DEPARTMENT OF NATURAL RESOURCES

Identifying Bluffs in the MRCCA

Purpose

The purpose of this guidance is to explain how to identify bluffs in the Mississippi River Corridor Critical Area (MRCCA). Identifying bluffs, is important for applying land alteration, vegetation management, and structure setback regulations that protect bluff integrity and scenic views.

This document includes two parts:

1. An explanation of how to identify bluffs using the three bluff identification-related definitions (bluff, toe of bluff and top of bluff) included in the DNR MRCCA model ordinance (10/13/23 version and later), and
2. Examples showing how to identify a bluff. There are two examples:
    A. Analysis of a slope that rises directly from the OHWL, and
    B. Analysis of a slope that rises away from the OHWL.

This guidance assumes use of MnTOPO data, a site survey, or other mapped and scaled representation of slope data. This guidance uses data from MnTOPO, a useful website for viewing and downloading data to identify bluffs including the toes and tops of bluffs. It shows LiDAR-derived two-foot contour lines overlaid on a map and contains tools for selecting and analyzing slope data. Onsite surveys are still needed to conclusively determine whether a bluff exists and for accurately locating the toe and top of a bluff.

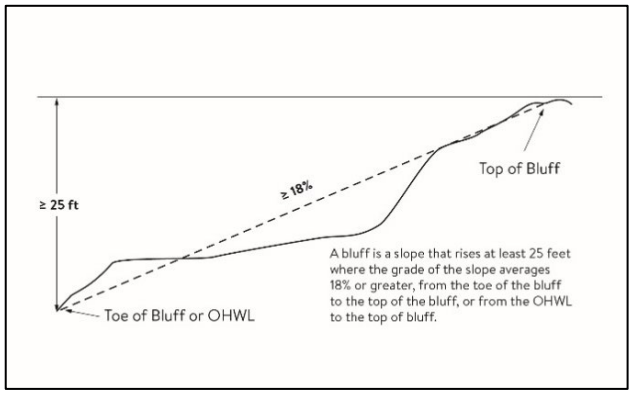
How to Identify Bluffs

Definition Overview

Bluffs are determined using the following bluff-related definitions from the model ordinance:

Bluff. A natural topographic feature having a slope that rises at least 25 feet where the grade of the slope averages 18 percent or greater, from the toe of the bluff to the top of the bluff, or from the ordinary high-water level (OHWL) to the top of bluff, whichever is more restrictive. See Figure 1.

Figure 1: Bluff Definition Graphic from Model Ordinance



Man-made topographic features such as road and railroad embankments are not natural topographic features and are not regulated as MRCCA bluffs. Natural topographic features that have been altered are very common in the MRCCA. Such altered features are still natural and are regulated as MRCCA bluffs.

The current model bluff definition does not include the phrase "measured over a horizontal distance of 25 feet" used in earlier models and the rules (MR 6106.0050 Subp. 8.A.) The current model omits this phrase because it duplicates the same phrase used in both the toe and top of bluff definitions, which are

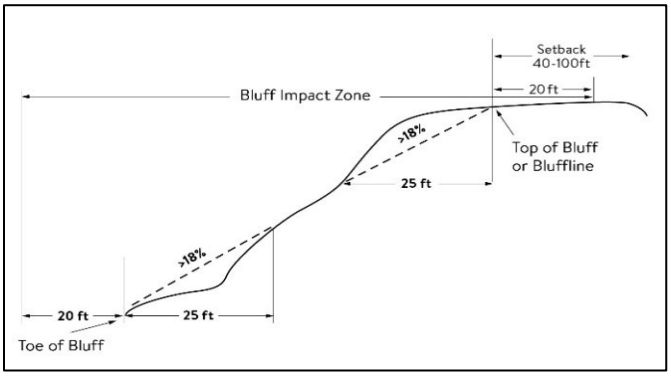
inclusive to the bluff definition, and was confusing to administer. Removing this phrase does not alter the meaning of the bluff definition.

The model also includes the optional phrase, "whichever is more restrictive." This text addresses situations when a bluff starts at both starting points, the OHWL and at another point higher up the slope.

Toe of Bluff. The lower point of a 25-foot horizontal segment with an average slope exceeding 18 percent, requiring field verification (Figure 2).

Top of Bluff. The higher point of a 25-foot horizontal segment with an average slope exceeding 18 percent, requiring field verification (Figure 2).

