WARNELL PUBLICATION

Timber Harvesting

The University of Georgia WARNELL SCHOOL OF FORESTRY & NATURAL RESOURCES

WSFNR-15-11 August 2015

Watershed Delineation and Road Culvert Sizing Using Web Soil Survey

Ben Jackson, Professor

Introduction

Web Soil Survey (WSS) is an online interactive site created by the USDA Natural Resources Conservation Service that provides soils data and information produced by the National Cooperative Soil Survey. It has many potential applications for natural resource managers and forest landowners. The WSS web address is http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

Getting Started

This publication is a companion to one entitled "Web Soil Survey: A Timber Harvest Planning Tool" published in February 27, 2015 as Warnell Publication Number ??? It provides detailed navigation procedures for finding a site on the ground you wish to examine (**Area of Interest**). On the front page of WSS, **Area of Interest** is always the menu tab highlighted as you start (Figure 1). Under this tab use the **Address** option within **Quick Navigation** to locate the **Area of Interest (AOI)** found the address for our example (Figure 2). The address used here is Phoenix Road in Clarke County, Georgia as seen in Figure 3. After clicking **View** as seen in Figure 3, the next image in the Area of Interest panel will be the initial aerial image of the AOI and surrounding area at a scale of 1:12,500 (Figure 4). Use the **Scale** button to change the scale to 1:24,000 as shown in Figure 5. The resulting image (Figure 6) shows the general area of the AOI at a scale of 1:24,000.

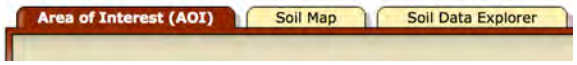

Figure 1: AOI Tab

Figure 2: Quick Navigation Panel

Figure 3: Address panel opened with address entered

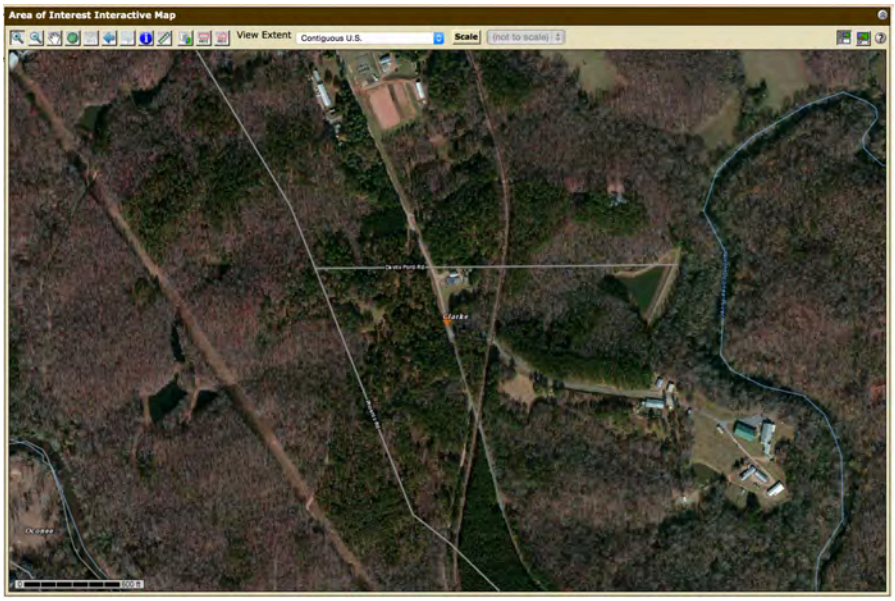

Figure 4: Initial map view of AOI address

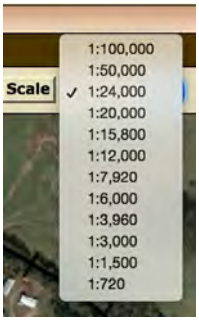

Figure 5: Image scale options

Figure 6: AOI Delineator button

Identifying Topography Features

For our purposes, we want use a topography map as the background instead of the aerial photo. The way to do that is to open the **Legend** panel as seen in Figure 7. The panel will open and you will see the **Layer Properties Menu** (Fig 8). Click on the **Topographic Map** option in Figure 9 and it will display the AOI over the topography map (Fig 10).

