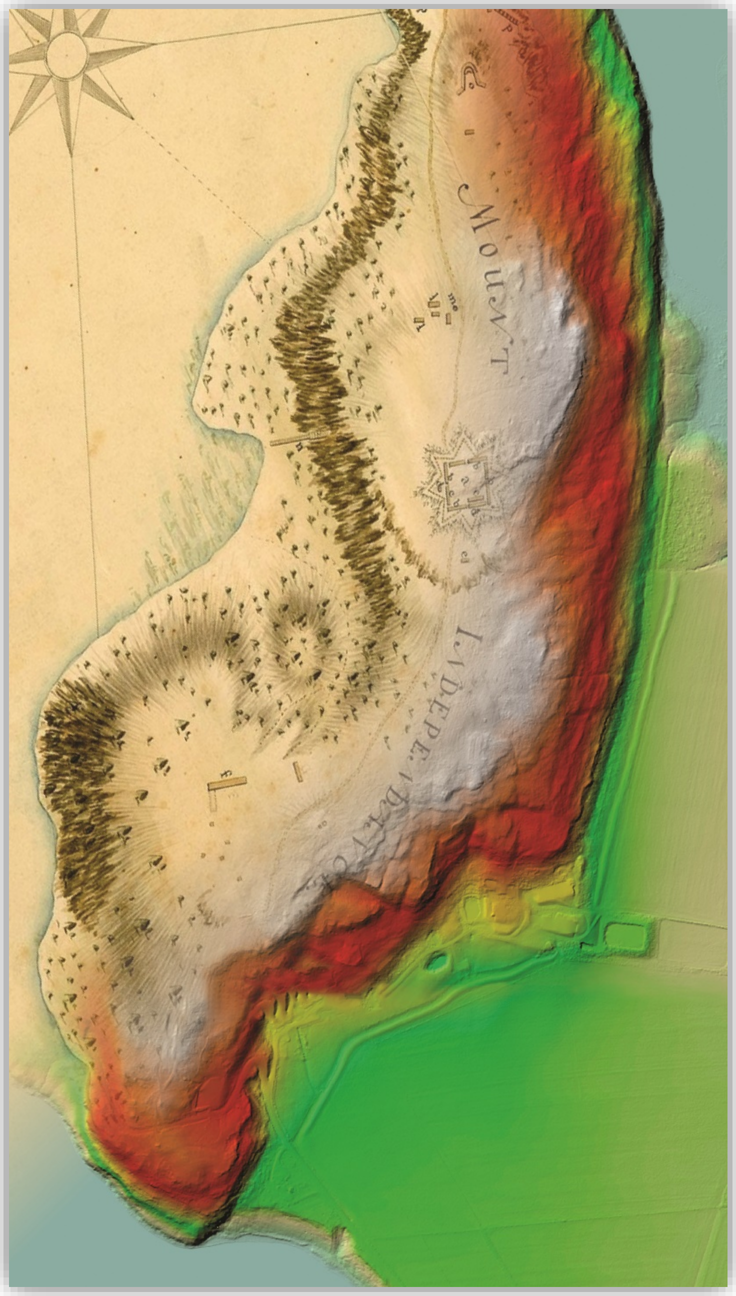
Geospatial Mapping of the Landward Section of Mount Independence Project

Grant #GA-2287-16-020



A Cooperative Project between the American Battlefield Protection Program and the Vermont Division for Historic Preservation

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Acknowledgements

The author and the Vermont Division for Historic Preservation (VDHP) wish to thank the National Park Service, American Battlefield Protection Program and specifically Kristen McMasters, for her assistance through the grant cycle. We also wish to extend our thanks to the Mount Independence Coalition for their support and encouragement. Additional thanks are gratefully extended to: Mike Broulliette, John Crock, PhD, Kate Kenny, Otis Monroe, Brett Ostrum, and Melissa Prindeville for their help with this project.

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Introduction

Mount Independence, now a Vermont State Historic Site and National Historic Landmark, played a pivotal role in the contours of the Revolutionary War's Northern Campaign (NRHP 1971). Combined with the fortifications at Ticonderoga across the narrows of Lake Champlain, the fortifications at Mount Independence enabled the Americans to control a central artery of travel and trade between the Hudson River corridor and Canada through 1776 and into the spring of 1777. Indeed, the Mount Independence/Fort Ticonderoga complex constituted one of the largest defenses built by the Americans during the Revolutionary War, and was known by some as the 'Gibraltar of the North' (Hibbert 1990:169). In the fall of 1776, the military complex at Mount Independence represented one of the largest communities in North America, rivaling the population of Boston.

Today, it contains remnants of the occupations and defensive fortifications of American, British, and German soldiers. Its current status as a State Historic Site assures careful stewardship of the property; yet identification and accurate mapping of the resources are essential to the site's long-term preservation and interpretation.

This grant-funded study sought to create a geospatial map of the southern (landward) portion of Mount Independence; the central locus for a latter American attack described below. It will build upon work completed under previous grants from the South Lake Champlain Fund that facilitated initial identification and Global Positioning System (GPS) point collection of visible features across the Mount, and various locus-level archaeological reconnaissance and data recovery excavations undertaken since the 1960s.

Mount Independence Physical Geography

Mount Independence is located in Orwell, Addison County, Vermont (Figure 1). Prior to the declaration of America's independence, which caused the soldiers to rename it in commemoration of the event, it was known as "Rattlesnake Hill," and is depicted as such on early maps. Although now extirpated from the area, several soldier's accounts mention seeing or hearing rattlesnakes on the Mount or around Fort Ticonderoga, suggesting the name was not idly given.

Mount Independence measures approximately 2.2 km from north to south and slightly less than one km west to east. It is located on the southern portion of Lake Champlain at a narrows less than half a kilometer wide. The lake bounds it to the north and west and East Creek bounds it to the northeast. As such, the Mount can only be approached by land from the south. Although the summit of Mount Independence measures only 92 m (300 ft) above sea level (and approximately 60 m [200 ft] above Lake Champlain), the sides of the majority of the Mount are comprised of vertical cliffs or steep slopes, making it difficult to ascend. Numerous Revolutionary War accounts attest to its natural impregnability (Figure 2).

The limestone of the Mount contains nodules of a black chert that were utilized by Native Americans for over 10,000 years. The same chert was subsequently utilized for gunflints by the American soldiers on the Mount when traditional ballast gunflints became scarce (Turnbull 1934). It was originally forested prior to its Revolutionary War transformation and is currently covered with trees again. The soil on the Mount is quite thin and bedrock can be seen intermittently across its expanse, however. Standing water on the Mount is confined to a single small pond/wetland area, although several wells were dug during the Revolutionary War and after.

Figure 1. Satellite image of Mount Independence (center), Orwell, Rutland County, Vermont, and Fort Ticonderoga, Ticonderoga, New York (top), with Lake Champlain between them. Downloaded from VCGI, June 2018.