Figure 2: Toe/Top of Bluff definition graphics from model ordinance



*These two definitions, which have the same structure, have been modified from earlier model versions and the rules (MR 6106.0050 Subps. 77 and 78). The following phrase has been **removed** from earlier versions of the Toe/Top of Bluff definitions:*

> *"A line along the bottom/top of a bluff such that the slope above/below the line exceeds 18 percent and the slope below/above the line is 18 percent or less, measured over a horizontal distance of 25 feet"*

*and **replaced with**:*

> *"the lower/higher point of a 25-foot horizontal segment with an average slope exceeding 18 percent."*

The replacement phrases are shorter and a more consistent and locationally precise way of saying a "line along the toe/top of a bluff." Replacing these phrases does not alter the meaning of the toe and top of bluff definitions.

Bluff Analysis Basics

The objective of a MRCCA bluff analysis is to determine if the average slope of any natural topographic feature, that is at least 25 feet high, is at least 18 percent between the lower end and upper end of the feature. Determining a slope percentage is calculated by dividing the change in elevation between two points by the distance between those two points.

The locational points "toe of bluff" and "OHWL" are two potential lower ends or starting points for measurement. The "top of bluff" is the upper end or ending point. A starting point and an ending point need to be identified before calculating a slope percentage. In large bluff complexes, there may be more than one segment that meets the bluff definition, each with its own discrete starting and ending points.

Bluff Analysis Process

Figure 3: Steepest part of slope is where contour lines are closest.

Step 1: Assess the topographical feature. Examine the mapped representation of slope data to find areas where the contour lines are closer to each other. The closer the contour lines are to each other, the steeper the slope (Figure 3). This is the area of interest. Understand the elevation change represented by each contour line and the distance scale used.

Step 2: Find the bottom of the slope or starting point.

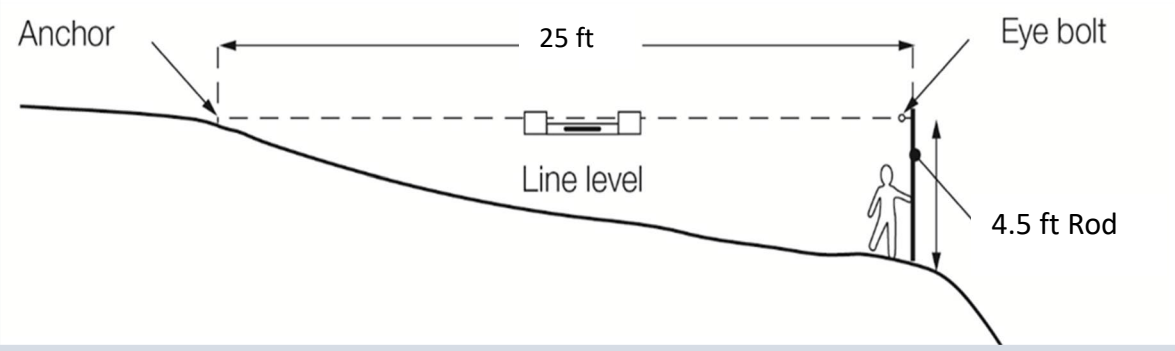
The bottom of the slope is where the contour lines become further apart. If the bottom of the steepest slope areas are near the river, the bottom of the slope may likely be a suitable proxy of an OHWL for the bluff exercise. If you don't know the OHWL elevation, it is reasonable to use the contour line closest to the river as a starting point for the bluff exercise. If the actual OHWL elevation is needed for greater precision, please contact the DNR Area Hydrologist for your area.

If the slope rises at a distance away from the river, then one first needs to use the toe of bluff definition to find the starting point. An 18% slope over a 25-foot distance is the same as finding an elevation rise of 4.5 feet over a 25-foot distance. The toe of the bluff elevation is the lower end of the 25-foot horizontal distance that rises 4.5 feet. Figure 4 conceptually shows how to find the toe and top of bluff through field measurements.

Figure 4: Directions for locating the top and toe of a bluff.

The definitions for the "top of bluff" and "toe of bluff" are structured the same and the process for finding each is conceptually the same. The only difference is that the "top" definition is used to find the higher point of a 25-foot segment and the "toe" definition is used to find the lower point of a 25-foot segment. Instructions for locating the top of bluff is shown below (text for the toe of bluff is shown in parenthesis).

The MRCCA model ordinance defines the top (toe) of bluff as "the **higher (lower) point** of a 25-foot segment with an average slope exceeding 18 percent."



For finding the top (toe) of bluff, imagine moving a 25-foot string segment up (down) the face of the bluff. The top (toe) of bluff is the location of the uphill (downhill) end of the string when the slope, over the 25-foot segment, is marginally greater than 18%, or for practical purposes, 18%. This is the point where the slope rises 4.5 feet over the 25-foot distance.

