LIDAR ASSESSMENT OF THE NEWARK EARTHWORKS

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LiDAR is an acronym for Light Detection and Ranging. In some applications the technology is alternatively referred to as Laser Detection and Ranging. In either case, the concept is the same. Laser light is aimed at a target and used to determine the distance to that target. The distance information is combined with GPS (Global Positioning Satellite) data. The result is a precise set of three-dimensional coordinates for any given point. For GIS applications, LiDAR is typically employed from aircraft. During a fly-over of a selected area, thousand of laser pulses are bounced off the ground and anything else on or above the ground. Once properly filtered, the resulting LiDAR data can then be used to create very accurate surface maps using software programs such as ESRI ArcView. LiDAR data are available from a variety of private and public sources, including the USGS Center for LIDAR Information Coordination and Knowledge.

In this article we demonstrate how LiDAR technology can be applied to the study of prehistoric earthwork sites. For the purposes of this demonstration, we take a closer look at the LiDAR data from the Newark Earthworks, located in Licking County, Ohio.

Figure 1 presents a LiDAR image showing the Newark area. It was created using over 15 million LiDAR data points. Highest elevations are shown in red while lowest elevations appear in blue. In this image, the Octagon-Observatory Circle and Great Circle earthworks are noted, as well as Geller Hill—a prominent topographic feature on the Newark plain. The Salisbury map (Salisbury and Salisbury 1862) of the Newark area indicates several mounds on the hill. Of course, at this distance, the possible mound features look quite small. From an interpretive perspective one of the things that Figure 1 shows is how the earthworks are situated on a plain, almost completely surrounded by watercourses and hills.

One of the most useful capabilities of LiDAR is that it provides the ability to manipulate surface models in three-dimensional space. Figure 2, for example, shows the Newark Octagon and Observatory Circle from an oblique view. Places where the walls of the Octagon appear missing are areas with dense tree cover. Also evident are features of the golf course within the earthworks. A similar oblique view of the Great Circle is shown in Figure 3. Clearly visible in this image is the so-called Eagle Mound in the center of the earthwork. Also evident is a depression to the northeast of the earthwork—shown in shades of blue—and the curved walls that extend from near the entrance of the Great Circle toward the Wright square off the map to the northeast. The rectangular raised area just outside the gateway of the Great Circle is the footprint of the museum building. While it is possible to filter trees, buildings, and other above ground features from the LiDAR data, not all signs of modern landscape features can be deleted. Thus we see South 21st Street arcing around the west side of the circle at the bottom of the image.

Since LiDAR surface maps are generated from individual coordinate points to include data in the vertical, or Z-axis, it is possible to generate accurate profiles of the terrain. In Figure

4, a dashed mensuration line has been drawn across the Great Circle earthwork. Also shown is the resulting profile along that line, somewhat exaggerated in the vertical axis. From the profile data, we find that the perimeter walls along this cross section are 7 to 9 feet in height and the ditch located along the inside wall perimeter is between 5 and 7 feet deep. The profile further suggests that the Eagle Mound is situated on elevated terrain.

We can further investigate this latter observation by creating a contour map – again, using the LiDAR data. Figure 5 shows the result. In this model, the contour interval is set at two feet. The elevated area on which the Eagle Mound was constructed is clearly delineated. In Figure 6, the elevation contours have been filled with color, resulting in an even more distinct representation of the interestingly shaped raised area surrounding the mound. Of course, what we cannot tell from the LiDAR data, alone, is whether this raised area was artificially increased in height prehistorically, or if it is a natural feature of the terrain. Or, perhaps it is the result of more recent land modifications—such as when the mound was rebuilt after excavation or when the area was groomed after the racetrack was removed from the western third of the Great Circle's interior.

In the same way that LiDAR data can be used for assessments in the vertical plane, so too can it provide great accuracy for measurements in the horizontal plane. In Figure 7, a LiDAR model of the Newark Observatory Circle has been generated. In this case we are interested in determining the diameter of the earthwork. To help visualize and accurately position our mensuration line, the vertical height of the earthwork is exaggerated. The Z-scale box shows the exaggeration value: 1.5. The dimension we are interested in is shown as a red dashed line across the earthwork. In the accompanying mensuration screen, we find that the distance across the earthwork is roughly 1,054 feet.

LiDAR imagery can also be used to examine the relationship between a selected earthwork or other feature and the local topography. In Figure 8, the longitudinal axis of the Newark Octagon and Observatory Circle earthwork is indicated by a yellow line. Just to the north of that line is a second yellow line that is parallel to the first. In the LiDAR model, elevations are indicated by color. Red shows the highest terrain; blue shows the lowest. Looking to the yellow lines, a visual assessment can be made with respect to how closely the orientation of the earthwork corresponds to the strike, or lay of the land.

LiDAR data further provide the ability to determine the highest point for any given area. So, for example, if we wish to know the location of the highest point on Geller Hill, a topographic feature in Heath Community Park located southwest of the Circle-Octagon, we simply computer-generate a marker that automatically searches for and indicates the highest LiDAR point in the area. This has been done in Figure 9; and as can be seen from the data screen, the height of that point is given as 918.4 feet. The marker provides a good visual representation of where the highest point is situated. However, if for some reason we needed more precise information, the data screen also provides the X and Y coordinates for that point.