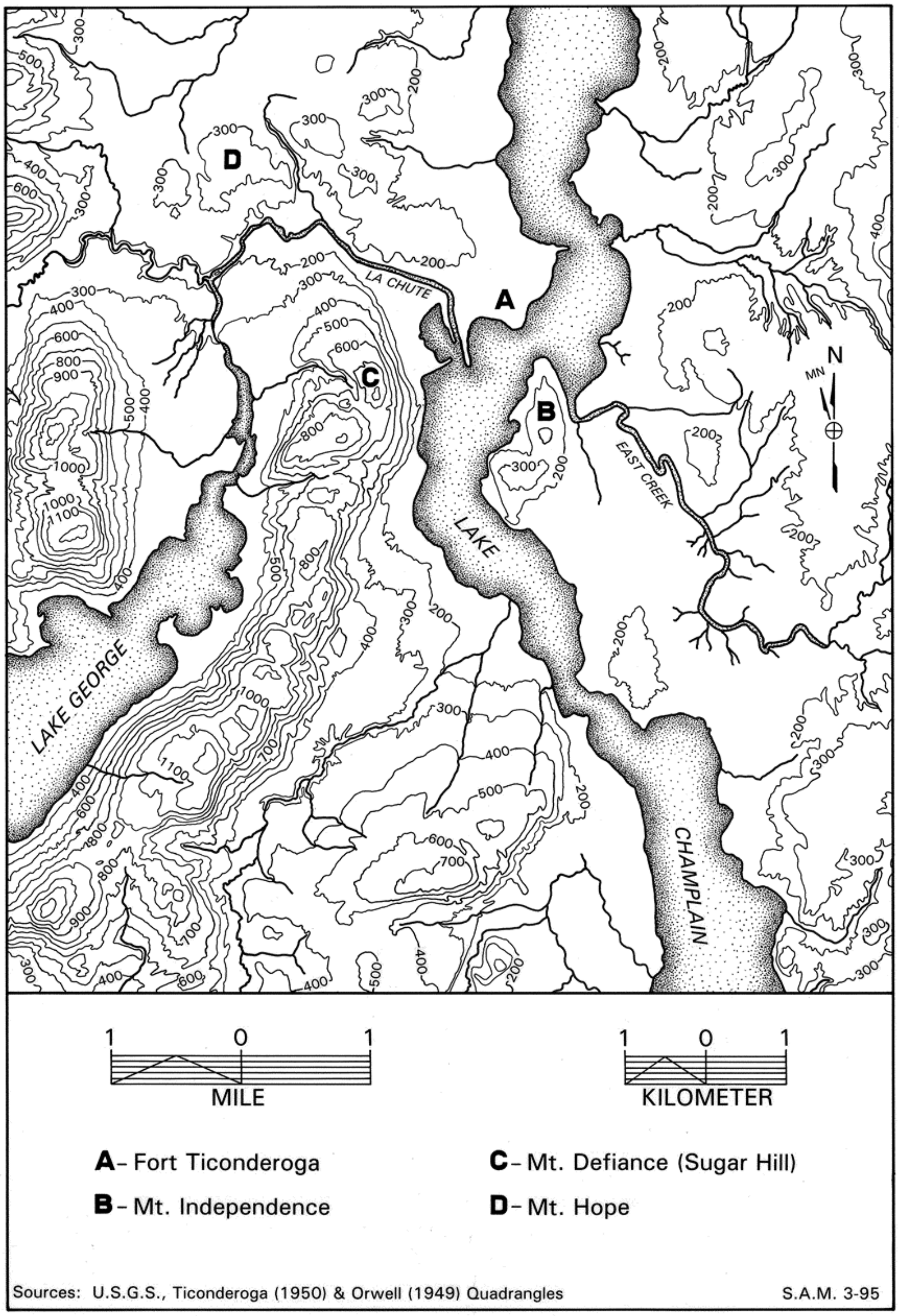

Figure 2. Illustration of Mount Independence and nearby fortifications and waterbodies. Illustration courtesy of the Mount Independence archives.

Historical Background

In the middle of 1776, General Philip Schuyler ordered his American soldiers, many of whom had recently fought in the ill-fated invasion of Canada at the end of 1775, to reoccupy and better fortify the former French Fort Carillon (Ticonderoga) on what is now the New York side of Lake Champlain. He also directed to be built a large defended encampment on the “wooded hill” on the east side of the Lake (Starbuck and Murphy 1994:115). In a letter to George Washington sent on July 12, 1776, Schuyler wrote that:

> On the 8th we returned to Tyconderoga and on the 9th we went over the Ground for the intended post on the East Side, which we found so remarkably strong as to require little Labour to make it tenable against a vast Superiority of Force, and fully to answer the purpose of preventing the Enemy from penetrating into the Country to the South of it” (Schuyler to Washington July 12, 1776).

In October, 1776, the American Engineer Colonel Jeduthan Baldwin began construction of a star-shaped, wooden picket fort on the highest level portion of Mount Independence. The following month he began the construction of eight barracks buildings within the boundaries of the wooden stockade (Starbuck et al. 1989). At around that time, the population on the Mount swelled to between 12,000 and 13,000 people, rivaling the population of Boston.

Meanwhile, in mid-October, Guy Carlton’s British fleet engaged with Benedict Arnold’s small American fleet farther north at the Battle of Valcour Island. Although Arnold and the Americans staged an historic escape, the vast majority of their ships, equipment and munitions were destroyed, leaving Carlton with complete naval dominance of Lake Champlain (Lundeberg et al. 2017). Hoping to take advantage, on October 28 Carlton sailed down the lake with approximately 8,000 men with the aim of clearing the way for the English through to Albany (Starbuck et al. 1989). Arriving within three miles of the defensive positions at Ticonderoga and Mount Independence, however, Carlton witnessed thousands of soldiers encamped behind established fortifications and cannon emplacements. Understanding that winter would soon be upon them, he chose to retreat to Canada rather than engage in a protracted battle against a well-defended enemy. This easy success bolstered American morale and delayed the British advance for nearly a year (Starbuck and Murphy 1994:115).

In order to further fortify their defensive position, obstruct travel, and connect the two sides of the narrows, Jeduthan Baldwin ordered the construction of a chain boom and bridge across Lake Champlain between Mount Independence and Fort Ticonderoga (Cohn 1995a, 1995b; Hibbert 1990:169) (Figure 3). Although it was functionally destroyed on December 14 by wind-driven waves, it was ordered rebuilt by Baldwin and was thereafter under continual repair through the summer of 1777.

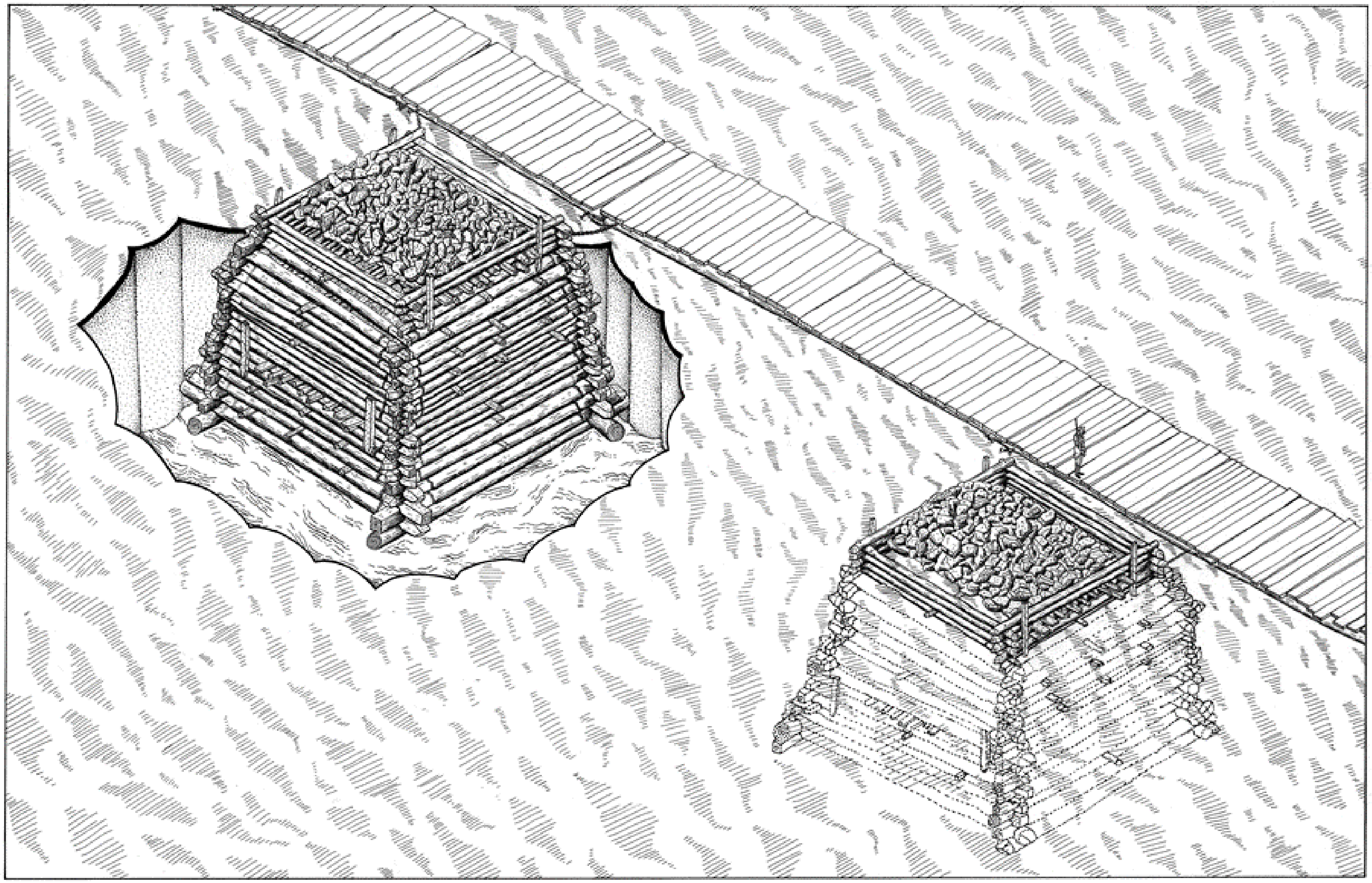

Figure 3. Illustration of the caissons and the “Great Bridge” built by the American engineer Jeduthan Baldwin between Mount Independence and Fort Ticonderoga. Illustration courtesy of the Mount Independence archives.

With the onset of winter, 1776, many men stationed on the Mount were sent home to their farms. Of the 3,000 or so that remained, conditions were extremely difficult. Common soldiers were crowded into rows of thin tents or makeshift cabins, while officers lived in rough planked houses; only some of which apparently contained windows (Starbuck and Murphy 1994). The temperatures were often extremely cold, and the wind blew unabated across the Mount due to the clearcutting of the trees for construction timber and firewood. Starbuck and Murphy (1994:116) report that during the coldest months, an average of seven or eight soldiers froze to death every night. Munsell (1859:81-82) relays the lamentations of one soldier from Pennsylvania:

> Of all this Army at this Place, which did consist of twelve or thirteen thousand Men, Sick and Well, no more than nine hundred Pair of Shoes have been sent. One-third at least of the poor Wretches is now barefoot, and in this Condition obliged to do Duty. This is shocking to Humanity. It can not be viewed in any milder Light than black Murder. The poor Creatures is now (what's left alive) laying on the cold Ground, in poor thin Tents, and some none at all, and many down with the Pleurisy. No Barracks, no Hospitals to go in. ... If you was here, your Heart would melt.