Figure 7: Legend tab

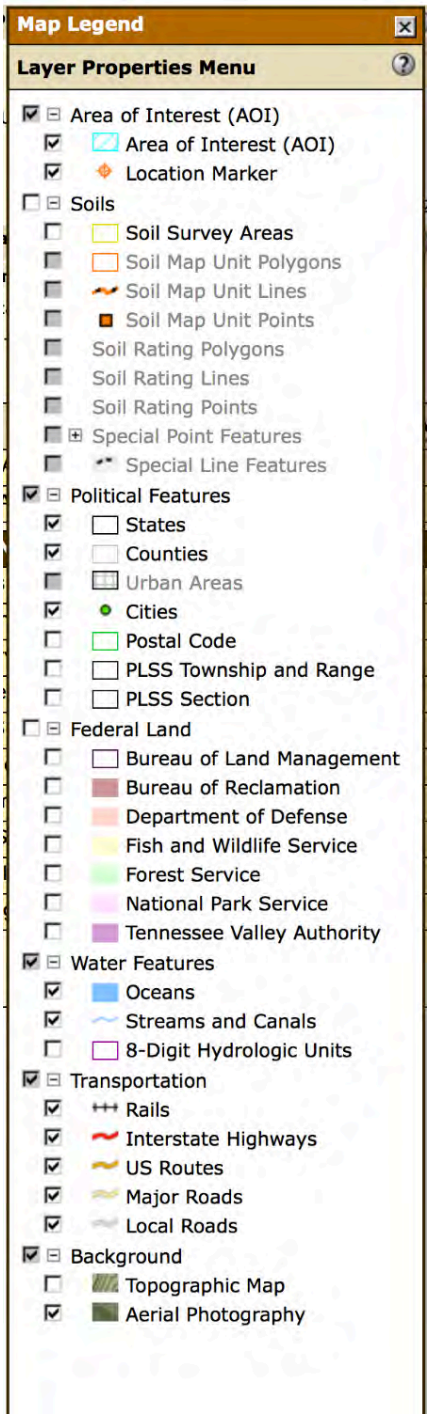

Figure 8: Opened Legend panel

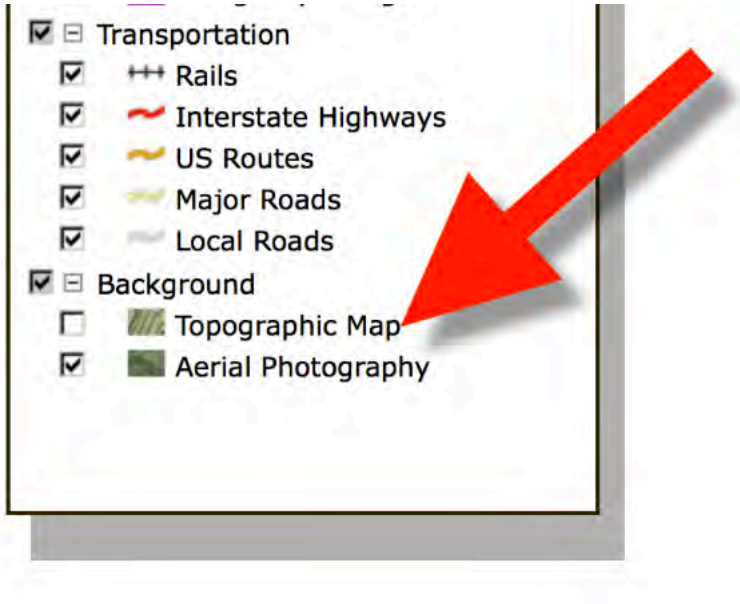

Figure 9: Topography Map background option in Legend panel

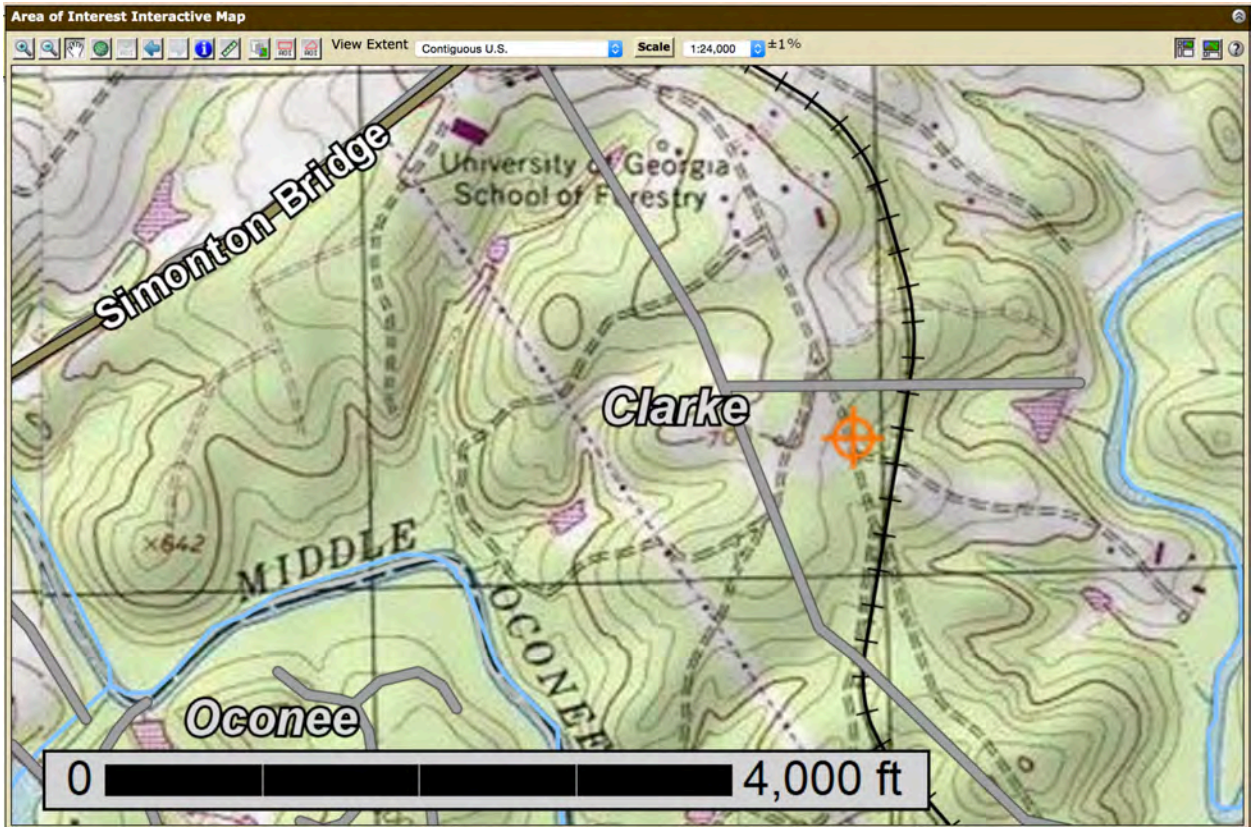

Figure10: Map of AOI over topography map

The following four figures (Fig 11-14) pinpoint on the topography map prominent features useful in delineating the size of the watershed in question and the size of the culvert that should be present to accommodate the flow of water through the culvert. The red arrow in Figure 11 highlights the current road system in the drainage area we want to examine. The arrow in Figure 12 shows the stream connecting the small pond with the Oconee River. From these figures we know that the road is a permanent road intended for long-term use. Secondly, the stream is an intermittent stream since it is denoted by a dotted line not a solid line as would be the case if it was a permanent stream. Please note there are scale differences in these images.

Figure 11: Portion of map showing the road system

Figure 12: Portion of map showing the intermittent stream

The location of the culvert in question is identified in Figure 13. Visualizing the roads, stream, and stream crossing locations are fairly obvious. What might be confusing are the contour lines identified in Figure 14. For this topography map the dark contour lines are in increments of 50 feet intervals. In this case the dark contour line to the right represents 700 feet in elevation as seen by the number on the line under the word "Clarke". The other dark line is at 650 feet. The

four light contour lines between represent ten-foot intervals, ie 690, 680, 670, and 660 feet. What this means is that the terrain is sloping downhill from right to left toward the river.