LiDAR surface models can also be used to show the relationships between earthworks. Figure 10, for example, shows the relationship between a selected point on Geller Hill and the centers of the Great Circle and Octagon. In this case, markers were earlier placed using close-up nadir views to correctly center them within the two earthworks.

One of the most powerful capabilities that LiDAR offers, of course, is the ability to view earthworks from new perspectives. LiDAR images also allow us to view features that might otherwise be very difficult to access. Figure 11 is a case in point. Shown in this figure is a prehistoric earthwork feature designated as Hill Fort 1 (33Li7) by Salisbury and Salisbury (1862:31). Close-up examination of the feature as provided by Figure 12 reveals a number of linear features, including what appears to be a portion of the earthwork ditch/embankment. Both of these observations corroborate the physical description provided by the Salisburys, who state:

> Around the level summit of the hill, generally about four rods below its brow is a ditch and low wall….This ditch is nearly circular, yet evidently conforming to the shape of the hill….The wall…is almost obliterated, having been washed into the ditch by the rains of centuries (Salisbury and Salisbury 1862:31).

Given that the ditch and wall features were described in 1862 as nearly obliterated, it is remarkable that today, we are able to see any remnants. Yet the features are indeed visible in the LiDAR images – thus demonstrating the impressive capabilities that this technology offers.

Of course, not all earthworks can be imaged with LiDAR as many are now so flat that they defy topographic detection. This is where we pick-up with a different set of remote sensing tools – namely, geophysical survey instruments. Between these two approaches to imaging Ohio earthworks, there is no reason why we should not be able to relocate and protect these important cultural resources and capture the public's imagination so as to further preservation.

Acknowledgments
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Salisbury, James and Charles Salisbury. 1862. Accurate Surveys and Descriptions of the Ancient Earthworks at Newark, Ohio. Transcribed from the original by B. T. Lepper and B. T. Simmons: Unpublished manuscript, American Antiquarian Society, Worcester, Massachusetts.

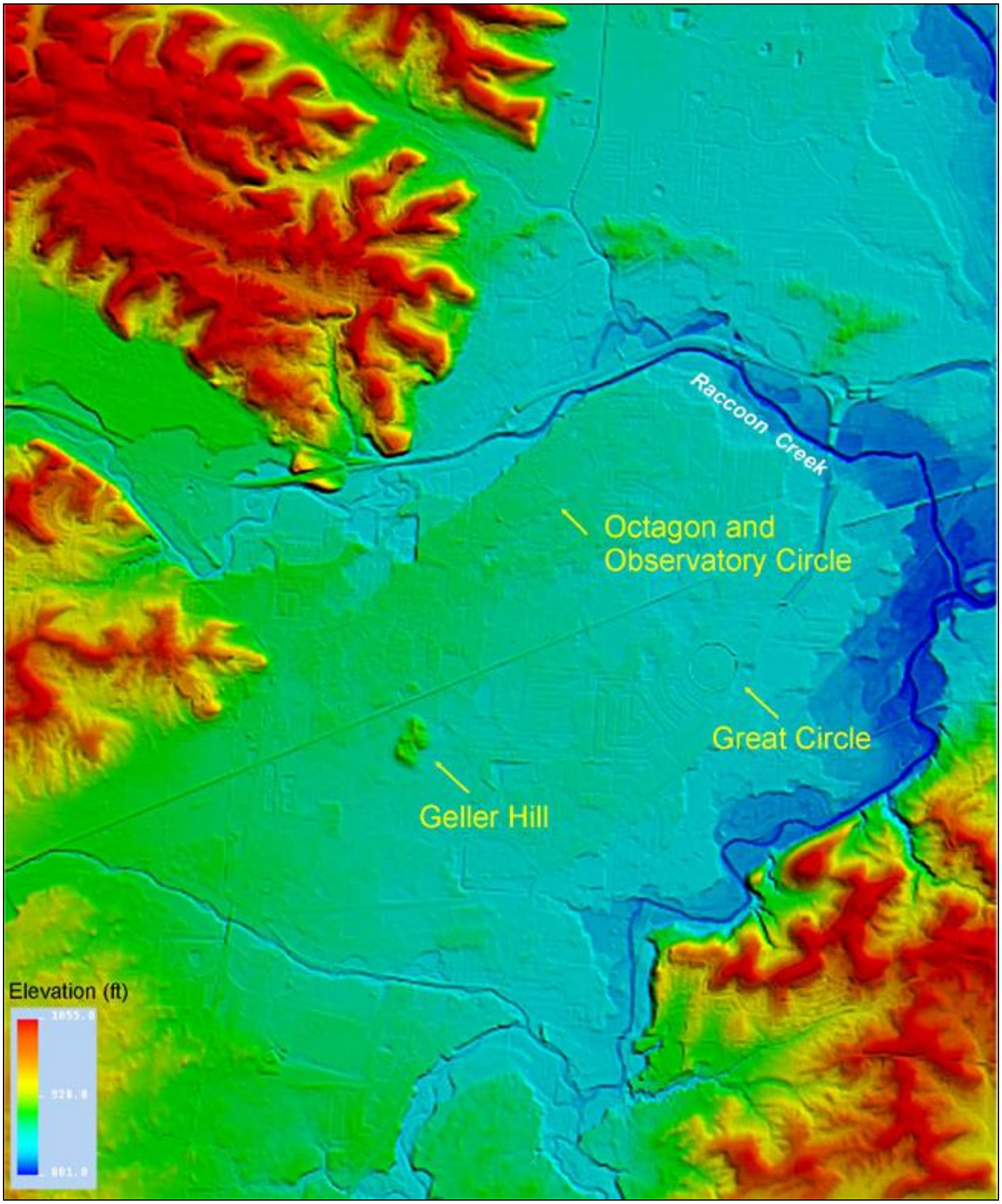

Figure 1. Lidar image of the Newark basin.