Despite these hardships, Baldwin, later assisted by Thaddeus Kosciuszko, continued to order to be built additional fortifications and infrastructure. Starbuck et al. (1989) estimate that several hundred cabins, artificer's shops, lookout posts and cannon emplacements were built over the period of the American occupation of the Mount. Unfortunately, there are few extant details about these works, apart from a hospital and boat crane that were ordered constructed over the winter (see Starbuck 1990).

As Spring 1777 arrived, it became clear to the new commander Major General Arthur St. Clair that there were insufficient militia returning to the area to effectively garrison the Ticonderoga and Mount Independence forts. Meanwhile, a refreshed army consisting of approximately 8,000 British, German (Hessian), Canadian and Native American troops under the command of Lieutenant General John Burgoyne left Canada for Lake Champlain.

On July 1, Burgoyne's army disembarked on both sides of the lake at a point three miles north of Ticonderoga with the aim of bracketing the American fortifications. Noting a prominent hill (Sugar Hill, now Mount Defiance) with a vantage of the entirety of both forts and bridge, Burgoyne ordered his men to construct a road, haul up cannons, and prepare emplacements. The Americans had earlier noted their vulnerability from the hilltop but surmised that it would be too difficult for the enemy to ascend with heavy munitions. Nevertheless, by July 5th British cannons were being readied at the summit.

Outnumbered more than two to one, and seeing their position now indefensible from cannon fire, St. Clair ordered a covert retreat from both forts on the night of July 5-6, 1777, setting the stage for the famous rear-guard action at the Battle of Hubbardton several days later. British forces and their Hessian mercenaries thereafter took over the fortifications on Mount Independence, which remained largely intact due to the Americans' desire to leave silently and without destructive fires.

Indeed, a junior officer in the Reidesel Hessian regimen wrote that:

> We were astounded when we caught sight of the place. There was one earthwork after another, each rising above the previous one, eleven to twelve in number. On the beach there was also one trench after another, and [both] shores were studded with cannon … The artillery stretched all the way from the water's edge right up to both the [stone] citadel and Fort Independence, one gun protruding above the other. The magazines – crammed with flour, meat, coffee, wine, porter beer, sugar, medicines, etc. – held stock in superabundance … (Barker 2006, quoted in Morgan 2016).

Henry Watson Powell, a General in Burgoyne's army, was given charge of the contingent at Fort Ticonderoga and Mount Independence. They set about building additional block houses on the landward side of the Mount, surmising that an American attack would likely come from land. On September 10, Powell heard word that all communication lines between Burgoyne's command and their position had been severed by the Americans. As such, Powell was forced to assume an independent command (Wickman 1995). He intuited that this action presaged an attack of some kind on the Mount, and he stood his soldiers at alert and ready for action (Friedrich von Hille [1777] 1993; Wickman 1995).

Powell was right to fear an attack. American Sergeant James Warner, who had recently escaped a make-shift prison near Lake George, provided to the American command detailed intelligence about the strength and position of the British around Mount Independence and Ticonderoga (Wickman 1995). It was determined that their overall situation was weak and undermanned. Nevertheless, Colonel John Brown noted that "…the Enemy have fortifyed Independence in such a Manner that by the block Houses and Redoubts which they have erected, together with their Shipping, they can cover and defend the whole of the Ground on Independence. The Enemy have about 700 Men in the Mount 500 of which they can turn out on an Emergency…" (Brown [1777] 1920: 292-293). Indeed, the natural cliffs facing the southern (landward) portion of the Mount, combined with a three-tiered defense of lower-tier abatis, middle-tier batteries, and top-tier blockhouses provided a formidable defense. Therefore, the Americans chose to avoid a direct attack on the Mount with the objective of taking it over. Instead, Colonel Samuel Johnson was ordered to take a detachment of troops to the Mount to attack its works if the opportunity presented itself, but otherwise to keep the soldiers engaged and in place as part of a larger series of actions in the Ticonderoga – Lake George area.

On the morning of September 18, Johnson's detachment attacked a British picket approximately 2500 feet south of Mount Independence on the Hubbardton Road. Afterward, they quickly moved through the woods toward Mount Independence. They attempted to overtake the second and third batteries (manned by Hessian mercenaries and the 53rd British regiment respectively), but heavy cannon fire from the batteries and grapeshot fired by the frigates *Maria* and *Carlton* moored just south of the Mount in the lake eventually repelled them (Friedrich von Hille [1777] 1993; Wickman 1995).

Meanwhile, on the other side of the lake, Colonel Brown had a number of quick successes achieved through the element of surprise (Brown 1777). These included the capture of the defenses on Sugar Hill (Mount Defiance), the capture of 293 soldiers and their arms, a total of 150 bateau between Lake George and Champlain, one armed sloop, seventeen gun boats, several cannons and ammunition, and provisions. In addition, they released 100 American prisoners (Brown 1777; Wickman 1995).

After this initial surprise attack, the Americans on both sides of the Lake stalemated with their British and Hessian adversaries for five days. On several evenings, Johnson's detachment engaged primarily with the second and third batteries on the Mount, causing them to expel a great deal of rifle and cannon fire, but no ground was won. Finally, late in the evening of September 23, the Americans on both sides of the lake slipped away.

Although these engagements were considered by earlier generations of researchers to be largely ineffectual, a review of the available documents and other recent research indicates that, in fact, they were very successful indeed. They harried the British significantly, destroyed important equipment, cannons, infrastructure, and released a large number of their prisoners. Perhaps most notably, however, they released all of the livestock in the area and otherwise appropriated stores of provisions from the British. In the subsequent months, the lack of provisions on the Mount and Ticonderoga would be a prove to be a significant impediment to the fighting ability of the British. The latter American attack on the southern portion of the Mount, and the relevant natural and archaeological signatures that were or may have been a part of it, were the subject of the grant-sponsored work this report summarizes.

KOCOA Analysis

Prior to beginning the field work and analyses summarized herein, the project manager conducted a KOCOA [key terrain (K), observation and fields of fire (O), cover and concealment (C), obstacles (O) and avenues of approach and retreat (A)] analysis in order to better frame the battlefield. The KOCOA system was developed by military experts to understand and analyze the defining features of a field of battle. This system has since been adapted by archeologists to understand the features of battles in the past and appropriately frame analyses. From the literature review conducted in preparation for our grant work, and from earlier pedestrian surveys, a number of natural and built features pertinent to the battle of 1777 along the southern portion of the Mount were identified for this KOCOA analysis.

The engagement that constituted the primary focus of the grant-sponsored work took place between September 18 -23, 1777. As summarized above, the engagement at Mount Independence was but a part of a series of planned actions at and around Fort Ticonderoga, Mount Defiance, and Lake George. The order of battle at Mount Independence was between a detachment of approximately 500 American militia under the direct command of colonel Samuel Johnson (Wickman 1995) against the entrenched Hessian (German) and British soldiers on the Mount. Specifically, a company of Germans under the direct command of Major General von Stammer was stationed at the first battery, the companies of Major von Hille, Captain von Tunderfeldt, and Captain Dietrichs were stationed on the lines surrounding the 2nd Battery, where the company of Lieutenant Colonial Prätorius was stationed. Finally, five companies of the British 53rd Regiment were stationed at the 3rd Battery, although they were very weak with probable dysentery or food poisoning (Friedrich von Hille [1777] 1993). The other soldiers stationed on the Mount were principally engaged with the Americans on the other side of the Lake. Existing documents do not discuss the weather over the five-day engagement at length, except to note that the initial attack by the Americans was aided by thick morning fog. The subsequent engagements on the mount were all carried out at night.

The Americans had only small arms at hand during the engagement (Wickman 1995). Friedrich von Hille (1777] 1993) wrote that the British and Germans stationed at the batteries were issued muskets with 60 cartridges at hand and 40 in reserve. Bayonets were also issued to each soldier and were to be employed should the Americans overtop the batteries. The number of cannons positioned along the landward portion of the Mount is not clear, although it appears that each battery had at least one; as did some of the blockhouses. The frigates *Maria* and *Carleton* were well-equipped with canons and Friedrich von Hille (1777] 1993) noted that they fired fusillades of grape shot upon the Americans during the initial attack on the morning of September 18, 1977.

Key and Decisive Terrain

- Mount Independence (British): The Mount was the single-most important feature within the field of battle. Its height provided an unobstructed view of the landscape on all sides and its steep cliffs meant that it was well-protected. The American and subsequent British occupations on the Mount also meant that there were provisions, munitions, equipment, and infrastructure that could be leveraged.
- Batteries: The three middle-tier batteries were placed upon level terraces along the southern cliff faces. They were specific key terrain features and were the subject of the Americans' attacks. They provided a broad view and fields of fire across of the flat plains and Hubbardton Road to the south (Figures 1 and 2). They also provided defense to the lowest-level abatis. It should be noted, however, that records indicate that many abatis were disassembled and burned during the winter of 1776-1777 for fuel, and so it is unclear if or how extensively they were rebuilt by the time the American detachment attacked the Mount.
- Blockhouses: The extant records and maps suggest that the upper-tier defense consisted of five blockhouses (some only partially constructed). These blockhouses were situated near or at the precipices of the cliffs. They had an unobstructed view of the flat plains to the south, had good fields of fire, and provided cover to the middle and lower-tier defenses.
- Bateau Bridge (British): the bateau bridge provided a means to prevent or monitor access into and out of East Creek and allow soldiers to cross to the land on the other side (Barker and Huey 2010:160-163). The only depiction of its position is from a map drafted by von Creutzbourg (Barker and Huey 2010:162). Because that map also depicts the British defenses and their fields of fire, the bateau bridge apparently had cannons emplaced upon it.