Step 3: Determine if the slope rises at least 25 feet from the starting point (OHWL or toe of bluff)

This is an evaluation of the change in elevation from the starting point. Add 25 feet to the elevation of the starting point (the OHWL elevation or the toe of bluff elevation). If the slope doesn't rise at least 25 feet from the starting point, then there is no bluff and a top of bluff location does not need to be found.

Step 4: Find the top of bluff.

Once the OHWL or toe of bluff is located, draw a line from that point uphill and perpendicular, as much as possible, to the contour lines. The top of bluff will be located where the contour lines become further apart, signifying the area where the slope decreases to less than 18%. The top of bluff elevation is the upper end of a 25-foot horizontal distance that rises 4.5 feet.

Step 5: Calculate the slope percentage between the beginning point (OHWL or toe of bluff) and top of bluff

The percent of a slope is calculated by **dividing the vertical change** between the two points **by the horizontal change** between the two points multiplied by 100. This is often expressed as "rise over run." In mathematical terms:

$$Slope\ (\%) = \frac{Y_2 - Y_1\ (rise\ or\ vertical\ change\ between\ two\ points)}{X_2 - X_1\ (run\ or\ horizontal\ change\ between\ two\ points)} x\ 100$$

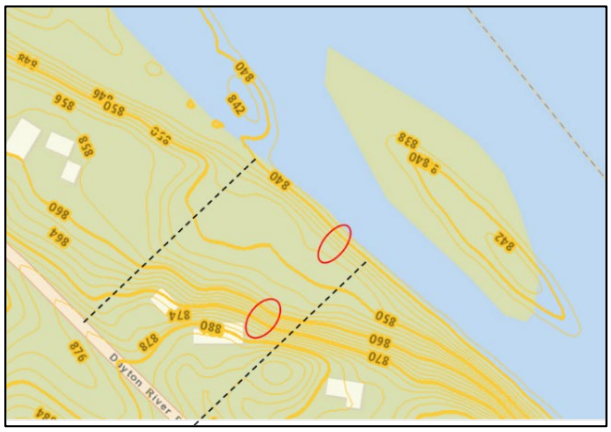
If the slope from the OHWL or toe of the bluff to the top of bluff is 18% or greater, then the slope is a MRCCA bluff.

Bluff Examples

In this next part, we will apply the above-described process to two examples.

Example A: The slope feature rises directly from the OHWL

Figure 5: Slope assessment. Find the steepest areas.



Step 1: Assess the topographical feature.

On the lot in Figure 5, there are two areas that are relatively steep, separated from each other by an area that is less steep. In this case, there could be two bluffs if each steep slope area rises at least 25 feet. There could also be one bluff if the slope from the bottom, near the river, to the top of the second steep area is 18% or greater. This figure shows two-foot contour lines.

Step 2: Find the bottom of the slope or starting point.

Since there is a steep area near the river, the OHWL will be the lower end or starting point for this bluff evaluation. In this case, we will use 836 feet as the elevation. If there were no steep areas near the river, like the area in the upper left of this image, one would need to find the toe of bluff further away from the OHWL.

Step 3: Determine if the slope rises at least 25 feet from the starting point - the OHWL.

Using MnTOPO, a line segment was drawn (Figure 6) from the OHWL, to an area beyond the upper steep area. The data from this line segment is represented in Figure 7 as a cross section profile of the slope. The OHWL is shown at an elevation of 836 feet and 25 feet above this is an elevation of 861 feet. In this example, the slope rises 47 feet to 883 feet.

Figure 6: Draw a line segment for slope analysis.