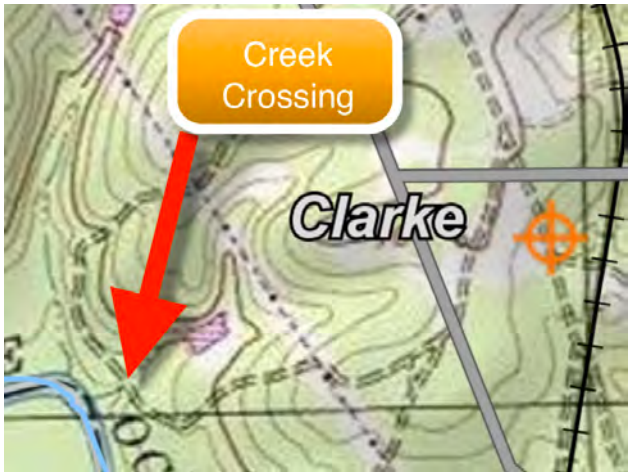

Figure 13: Portion of map showing culvert location

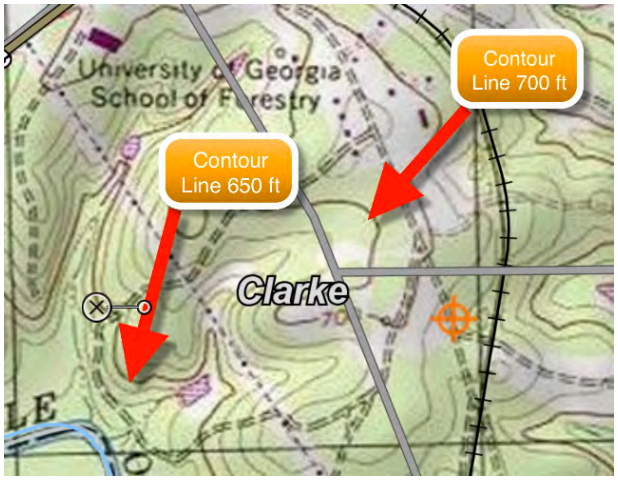

Figure 14: Portion of map showing contour lines

Delineating the Watershed

From this topography map we can determine the size of the watershed or land area for which water will drain to and through the culvert. A way to visualize the watershed boundary is to examine the five points identified in Figure 15. For convenience we can start clicking the boundary line of the watershed at point 1. The light contour line (small circle) is at elevation 710 feet. We know that since it is the only contour line between contour line 700 feet on either side of it. This then is the highest point in the subject AOI watershed. Some of the rainwater that lands in this area will flow toward the culvert and some will move in other directions.

Point 2 is at a saddle point or an elevation less than 700 feet but at least 680 feet in elevation. The two dark contour lines on either side of the "2" are at 700 feet. The AOI boundary line follows the road between the 710 and the 700-foot contour line since we presume that half of the water that occurs here will flow into the watershed and half will follow in another direction. The dark contour line (oval) to the left of the "2" is 700 feet. As with point 1 we know that part of the water will flow into the AOI watershed and part will not.

Point 3 shows the AOI boundary line following the contour line downhill. The object is to bisect the contour lines as they slope downward. Notice that the contour lines to the left of "3" appear to slope to the right where the existing road is. This area is outside the watershed since water will flow to the left and not right into the AOI watershed. Note the major contour line around "3" is 650 feet. Point 4 follows the road between 630 and 6610 feet elevation. From there the watershed boundary moves up the contour lines to point 5. The contour line around point 5 is 680 feet. Basically we will bisect the 680 contour to the 700 foot contour line just to the left of the "5". From here we bisect the 700-foot contour back to point 1 or the beginning. Double click the mouse at this this point to complete the AOI outline.

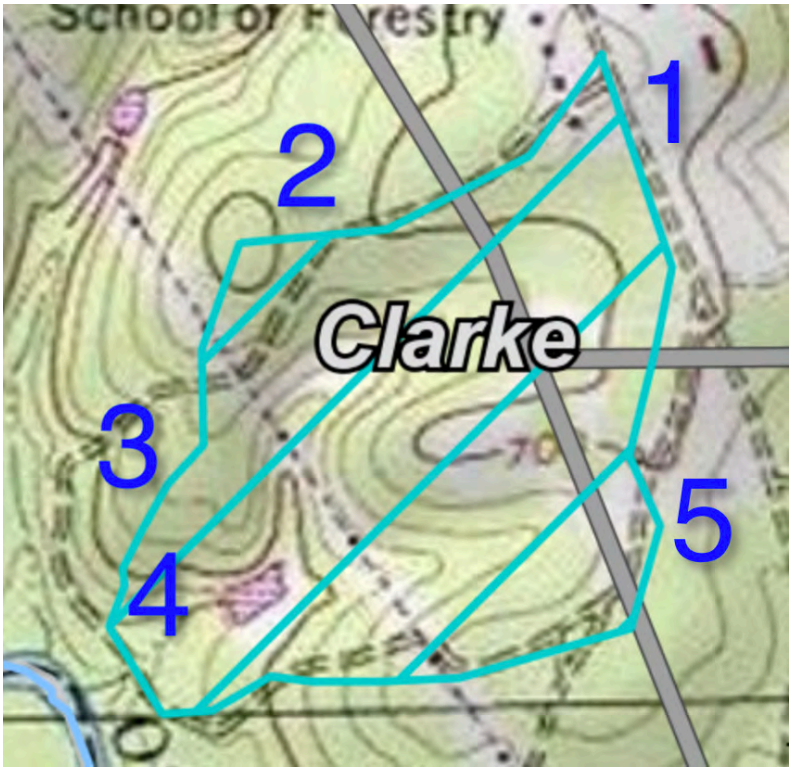

Figure 15: Portion of map explaining delineation of watershed

The green crosshatched area in Figure 16 is the new watershed AOI drained by the stream crossing identified in Figure 13. Once the AOI boundary is outlined you will see in the **AOI Properties** panel that the watershed area is 65.6 acres as shown in Figure 17. This information will be used to determine the size of the culvert needed to handle the flow of water during normal flow and even during 25-year storm events.