- Bay to the south of the American position: Two British frigates, the *Maria* and *Carleton*, were moored in a bay immediately south of Mount Independence. They guarded against any American naval passage up the lake, and also provided an angle of fire onto the plain that could not be achieved from the Mount (Barker and Huey 2010:162). Because of the high banks along this section of the lake, however, it is unclear how clearly they could have seen their targets on land.

Observation and Field of Fire

Observation

- Mount Independence (British): The Mount provided an unobstructed view of the landscape on all sides. Nevertheless, because of the Mount's prominence, its defenses could be readily viewed by the Americans within the forest to the south.

Fields of Fire

- The British fields of fire are primarily taken from von Creutzbourg's map (Barker and Huey 2010:162) (red in Figure 4). Fields of fire are shown from the frigates *Maria* and *Carleton* onto the plain to the east of the Mount, from the batteries onto the plain and Hubbardton Road, and from the bateau bridge south onto the plain. Presumably, fire was also coming from the blockhouses above the batteries, but specific fields of fire are not denoted. They would presumably be similar to the batteries.
- The American fields of fire can only be inferred indirectly (blue in Figure 4). From the research that resulted in the summary above, it appears that the Americans primarily concentrated on attacking the second and third batteries, and fields of fire have been rendered to reflect this.

Cover and Concealment

Cover

- Abatis (British): The lowest-tier defense on the Mount consisted of wooden abatis. These would have been provided some cover and concealment to the British and Hessian soldiers behind it. However, it is not now clear how intact this first defensive tier was after the Winter of 1776-1777.
- Batteries (British): The batteries on the middle-tier provided significant cover and concealment for the soldiers behind them, although the batteries themselves were likely readily seen from the plain below.
- Blockhouses (British): The blockhouses would have provided significant cover and concealment to the British and Hessian forces.
- Log Lines (British): The 1777 Wintersmith map of Fort Ticonderoga and Mount Independence indicates that the Americans constructed a near-continuous line of logs as a defensive wall along the cliff edge on the southern and eastern portions of the Mount. It is not clear how much of this line remained intact in the summer of 1777.

    - Log Houses (British): Several log houses were situated near the blockhouses on the upper portion of the Mount and would have provided cover and concealment.

Concealment

    - Forest (American): The Americans' primary means of concealment (and cover to a lesser degree) was to position themselves in the forest to the southeast of the Mount.
    - The major positions of the Germans and British could not be concealed due to their prominent positions on the landscape

Obstacles

Natural Obstacles

- Mount Independence (British): The Mount itself was a significant obstacle. The steep cliffs along its southern and eastern sides offered a significant impediment to any enemy attack.
- Lake Champlain: the lake provided a fixed boundary to the west, north, and northwest.
- East Creek: East Creek was also a significant obstacle along the northeast of the field of engagement.

Reinforcing Obstacles

- Abatis (British): The lowest-tier defense on the Mount.
- Batteries (British): The periodic middle-tier defenses on the Mount.
- Blockhouses (British): The upper-tier defense on the Mount
- Log Lines (British): a near continuous line of logs as a defensive wall along the cliff edge on the southern and eastern portions of the Mount.

Avenues of Approach/Withdrawal

- Hubbardton Road: The Hubbardton Road was the single avenue of the Americans' approach and retreat.

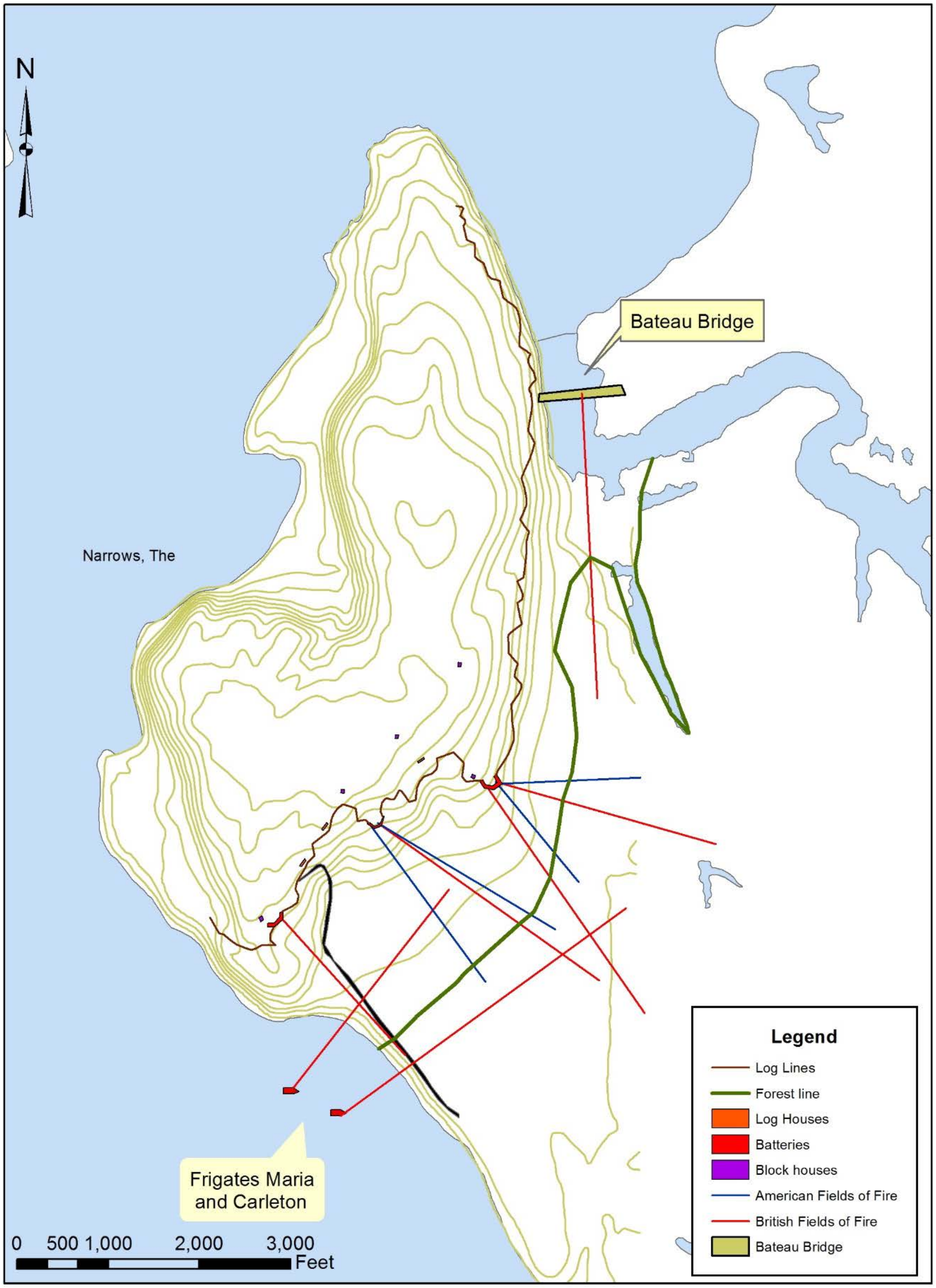

Figure 4. Mount Independence elevation contours with prominent KOCOA features and fields of fire indicated.

Data Sets

The data generation and analyses summarized herein were informed by a wide variety of previously generated data, research, and primary sources. Before the fieldwork began, the project manager met with local historians and experts on the history of Mount Independence to determine appropriate historic records, archives, and maps to consult regarding the fortifications and other infrastructure once located along its southern portion. Thereafter, all relevant historic publications, records, maps, and previous archaeological surveys on the Mount were consulted and in order to understand the universe of possible features or the remnants thereof in the area of study (e.g. Charles 1992; Charles et al.2002; R. Goodwin and Associates, Inc. 1997; Starbuck et al. 1989; Starbuck et al. 1990; Starbuck et al. 1992). These research data were then compared to the previously collected point data in the area to determine in as much as possible the probable nature and function of these features. These Global Positioning System (GPS) points were collected in sections over several days nearly every year since 2008 as part of a number of grants provided by the South Lake Champlain Fund. The combination of this historic background research and GPS point data provided the project manager and the consultant with a critical baseline data set from which to identify and record extant features in real space

The data sets generated as part of the ABPP grant are summarized in greater detail by category below. Data sets collected and interpreted by the consultant and those generated and interpreted by the project manager are explained under separate headings.