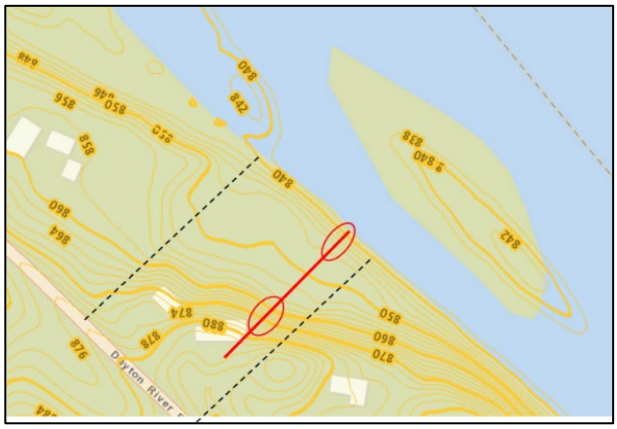
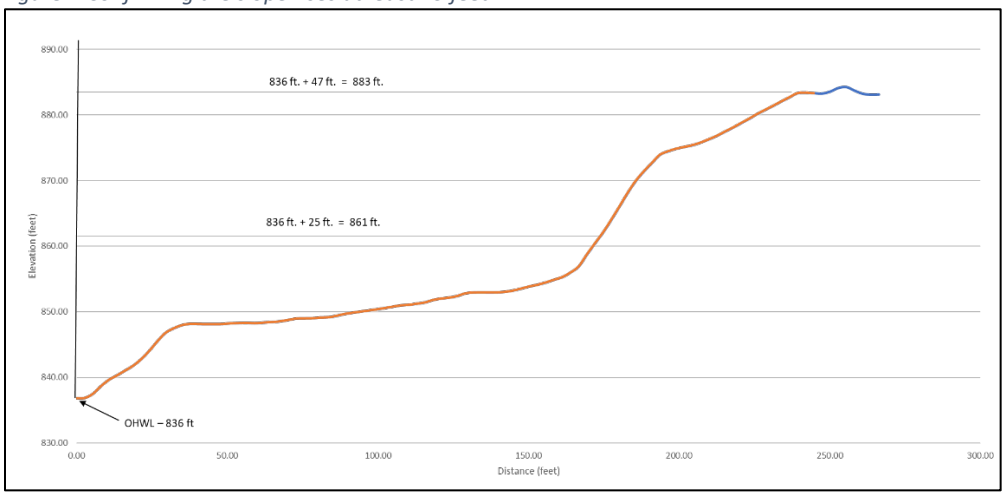


Figure 7:Confirming the slope rises at least 25 feet.



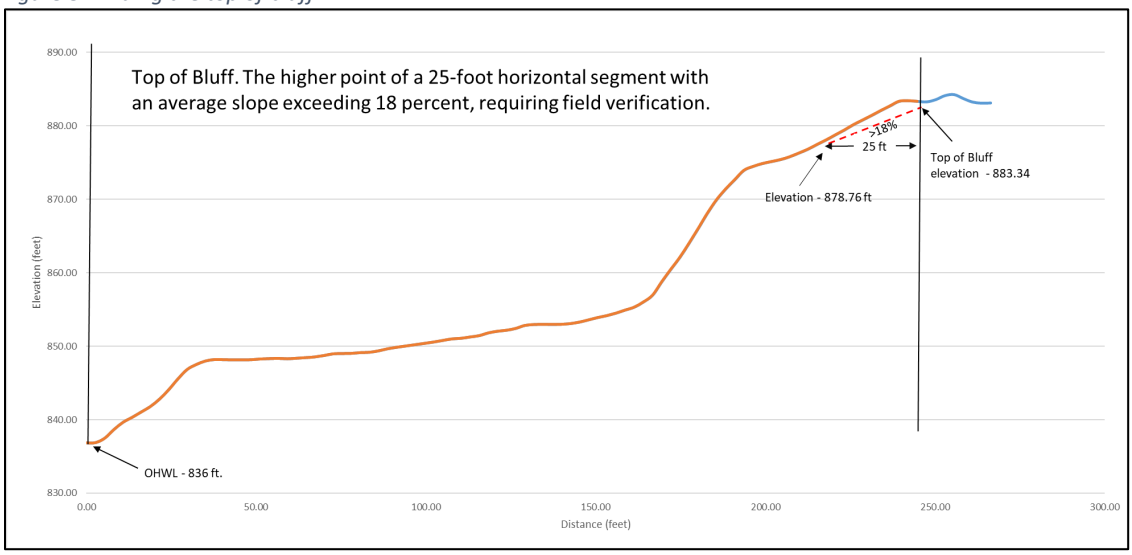
Step 4: Find the top of bluff.

Continuing to use data points extracted from the MnTOPO line segment shown in Figure 7, we apply the top of bluff definition "the higher point of a 25-ft horizontal segment with an average slope exceeding 18 percent" and find that the top of bluff is roughly at an elevation of 883.34 feet. See Figure 8.

883.34 ft – 878.76 ft = 4.58 ft elevation change / 25 ft distance = 18.32% slope

Upslope beyond this point, the average slope for a 25-ft distance is less than 18 percent. Downslope below this point, the average slope is greater than 18%. The top of bluff elevation determines where the 20-foot bluff impact zone and the structure setback (either 40 ft or 100 ft) begins.

Figure 8: Finding the top of bluff.



Step 5: Calculate the slope between the OHWL and the top of bluff.