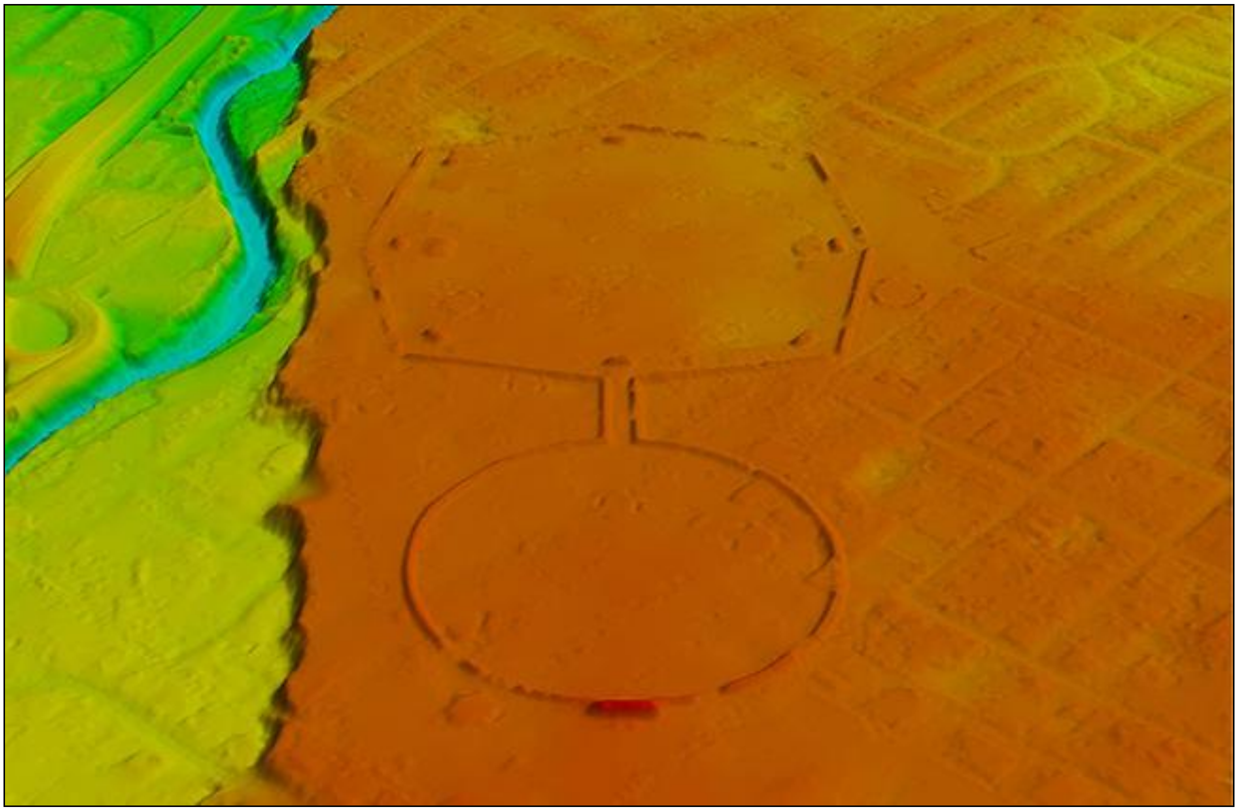

Figure 2. Oblique view of the Observatory Circle and Octagon.

