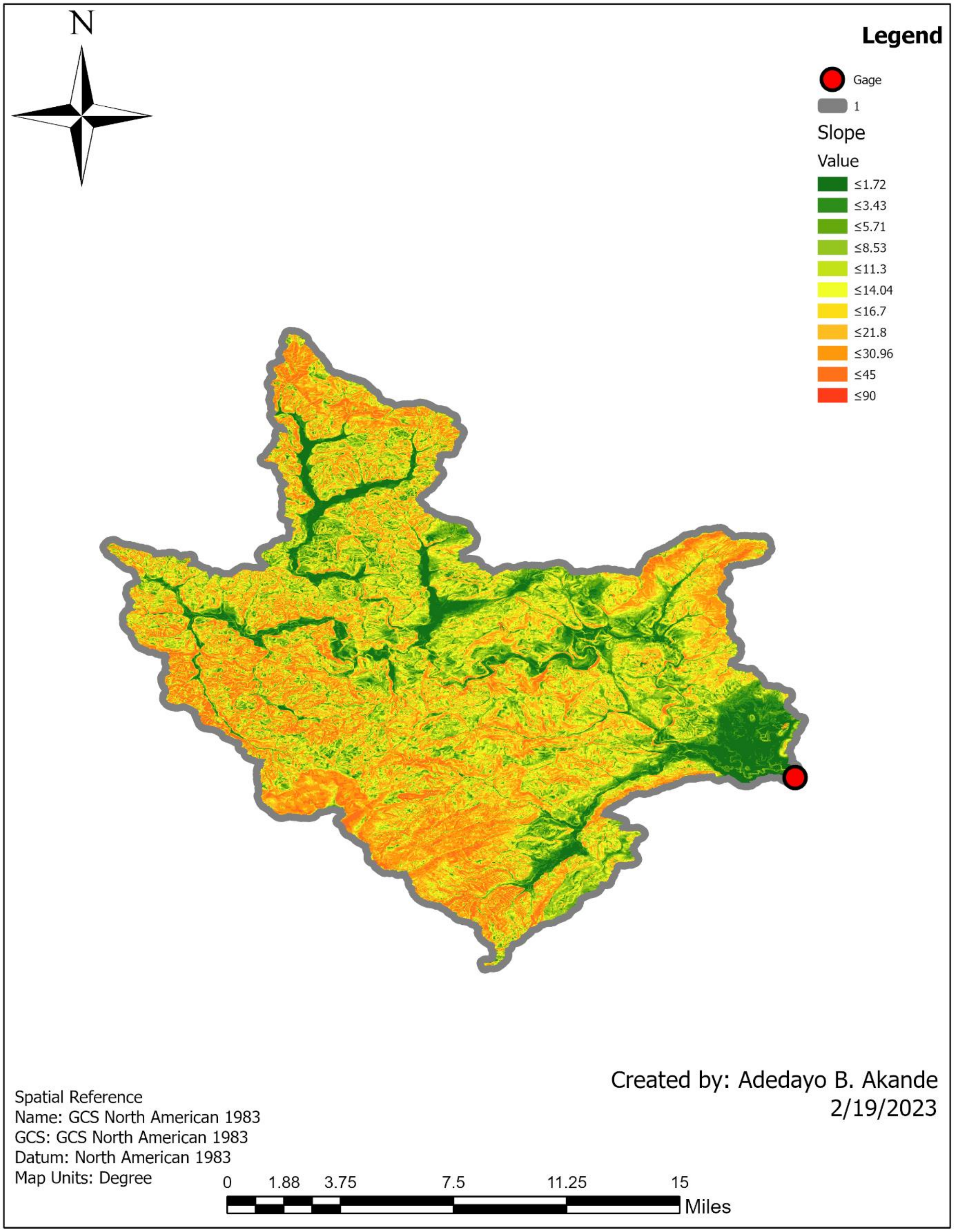
$$\text{Slope} = \frac{\text{Highest value (DEM)} - \text{lowest value}}{\text{Distance}} = \frac{1249.99-53.85}{11.09}$$