LiDAR Coverage

Perhaps the most important data set for this project came to the project manager and consultant serendipitously. The Vermont Center for Geographic Information (VCGI) has been working for a number of years to collect and make available as a map service LiDAR (Light Detection and Ranging) imagery with sub-foot accuracy for the entirety of Vermont. Bare-earth hill shade and slope imagery are among the derived products VCGI generates from the collected LiDAR point cloud data. Although the project manager knew that Addison County had been surveyed by plane the previous year, the imagery was released to the public as a map service and as individual, high-resolution tiles in May of 2017, just as the consultant began their drone survey. This imagery proved invaluable as a means to see features, such as the batteries, that had been formerly obscured by tree cover (Figure 5). It also was an important means to assess topography and perform checks on previously collected GPS points (Figure 6). Its value to the consultant is specifically detailed below.

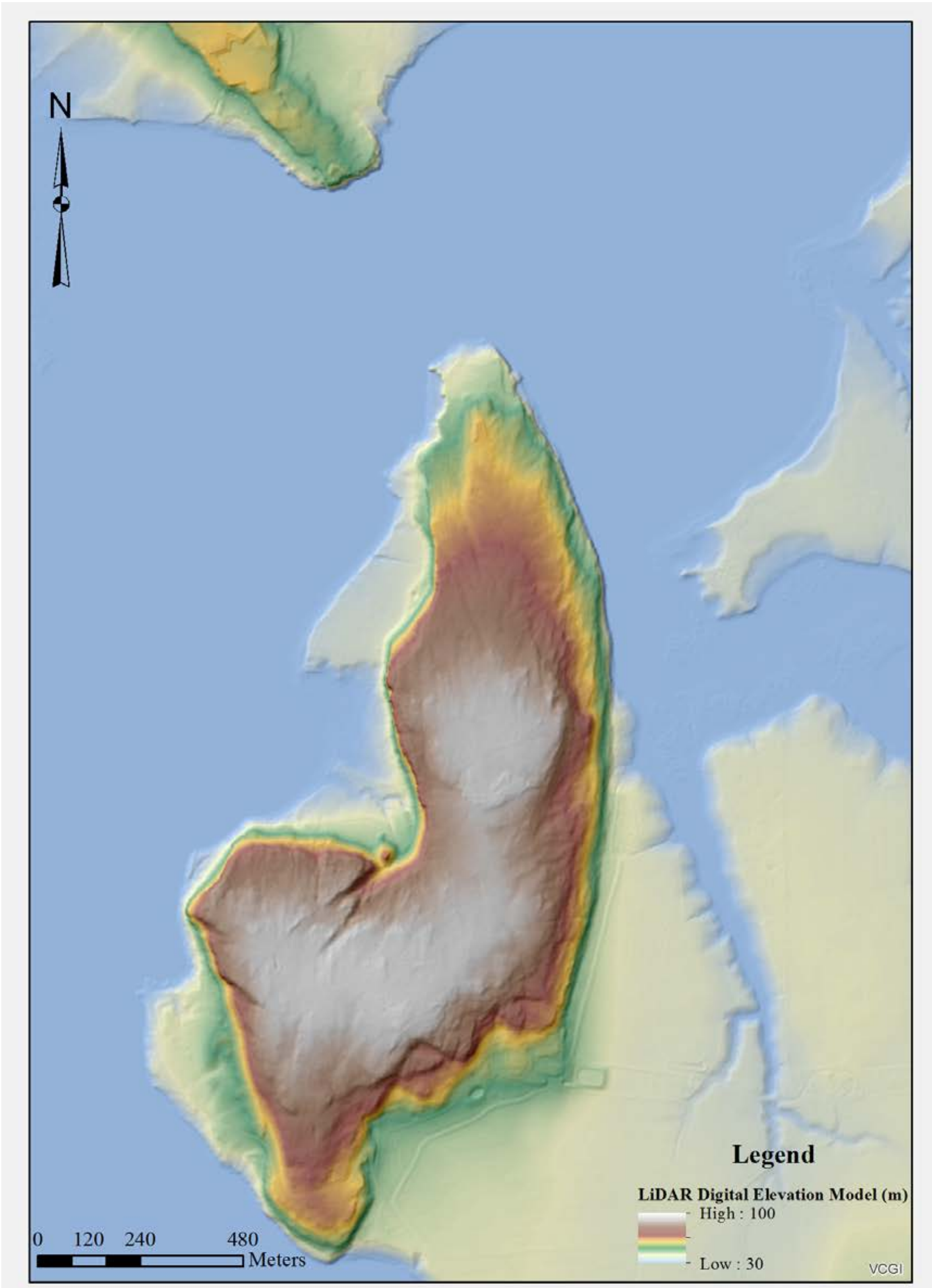

Figure 5. LiDAR hillshade overlaid with a LiDAR digital elevation model of the Mount Independence area. The color shifts indicate elevation changes.

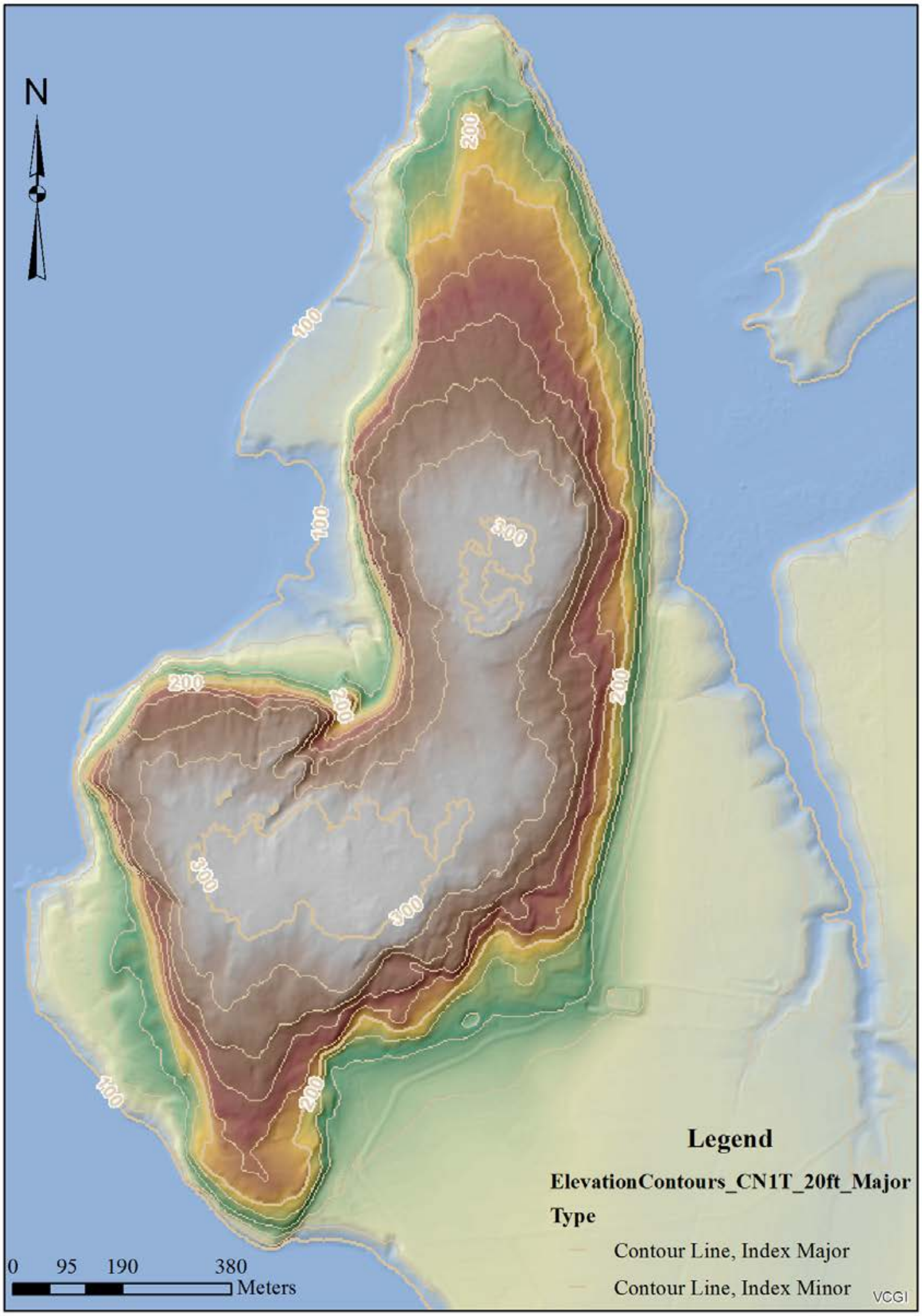

Figure 6. LiDAR hillshade overlaid with a LiDAR digital elevation model the Mount Independence. The color shifts indicate elevation changes. Contour lines show additional detail.

University of Vermont Consulting Archaeology Program Mapping Work

The following sections summarize and excerpt the University of Vermont Consulting Archaeology Program's (UVM CAP) summary report. The complete report is appended to the end of this document (Appendix A). In order to map the archaeological features and natural topography of the landward side of Mount Independence in the greatest detail possible, UVM CAP chose to utilize available remote sensing technologies, in addition to more traditional surface survey and ground-truthing methods. The goal was to build a Geographic Information System (GIS) dedicated to the various data layers contributing to the natural and cultural elements that comprise the southeast portion of the National Historic Landmark. This work was conducted in multiple phases and included the use of an Unmanned Aircraft System (UAS) "drone," a high precision GPS, and ground-level photogrammetry. The composite of data collected was viewed and archived within ESRI's GIS platform (ArcMap 10.4) in conjunction with existing spatial datasets.