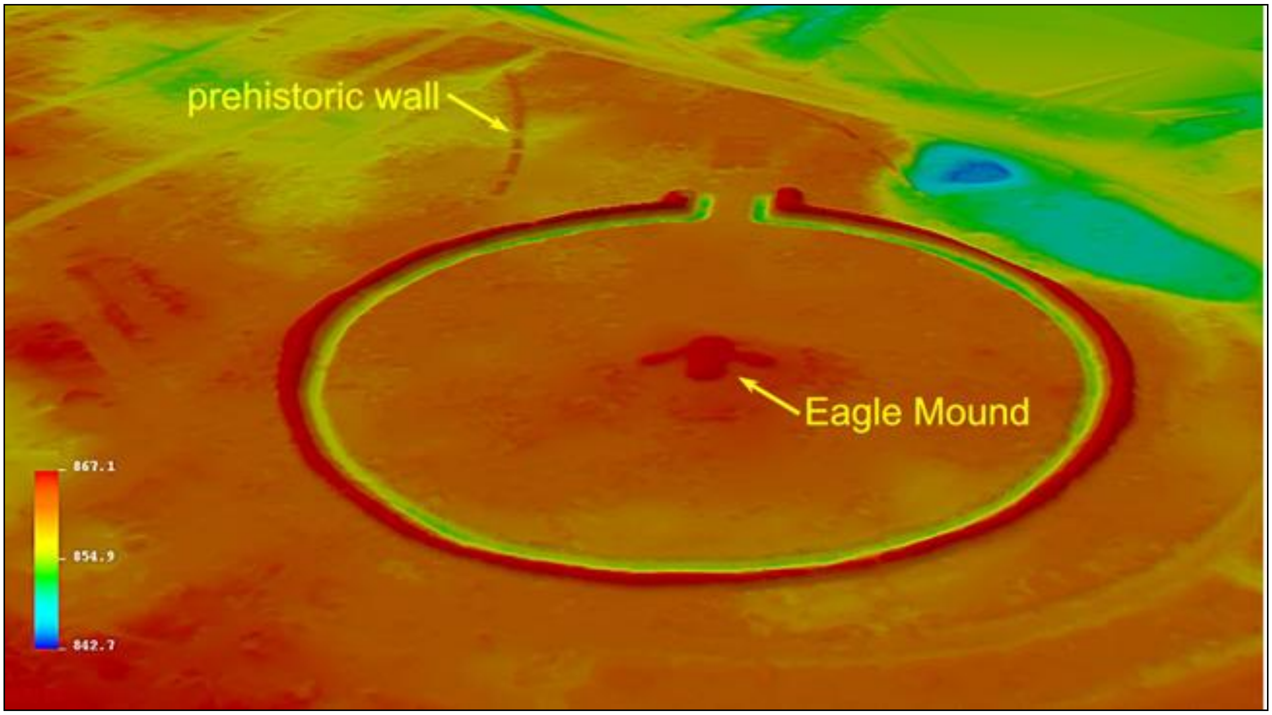

Figure 3. Oblique view of the Great Circle.

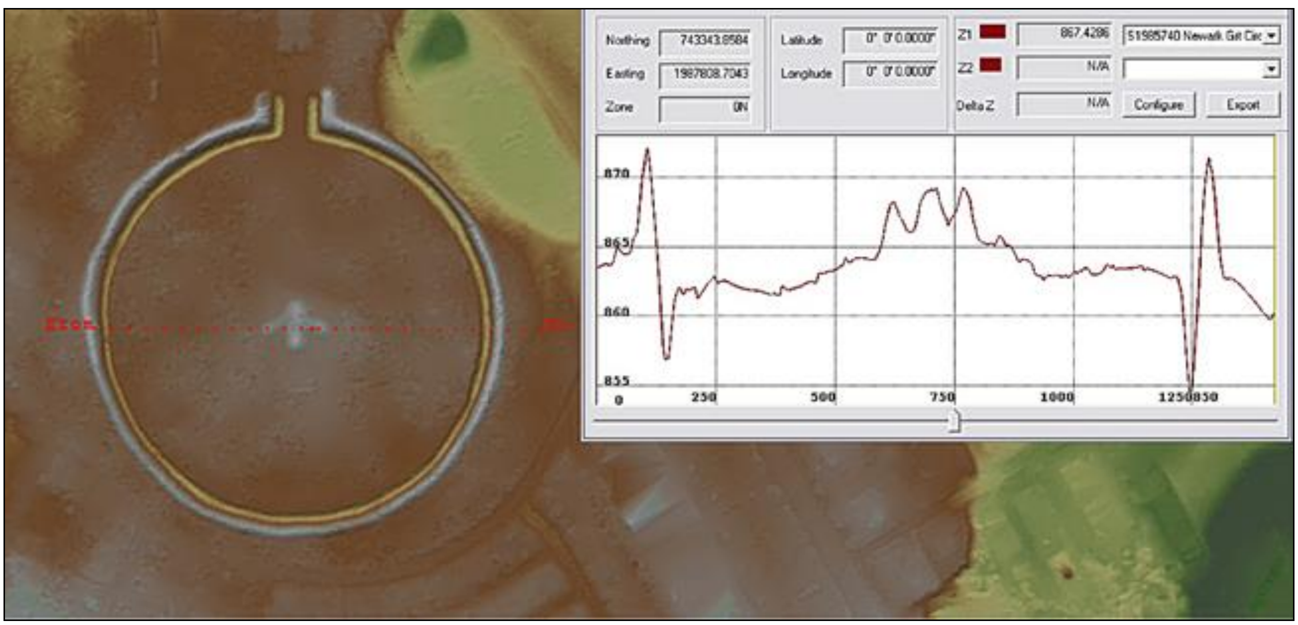

Figure 4. Examining profiles in Lidar data.