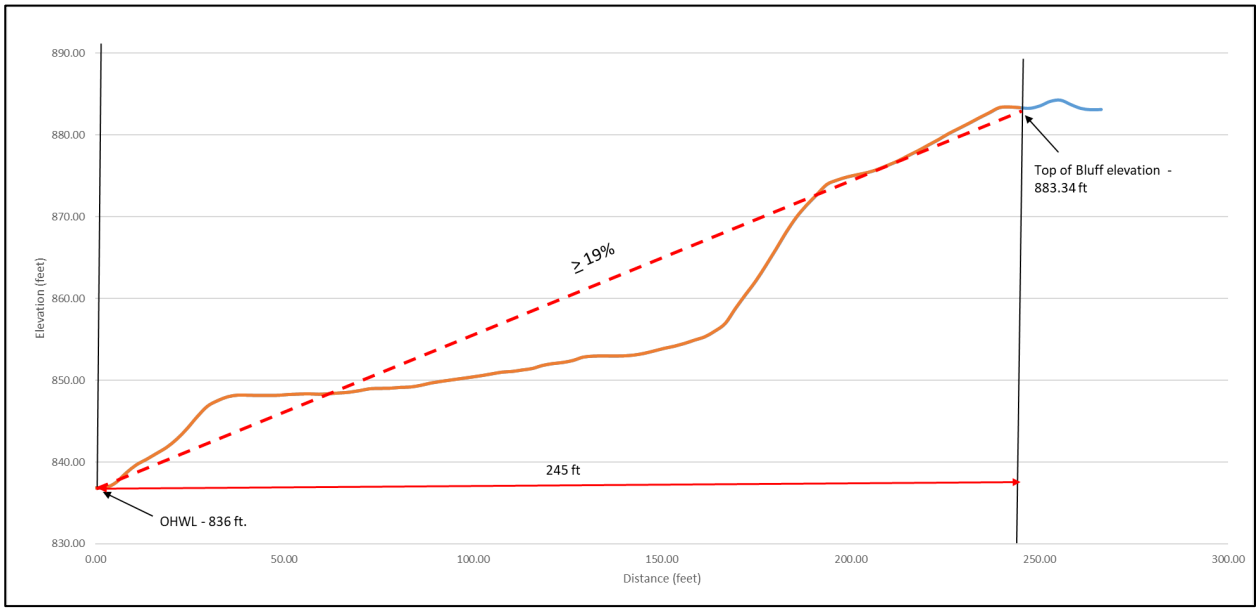
To determine a slope percent, we need to know the horizontal distance of the slope's rise from the OHWL to the top of the bluff. Figure 9 shows that the horizontal distance between the OHWL (noted as 0 feet on the horizontal distance axis) and the top of the bluff is 245 feet (see solid red arrow line).

In this example, the slope rises 47.34 feet (883.34 ft – 836.0 ft = 47.34 ft) over 245 feet for a slope of 19.32%

(47.34 feet/245 feet) X 100 = 19.32%

Since the average slope is greater than 18%, this slope feature is a bluff.

Figure 9: Determining the slope percent.

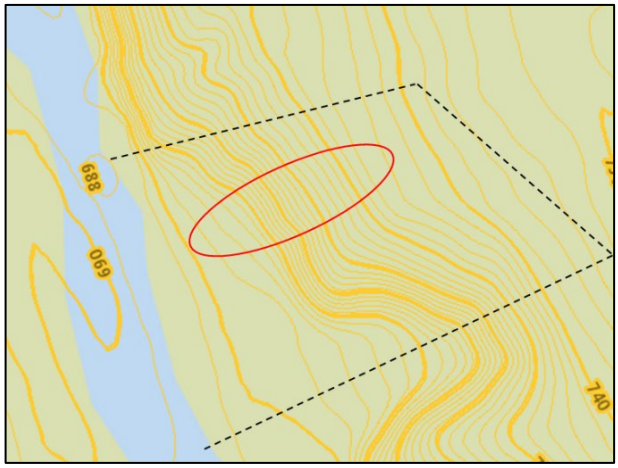


Example B: The slope feature rises away from the OHWL

Step 1: Assess the topographical feature.

On this lot the slope begins rising at a distance away from the river. The steepest slope area is shown in the red oval (Figure 10). The toe and top of slope are likely to be at or near the two ends of the red oval. This figure shows two-foot contours.

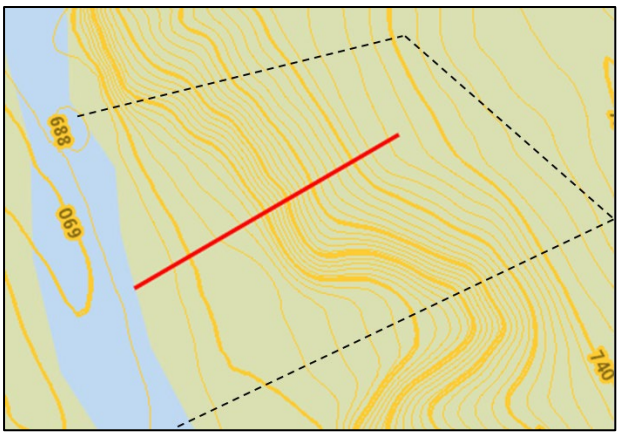
Figure 10: Slope assessment. Find the steepest area.