Unmanned Aircraft System Flights

The UVM CAP collaborated with the UVM Spatial Analysis Laboratory (SAL) to utilize their UAS to develop a digital elevation surface model (DSM) for the property. A licensed pilot from UVM SAL flew the project area using the *senseFly eBee RTK* UAS on May 4, 2017. Six 25-minute flights were conducted over the project area at an average elevation of 399 ft above ground level in overlapping parallel and perpendicular flight lines. All flights were completed in compliance with FAA Section 333 exemption and FAA Part 107 UAS regulations.

The data gathered during the aerial survey was then processed by UVM SAL using *Pix4D* to generate overhead imagery in a 3-band, true color, GeoTIFF format, orthorectified in NAD 1983 StatePlane Vermont, survey meters. The resulting imagery has 5cm maximum pixel size, and horizontal accuracy +/- 10cm or better (hard ground surfaces). This orthoimagery has a much higher resolution than services such as ESRI's and/or Google Earth currently provide (Figure 7). It will serve as an important reference of tree cover, trail alignments, and visible features, among other attributes, for the foreseeable future.

The orthoimagery was then converted into a photogrammetrically derived point cloud in LAS (3-D point cloud interchange) format with image matching key points from all photos with vertical accuracy of +/- 10cm or better (hard ground surfaces). A photogrammetrically derived raster surface model was then generated from the point cloud. A Digital Surface Model (DSM) was subsequently produced in GeoTIFF format (Figure 8).

The digital surface model was the primary goal of the UAS flight. It was hoped that flying the drone before full leaf-out conditions would provide ultra high-resolution elevational detail for the southern portions of the property. Unfortunately, even though leaves were largely still in their bud phase, the density of trees in many areas caused a significant amount of opacity from above and therefore resulted in a lack of desired detail in those areas closer to the ground surface upon interpolation of the points into a mesh. Nevertheless, some of the importance of achieving full coverage through the drone flight was mitigated through the release of the LiDAR data. Instead, the DSM provides higher-resolution coverage of areas without trees than even that of the LiDAR data, such as portions of the top of the Mount and in areas around the third battery, and provided a good record of elevation, modern Mount conditions, tree cover and even individual trees in other areas.

For instance, Figures 9 and 10 show two notable instances of the remarkable resolution provided from the DSM in open areas. Figure 9 shows an unidentifiable earthen feature near the second battery (Loci 112). This feature is barely perceptible on the ground and its function is currently unclear. It may be related to the second battery, but excavation would be required to confirm its origin for function. Figure 10 also highlights an unidentifiable earthen feature. This feature is also barely perceptible, and may be related to the period when a portion of the mount was used as farm land. Indeed, the shallow plow scars from that time are also still visible, even though the area hasn't been cultivated in decades. The straight rock wall adjacent to these features also appears to be a post-Revolutionary War farm construction and is not related to the wartime occupations on the Mount.

The interpolated digital point cloud from the drone was also found to have high value, particularly when rotated using software such as ESRI's ArcScene or the free software CloudCompare; both of which allow manipulation of three-dimensional point datasets. In particular, the imagery provides a dynamic perspective on the landward approach not available with two-dimensional imagery. Using software such as CloudCompare, the user can change perspective and zoom in and out looking at the Mount from the perspective of a military approach and in relation to defenses. The color point cloud also can be used to geolocate specific features, including individual trees, which can be helpful in identifying, on the ground, specific archaeological sites and landscape features (Figure 11).

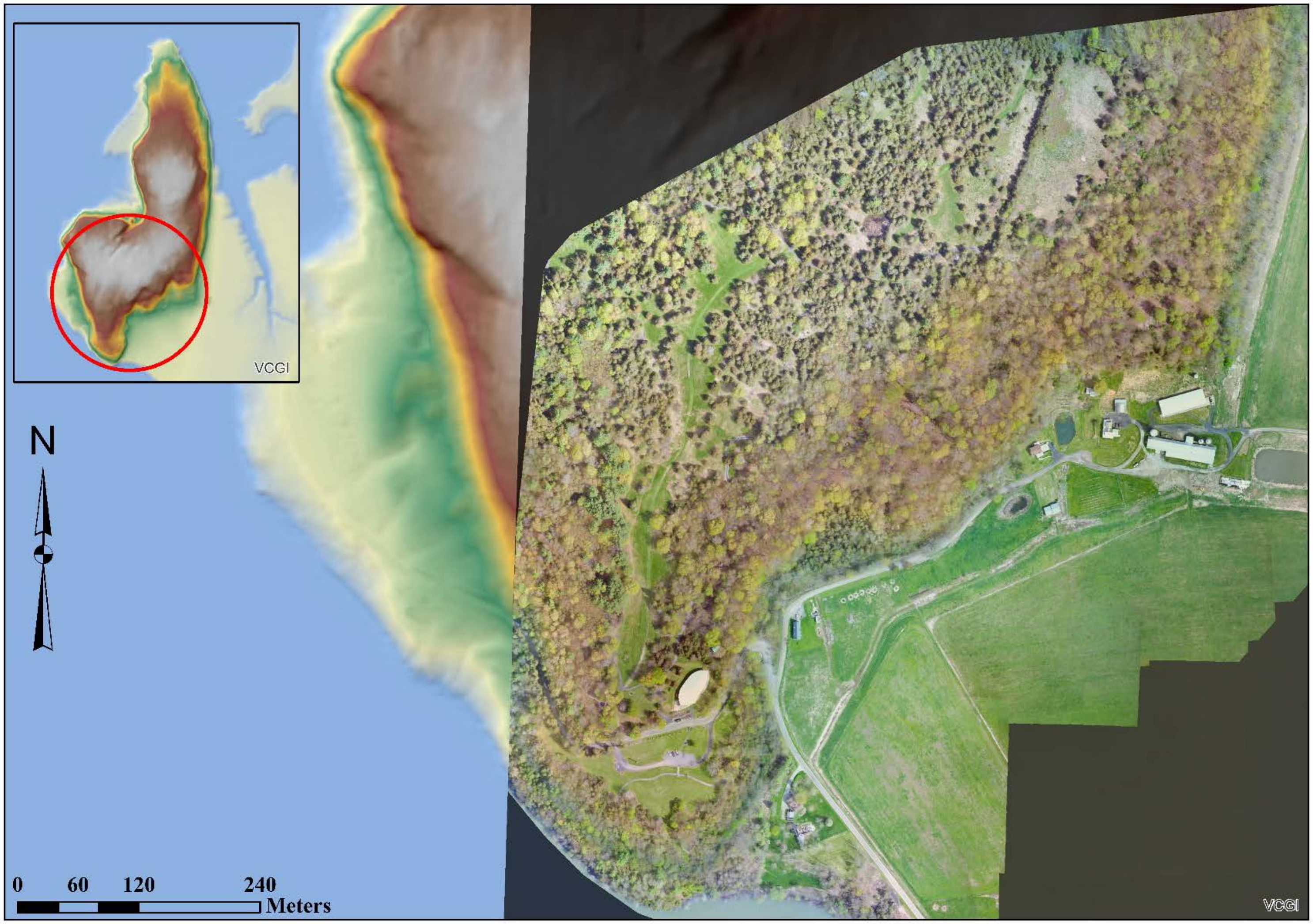

Figure 7. High-resolution orthoimage of the southern portion of Mount Independence constructed from UAS photographs.