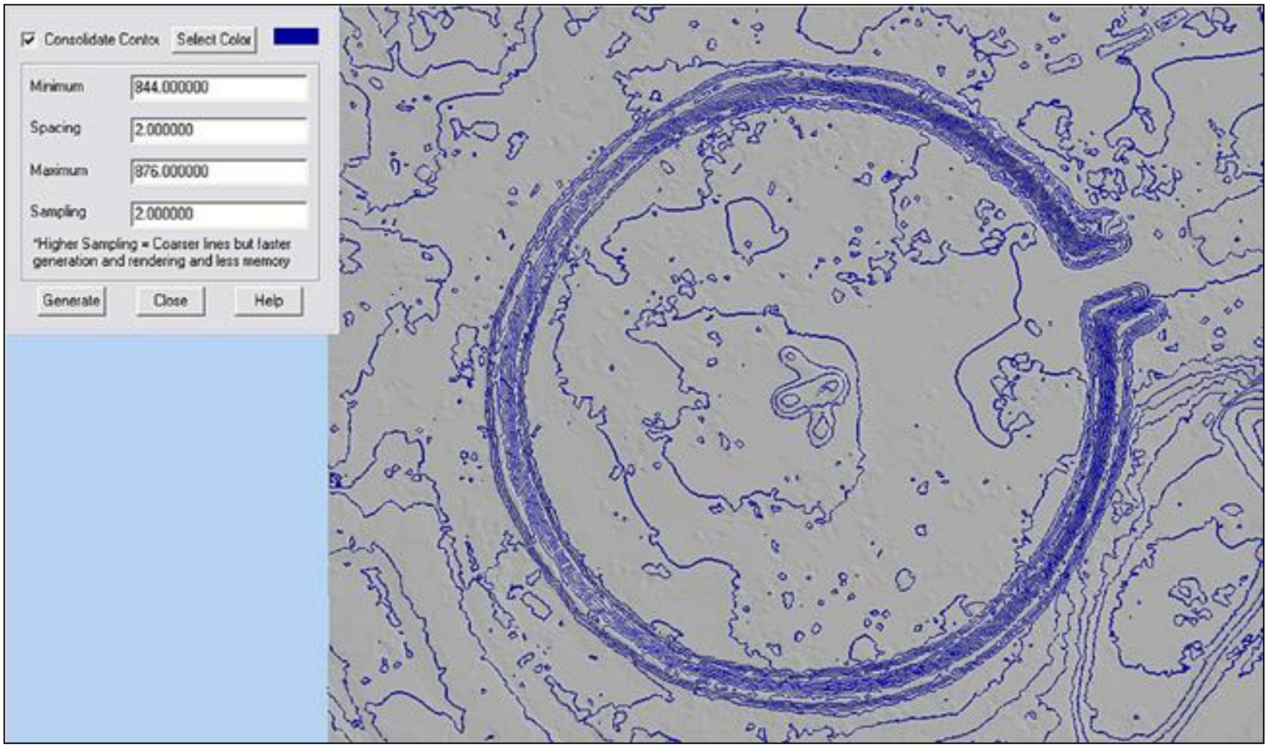

Figure 5. Contouring Lidar data at the Great Circle.

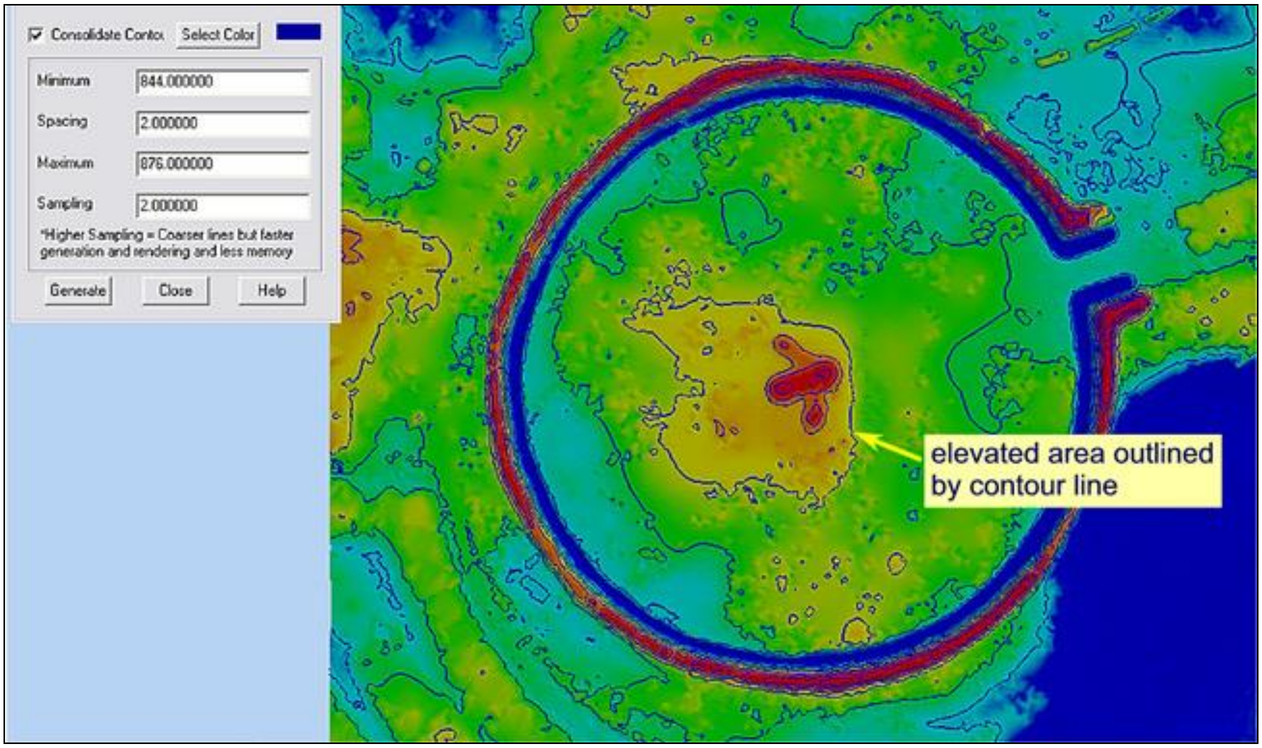

Figure 6. Filled counters at the Great Circle.