Figure 16: Watershed AOI drained by culvert

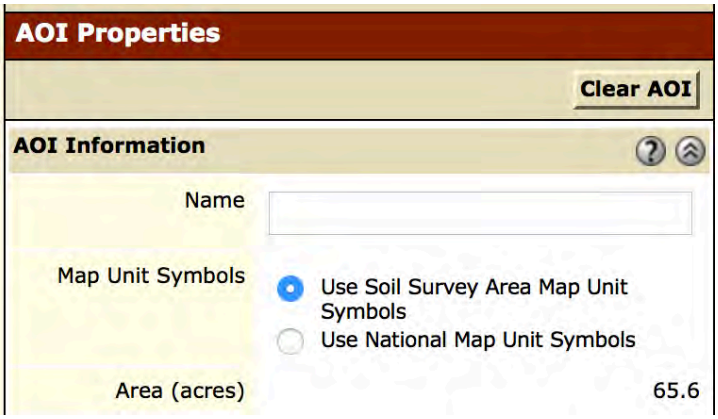

Figure 17: Watershed AOI acreage drained by culvert

Culvert Sizing

Now that we know the size of the watershed, we can determine the proper size for the culvert that should be installed as shown in Figure 13. You can use two methods to determine the culvert size. For some you might like to use Talbot's formula shown below in Figure 18. Plugging in 65 acres

for the AOI and a coefficient of 0.60 the culvert diameter is calculated to be 54 inches. The Talbot coefficient in Piedmont forested areas in the South is generally presumed to be 0.60.

Another way to determine the culvert size needed is to look at the forestry BMPs manual for your state and find the culvert-sizing table for a permanent road appropriate for the watershed in question. In the case of Georgia, Table 19 shows an excerpt from the Georgia Forestry Best Management Practices (BMPs) manual. Since a 65-acre drainage area is not shown, we must use the higher one of 100 acres. The recommended culvert size in the Piedmont is 54 inches in diameter. This is the same value derived from Talbot's formula.

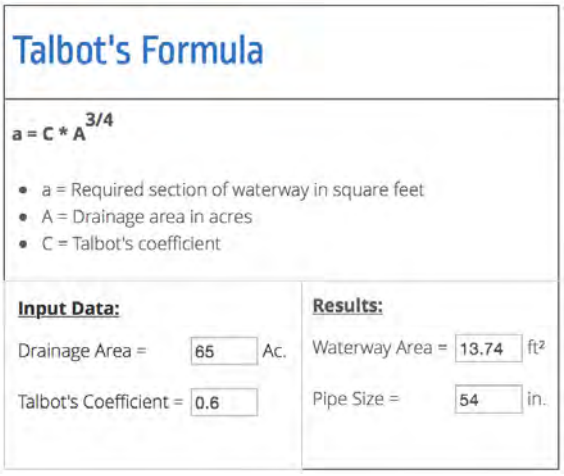

Table 18: *Online Talbot formula calculator*

http://sd-w.com/channel_flow/talbots_formula

Table 3-C: Recommended Diameters for Permanent/Temporary Culverts

Drainage Area (acres)	Lower Coastal Plain (inches)	Upper Coastal Plain (inches)	Piedmont (inches)	Mountains and Ridge and Valley (inches)
PERMANENT	BASED ON 25-YEAR, 24-HOUR STORM FLOWS)			
10	24	15	30	24
50	36 or (2-30")	18	48 or (2-36")	48
100	48	24	54 or (2-42")	60 or (2-48")
200	60	36	72 or (2-54")	72
300	2-48"	54	84 or (2-60")	78 or (2'60")

Table 19: Portion of culvert sizing table from Georgia's Forestry BMPs manual

http://www.gfc.state.ga.us/resources/publications/BMPManualGA0609.pdf

Conclusion

Using the Web Soil Survey's capacity to delineate the size of a watershed is not only a valuable tool for decision makers but it also represents a significant advantage of the traditional methods used. The traditional method required acquiring a topography map of the subject area and then hand delineating the AOI of the map. From this delineation you had to determine the area in question with a planimeter or dot grid. Not everyone has such tools handy to make these delineations.

Citations:

1. Georgia Forestry Commission: http://www.gfc.state.ga.us/resources/publications/BMPManualGA0609.pdf
2. SD/W Engineering Progress: http://sd-w.com

Athens, Georgia 30602-2152
Phone: 706.542.6819 • fax: 706.542.5073
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