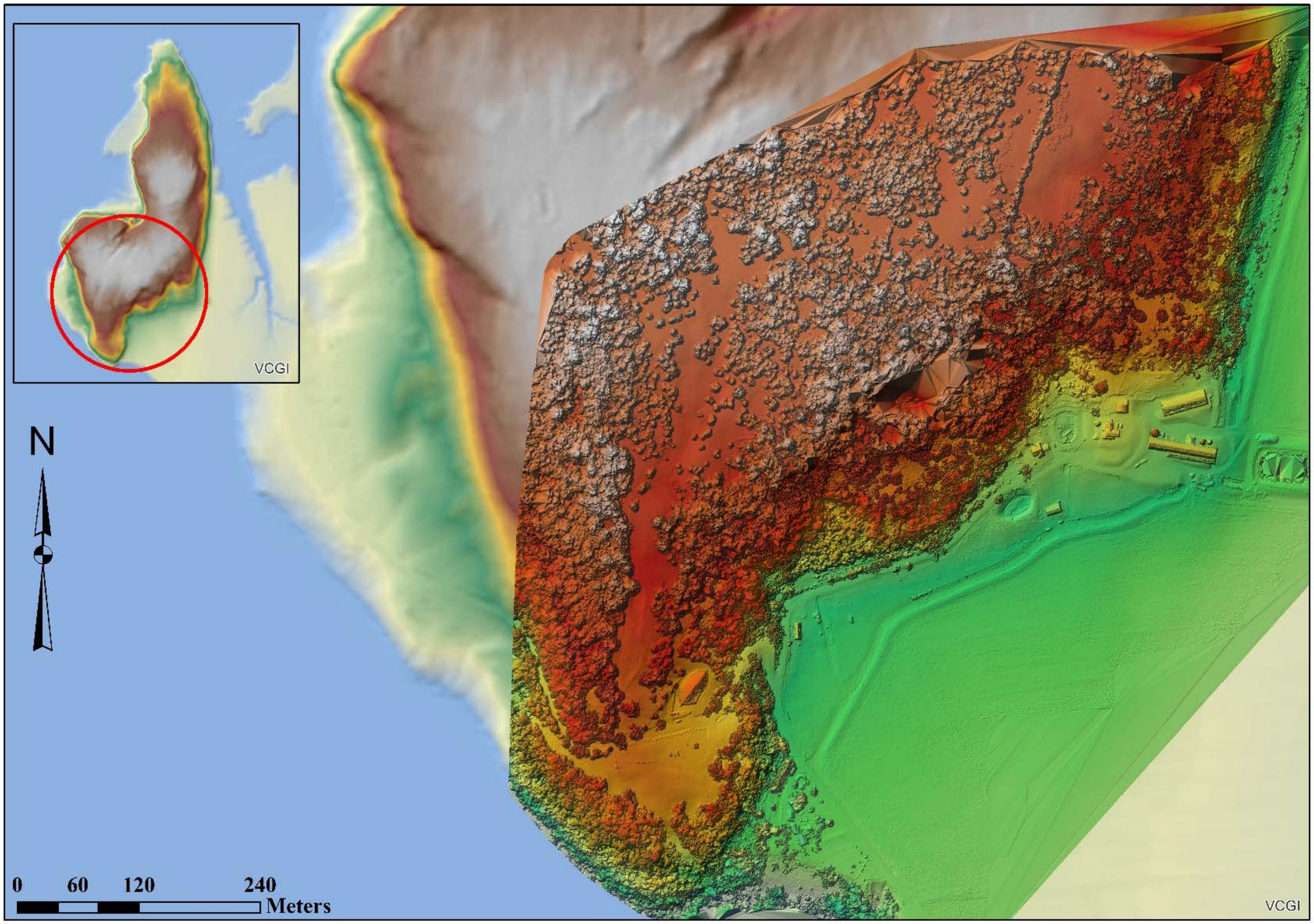

Figure 8. Interpolated high-resolution digital surface model (DSM) of the southern portion of the Mount made through UAS data.

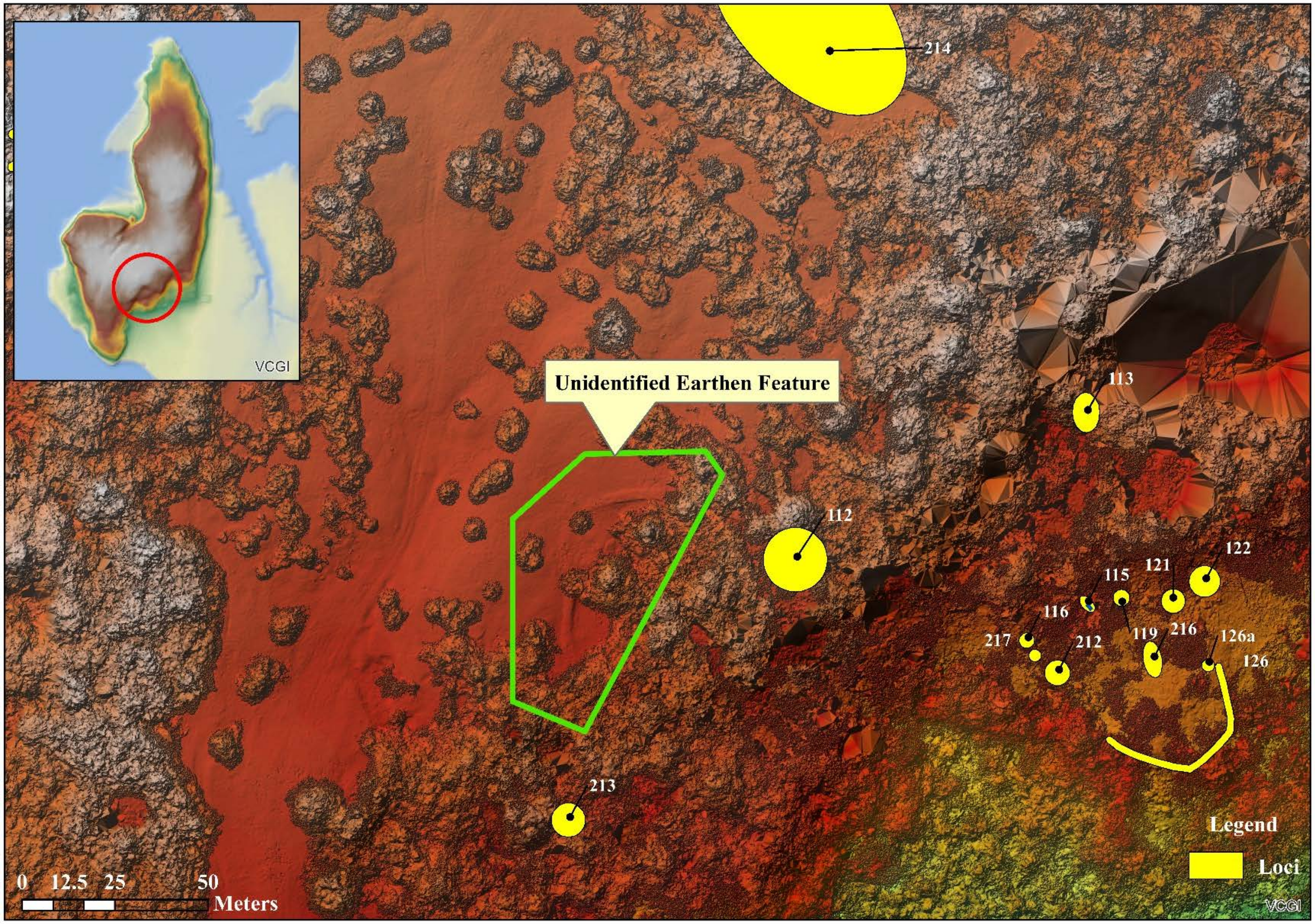

Figure 9. Close up view of digital surface model (DSM) showing an unidentified earthen feature not readily discernable from the ground. Numbered loci in yellow are explained below.

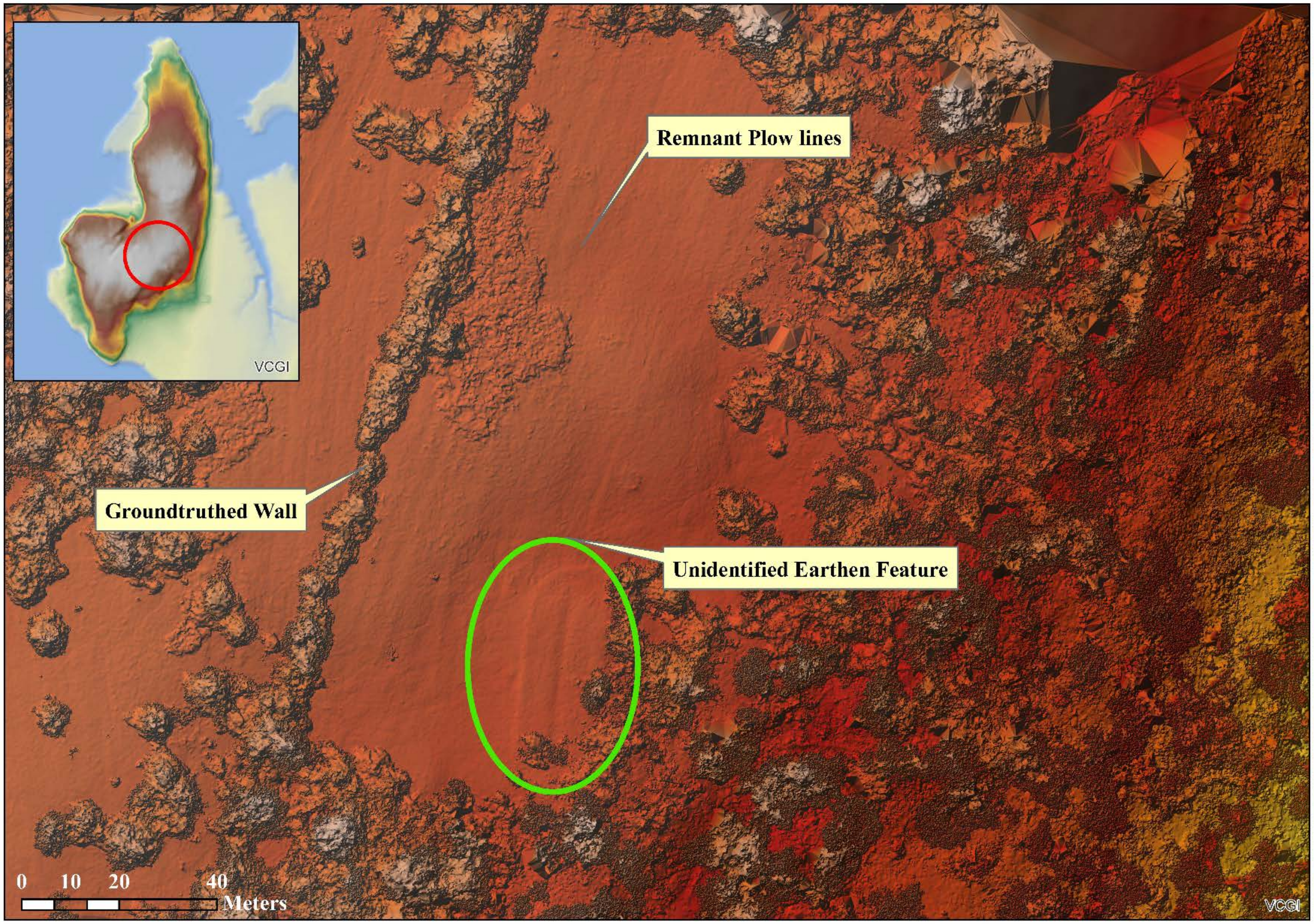

Figure 10. Close up view of digital surface model (DSM) showing an unidentified earthen feature not readily discernable from the ground. Remnant plow lines and trees along a probable farm wall are also visible.