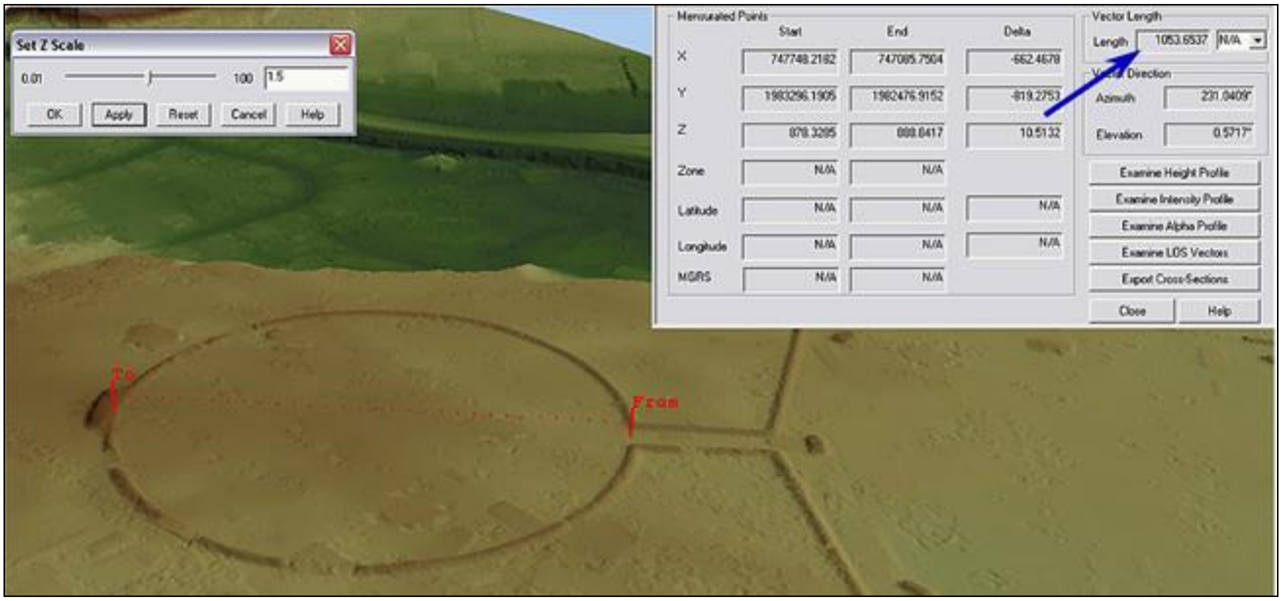

Figure 7. Measuring earthworks using Lidar data.

Figure 8. Looking for other kinds of alignments in Lidar data at the Observatory Circle-Octagon.

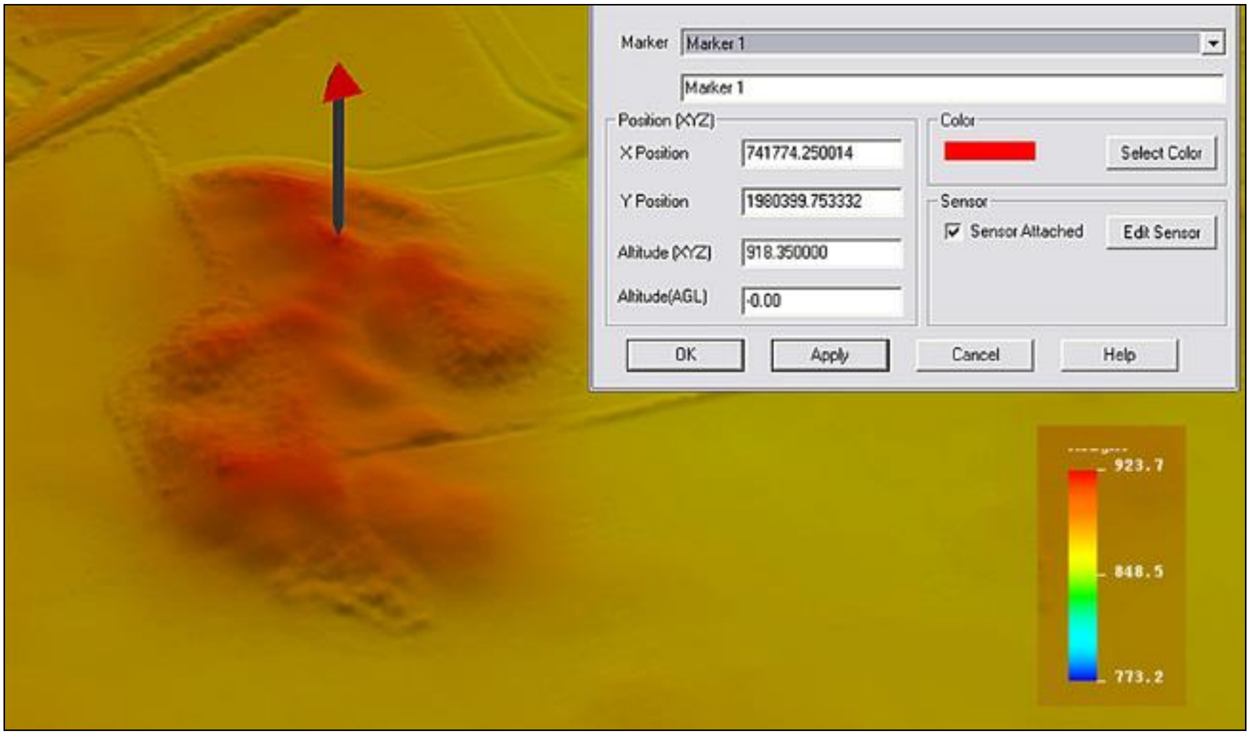

Figure 9. Placing a marker on Geller Hill and measuring elevation.