Step 2: Find the bottom of the slope or starting point.

Since the slope rises away from the river, the OHWL will not be the bottom or starting point. Instead, a toe will need to be found. Using MnTOPO, a line segment was drawn (Figure 11), extending just beyond the lower and upper steep areas. The data from this line segment is represented in Figure 12 as a cross section profile of the slope. This data will be used to find the toe of bluff. Later, this data will be used to determine whether the slope rises 25 feet and to find the top of bluff and the slope percentage from the toe of bluff to the top of bluff.

Figure 11: Draw a line segment for slope analysis.

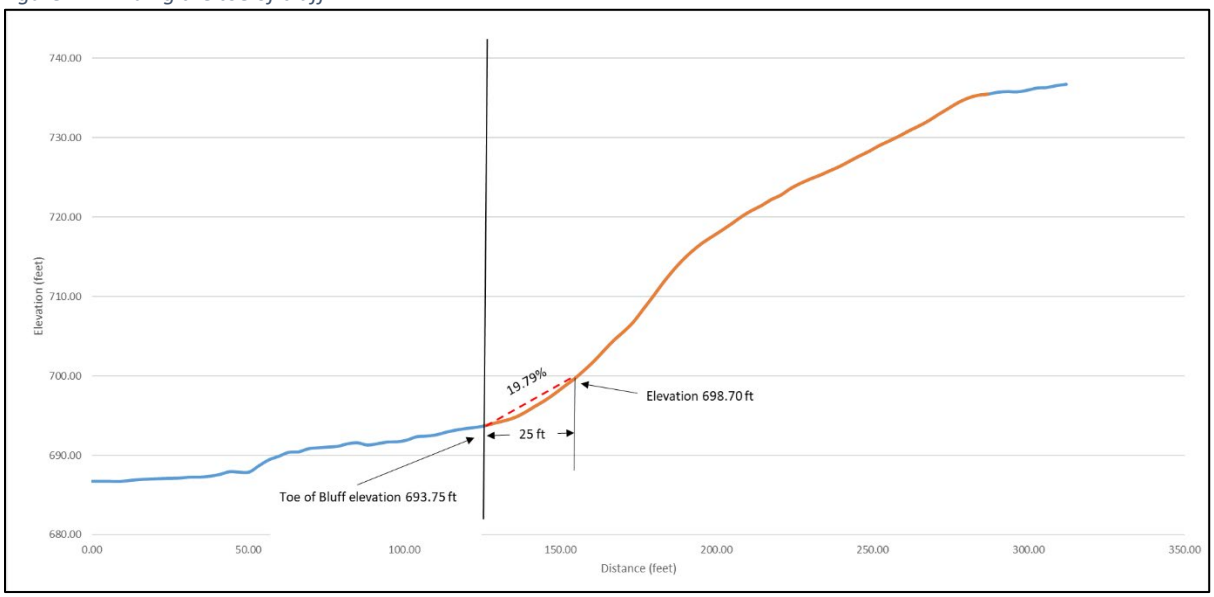


To find the toe, we apply the toe of bluff definition "the lower point of a 25-ft horizontal segment with an average slope exceeding 18 percent," and use data points extracted from the MnTOPO line segment shown in Figure 11. In this case, we find that the toe of bluff is roughly at an elevation of 693.75 feet. See Figure 12. The 19.79% slope exceeds 18% and is within the acceptable range for meeting the toe of slope definition when working with MnTOPO data. Field surveys should be more precise.

698.70 ft – 693.75 ft = 4.95 ft elevation change / 25 ft distance = 19.79% slope

Downslope of this point, the average slope for a 25-ft distance is less than 18 percent. Upslope beyond the toe, the average slope is greater than 18%. The toe of bluff elevation determines where the 20-foot bluff impact zone begins.