Slope = **107.85** °

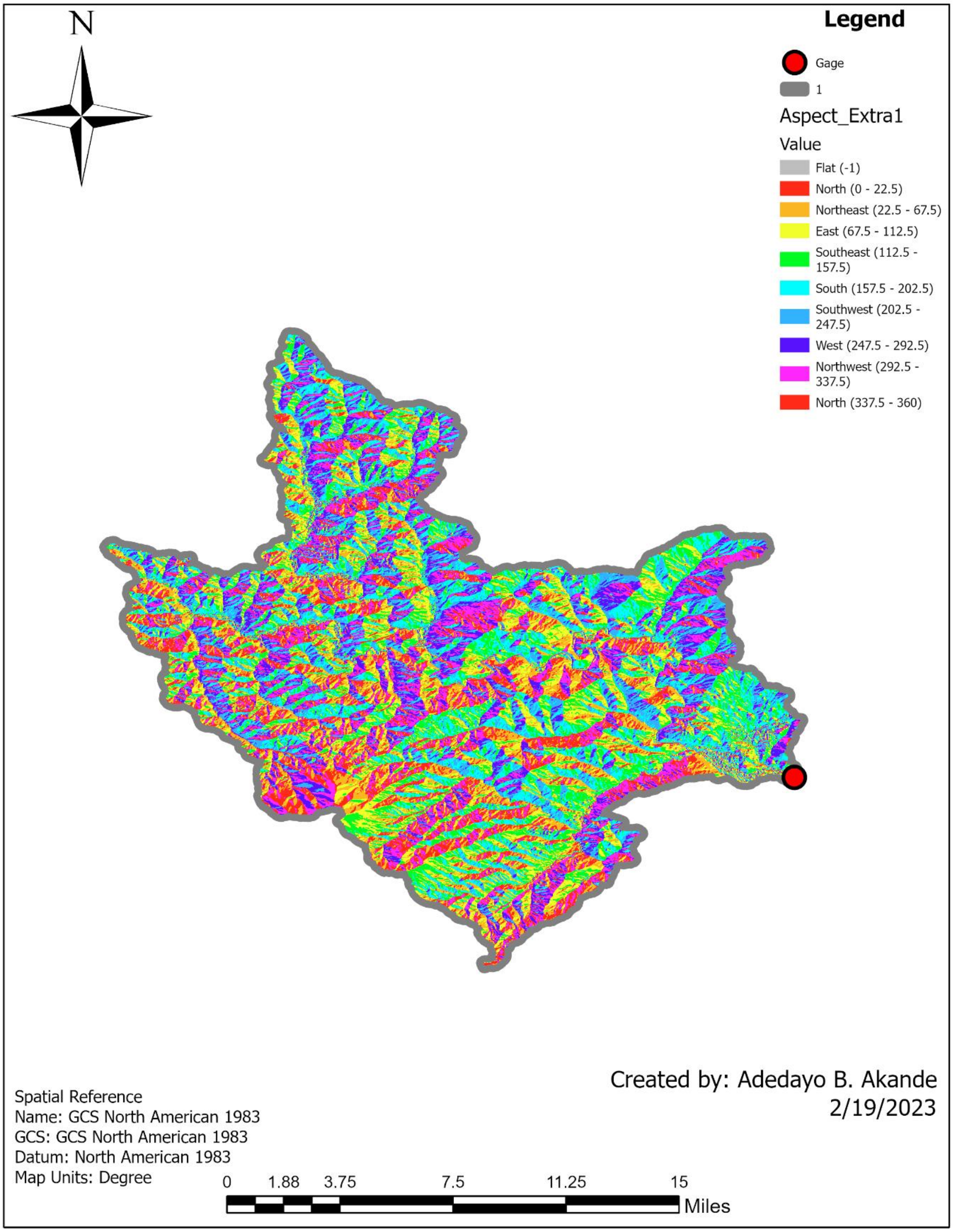
Aspect = $\tan^{-1}$ (slope) = **89.46°**


Drainage Basin Map of Mary's River
Legend
Gage
drainageline
StreamO_fac1
Value
1
1.001 - 3
3.001 - 6
6.001 - 9
1
N
Created by: Adedayo B. Akande
2/19/2023
Spatial Reference
Name: GCS North American 1983
GCS: GCS North American 1983
Datum: North American 1983
Map Units: Degree
0 1.48 2.95 5.9 8.85 11.8
Miles

Mary's River Slope Map



Mary's River Aspect Map



Limitations

The resolution of a DEM (digital elevation model) can have a significant impact on the accuracy of the analysis. A DEM with a 30m resolution means that the elevation values are averaged over a 30m x 30m grid cell, which can result in a loss of detail and accuracy in the representation of the terrain. Let's assume I used a DEM with a 5m resolution, the elevation values would be averaged over a smaller grid cell, resulting in a more detailed representation of the terrain. This could potentially lead to more accurate results, depending on the nature of the analysis. However, it's important to note that increasing the resolution of the DEM may also increase the computational demands of the analysis, and may require more resources such as storage space, processing power, and time.

Morphometric analysis provides quantitative data, but the interpretation of this data requires knowledge and expertise in the field. Therefore, interpreting the results can be so challenging. there is a risk of bias in morphometric analysis. Biases can arise from differences in the way measurements are taken or analyzed, or from the choice of methods used.

Conclusions:

To summarize all the analysis the basin area is 391. 788 km, basin perimeter is 167. 865 km, the stream length is 40.818 km, stream order of 9, form factor of 0.328, stream frequency of 830.798, drainage texture equals 1939.029 and so on. From these results, we have high stream frequency of 830.798 and form factor 0.328 which is low, this suggest that the landscape is highly dissected with many small streams, which could lead to flash floods and erosion. The resulting value for drainage texture indicates the degree of stream channel development in the watershed, with higher values indicating a denser network of streams.

After all the analyzes and interpretation of the results, it can be deduced that hydrologic and morphological aspects of the watershed are very essential and can be understood by its drainage morphometric parameters. This project shows the topography, drainage system, stream order, flow direction, flow accumulation, catchments and other important parameters. The basin's drainage system is primarily of the dendritic type, which aids in understanding a variety of topographical aspects, including infiltration rate and runoff, among others. For areas with flood risk, I recommend implementing flood control measures or conducting further analysis to better understand the flood risk.

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