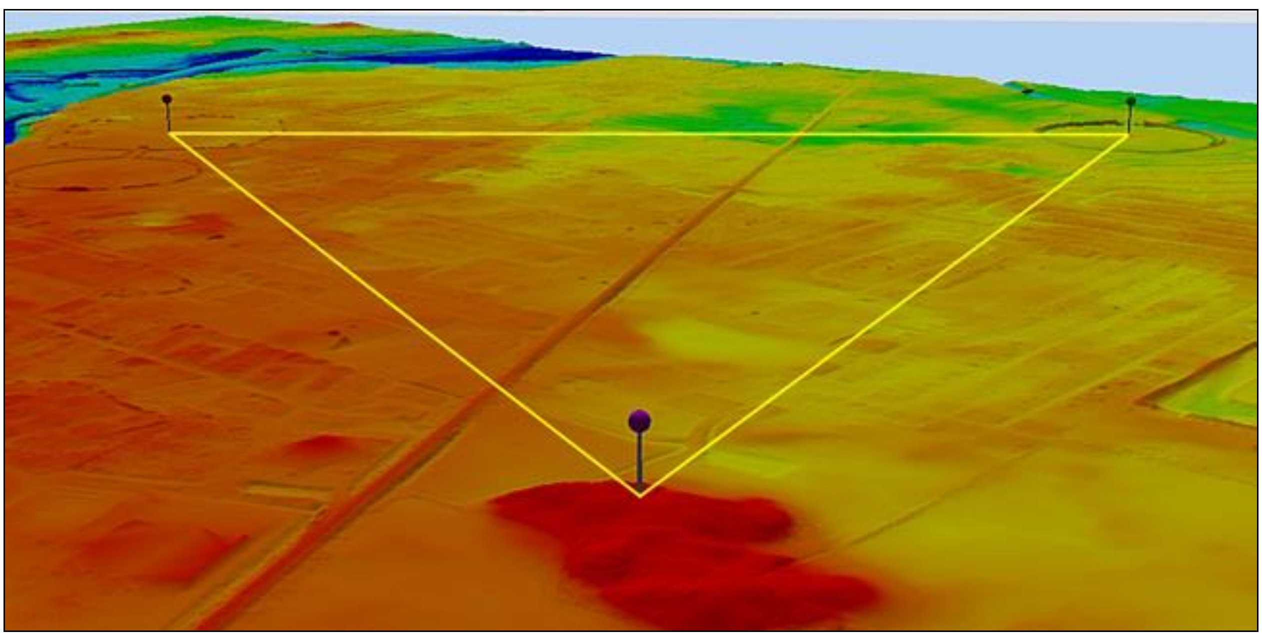

Figure 10. Examining the relationship of markers placed at other features within the Newark Earthworks.