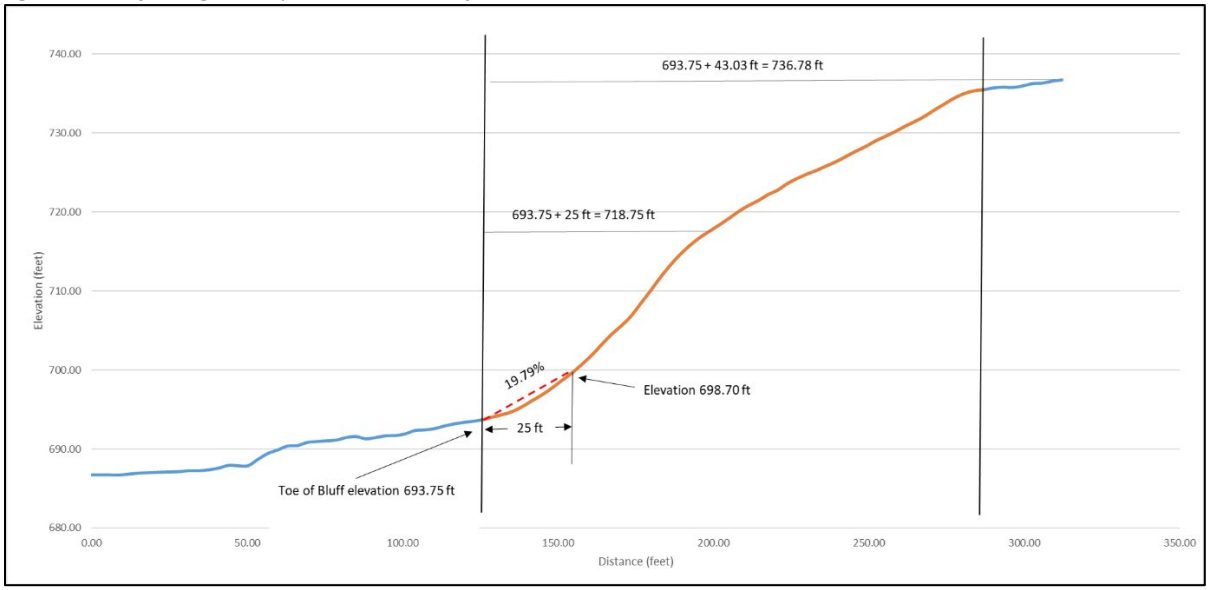
Figure 12: Finding the toe of bluff.



Step 3: Determine if the slope rises at least 25 feet from the starting point - the toe of bluff.

Using the same MnTOPO data representing the slope profile in Figure 12, we can see from Figure 13 that the slope rises over 43 feet from the toe of bluff at 693.75 feet, a rise well over 25 feet.

Figure 13: Confirming the slope rises at least 25 feet



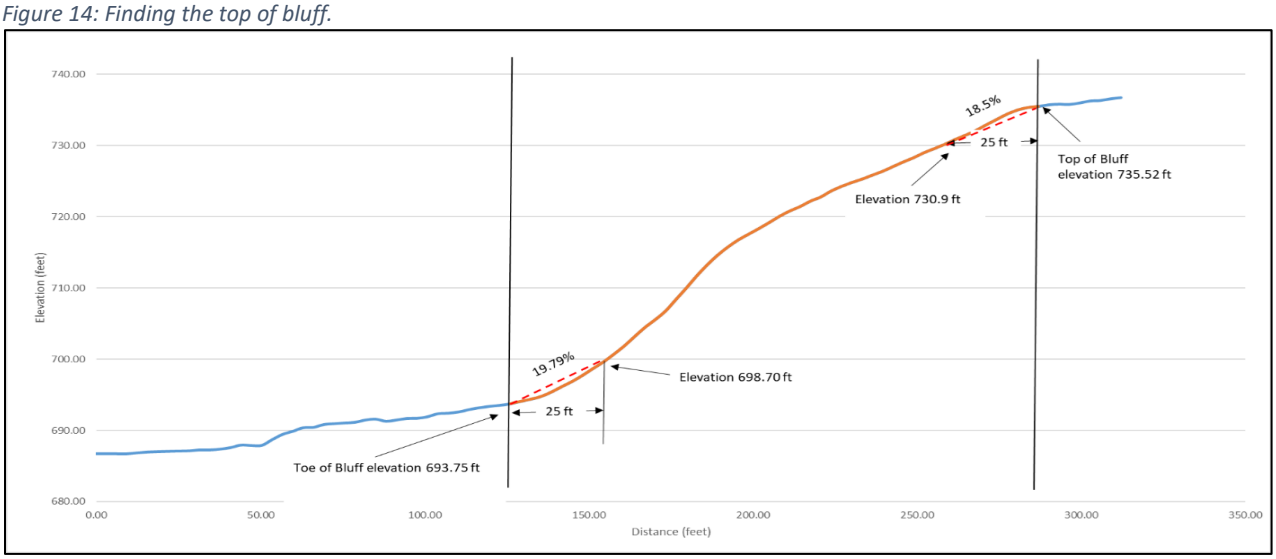
Step 4: Find the top of bluff.