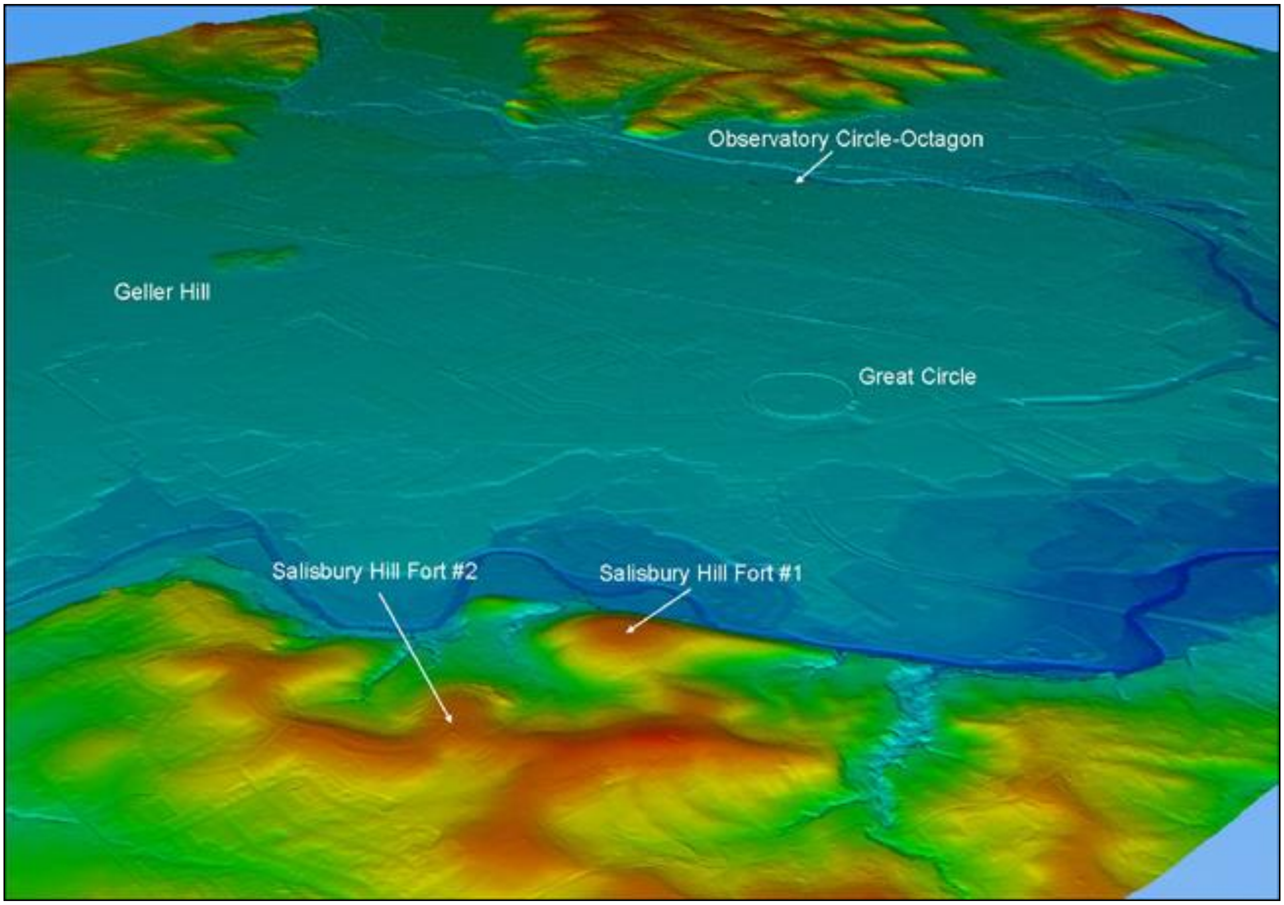

Figure 11. Using Lidar to examine hard-to-access sites, like the Salisbury Hill Forts above Newark.

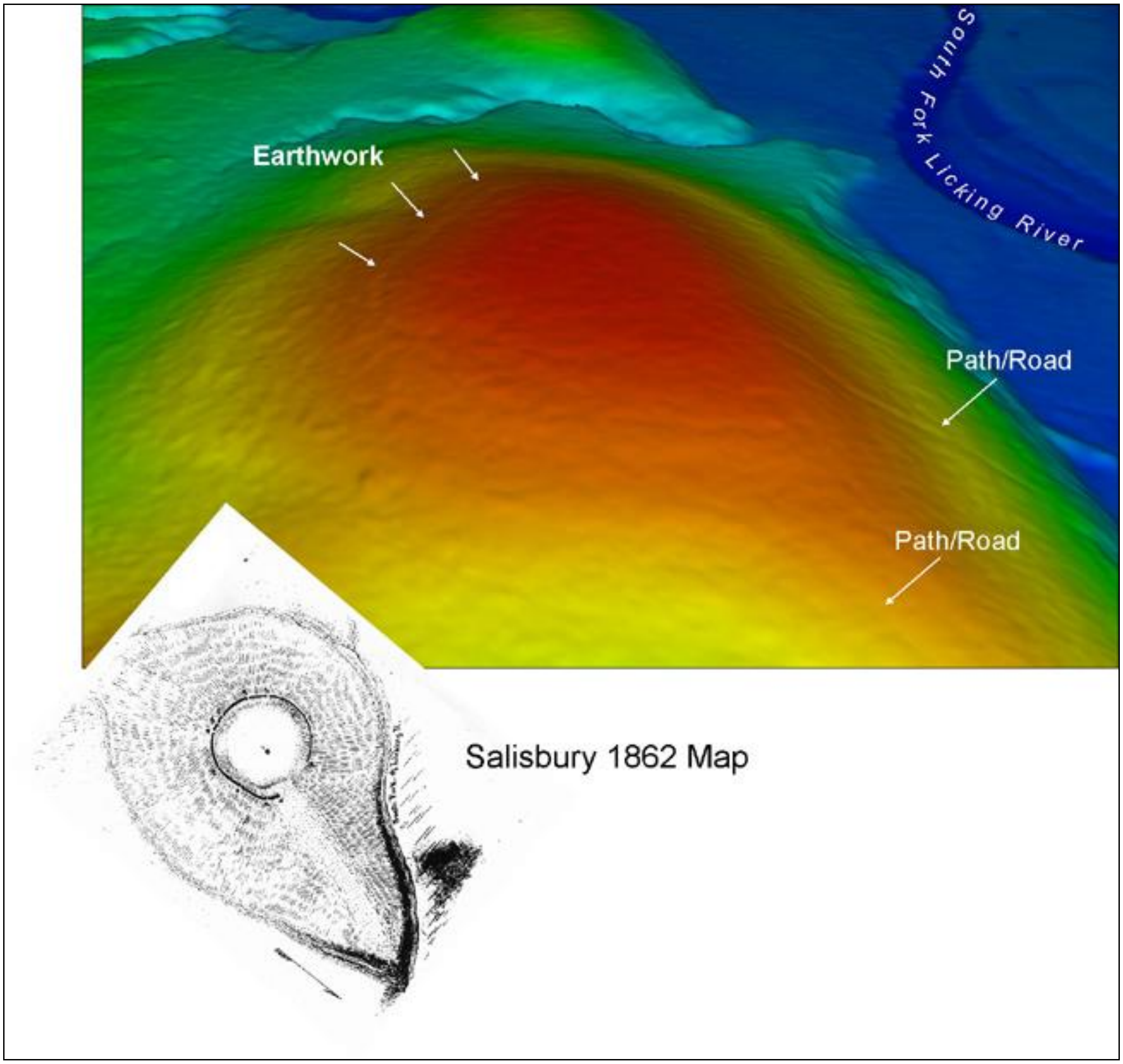

Figure 12. A Close-up view of Salisbury Hill Fort #1. (Salisbury 1862 map courtesy of the American Antiquarian Society)