Continuing to use the same MnTOPO data, we apply the top of bluff definition "the higher point of a 25-ft horizontal segment with an average slope exceeding 18 percent" and find that the top of bluff is roughly at an elevation of 735.52 feet. See Figure 14.

735.52 ft – 730.9 ft = 4.62 ft elevation change / 25 ft distance = 18.5% slope

Upslope beyond this point, the average slope for a 25-ft distance is less than 18 percent. Downslope below this point, the average slope is greater than 18%. The top of bluff elevation determines where 20-foot bluff impact zone and the structure setback (either 40 ft or 100 ft) begins.

Figure 14: Finding the top of bluff.



Step 5: Calculate the slope between the toe of bluff and the top of bluff.

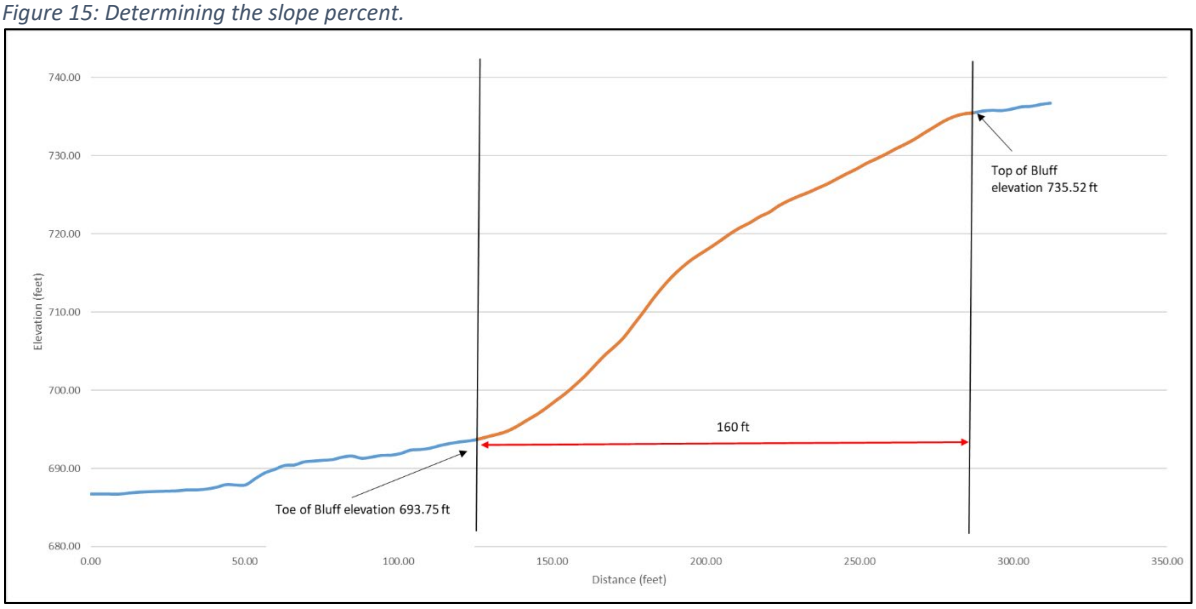
To determine a slope percent, we need to know the horizontal distance of the slope's rise from the toe of the bluff to the top of the bluff. Figure 15 shows that the horizontal distance between the toe and the top of the bluff is 160 feet (see solid red arrow line).

In this example, the slope rises 41.77 feet (735.52 ft – 693.75 ft = 41.77 ft) over 160 feet for a slope of 26%.

(41.77 feet/160 feet) X 100 = 26%

Since the average slope is greater than 18%, this slope feature is a bluff.

Figure 15: Determining the slope percent.



Sources

MNDNR Lakefinder webpage – OHWL information is available for many individual lakes. For lakes not listed here and for rivers, please contact your DNR Area Hydrologist or your local government for OHWL information.
MnTOPO – is a website containing elevation data and is useful for estimating whether a bluff may exist on a property. Properties can be located by address.
MnTOPO Guidance Document – a DNR publication explaining how to use MnTOPO tools and data to evaluate slopes – useful for local government staff and DIY property owners.

The statements in this document do not have the force and effect of law. This document is informational only and should not be interpreted as creating new criteria or requirements beyond what is already established in the relevant statutes and rules. Whether a local shoreland ordinance complies with the relevant statutes and rules will be determined on a case-by-case basis. Nothing in this document should be considered legal advice. Local governments should consult their attorney for specific advice in adopting, amending, and administering ordinances.