Figure 11. Three-dimensional view of point cloud generated from UAS flight data. The location of the second battery is indicated. Image reproduced from UVM CAP's technical report. See Appendix A.

GPS Locations

Following the drone flight, UVM CAP utilized previously collected Global Positioning System (GPS) data and the recently released LiDAR imagery to identify likely or possible archaeological features along the landward portion of the Mount. During subsequent visits to the field, these features were sought out and then GPS'd using a Trimble Geo7X hand held unit with sub-meter accuracy.

While some of these features had previously been mapped during earlier projects using traditional survey equipment, these earlier data are limited in that they represent a few points along an alignment with variable accuracy or are based on even earlier analog maps derived from angle and distance measurements in a forested landscape. GPS point collection was concentrated on the southernmost portion of the Mount where the batteries and blockhouses were located. Among other factors, these high-accuracy data points enabled georeferencing of previous excavation maps by the project manager. The results of that work are explained and explored further below.

Ground-level Photogrammetry

The final technique employed by UVM CAP was the use of hand held and pole-camera photogrammetry order to generate three-dimensional models of certain features on the southern portion of the Mount. The work included a selection of three archaeological features/complexes that were relatively open in terms of vegetation coverage and therefore were more accessible to pedestrian and particularly pole-mounted photogrammetry. These included the 2nd Battery (Locus 126), a locus interpreted by Starbuck as a storehouse (Locus 214; see Starbuck et al. 1992 and below), and a blockhouse (Locus 105) located above the 3rd Battery (Locus 302). The images were taken using a Canon SLR EOS Rebel T6 24-megapixel camera for the hand-held images, and a GoPro 5 Black for the pole and shot-stick images. The imagery was processed using *Pix4D* licensed to UVM SAL and Agisoft software licensed to the Department of Anthropology at UVM.

The process included systematic photography of stone wall features and associated landscape in parallel lines or arcs so that individual images overlapped sufficiently to allow for alignment and "meshing" by the software. In the same way the drone images were combined through photogrammetry to create a 3D model point cloud and a digital surface model of the landward side of the Mount, the ground-based images were combined to produce 3D models and digital surface models of individual archaeological features/complexes. These individual outputs were then georeferenced and placed in the GIS model.

The 2nd Battery (Locus 126) was photographed using a pole-mounted GoPro in systematic arcs across the terrace landform (Figure 12). The arcs were GPS'd to record the paths used to cover the area. Cardboard box "targets" were placed across the landform and GPS'd to provide ground control and enable subsequent georeferencing of the models that were generated. The imagery was later processed by UVM SAL using *Pix4D*. Further processing of the model into a textured mesh provided even more detail as the software interpolated the points in the cloud. When manipulated, different rotations and zoom levels reveal other features as well including walled platform, likely a gun placement, in addition to topographic depressions in the area of excavations conducted in 1993. The model also enables measurement of individual stones, alignments and features, and also provides the ability to change the perspective and look at the battery from a defensive or opposing offensive perspective. The rendering provides a dimensional quality to the archaeological record that is impossible in a two-dimensional format. Finally, the model was georeferenced using the box targets and incorporated into the overall GIS map.

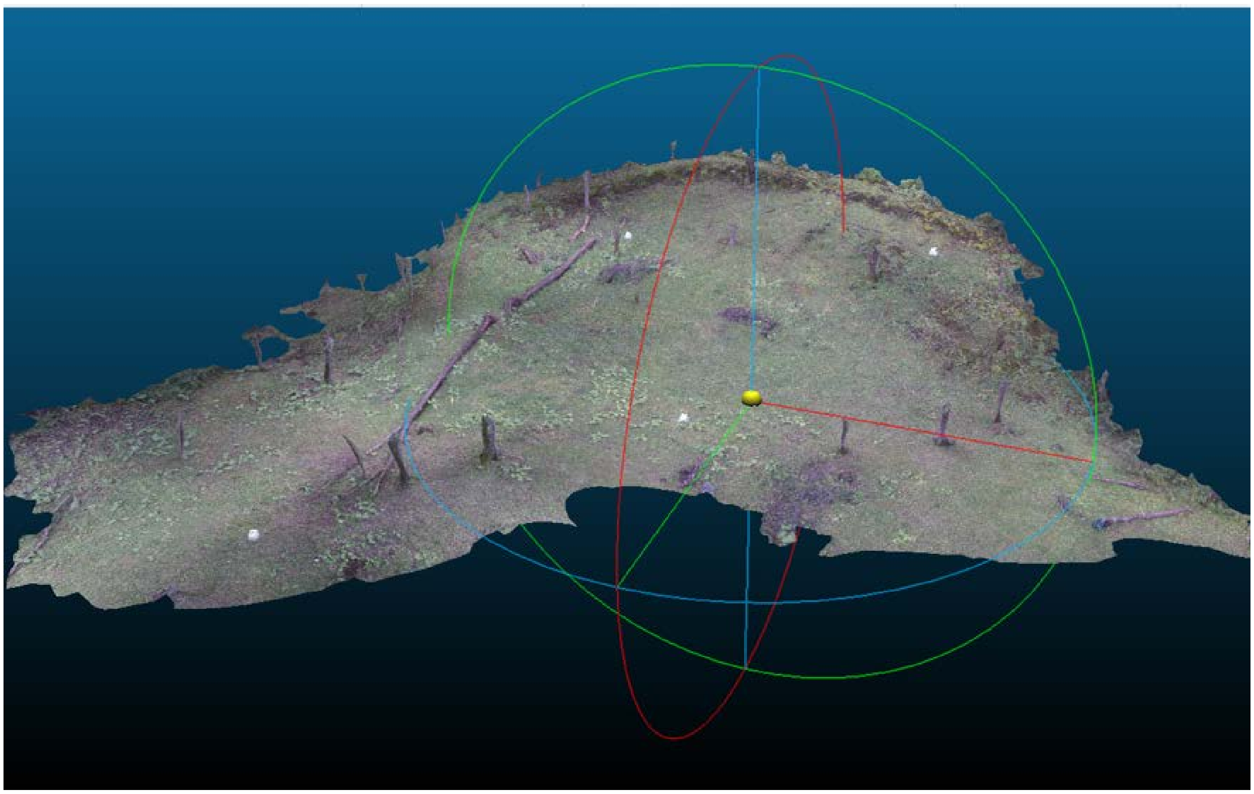

Figure 12. Three-dimensional view of the second battery generated through photogrammetry. Image reproduced from UVM CAP's technical report. See Appendix A.

Ground-based photogrammetry also was used to capture two other archaeological features on the southern, landward side of the Mount to evaluate the technique as a method for future documentation. The possible storehouse locus was located on the level plateau above the 2nd Battery. Instead of utilizing the pole-mounted GoPro camera, which would have been difficult given the tree cover, UVM CAP recorded the images using a hand-held digital SLR camera with images taken across and around the visible foundation remains. The imagery was then processed using Agisoft software to produce a photogrammetric point cloud and a textured mesh. An image field was exported from the software and georeferenced using GPS points taken on foundation corners in the field. The level of detail recorded is excellent and, as in the case of the 2nd Battery data, easily rotated and manipulated to change perspective, execute measurements, etc.

Finally, ground-based photogrammetry was used was on a blockhouse foundation above the 3rd Battery (Locus 105). Here a shorter pole mount was used to elevate the remote-controlled GoPro camera. Images were taken across the foundation and around its perimeter. These images were then processed in Agisoft to generate point clouds and textured meshes. A digital surface model also was generated in georeferenced geotiff format (the GoPro images are all geotagged and therefore have embedded coordinate data). The geotiff of the blockhouse shows excellent relief associated with the foundation walls, as well as a mound in the center of the foundation, which now covers the area of the chimney and a prior excavation (see additional explanation below).

Georeferenced Maps and Excavation and Locus Plotting

Following the receipt and proofing of UVM CAP's deliverables and report, the project manager utilized the data combined with the previously generated GPS points and LiDAR imagery to georeference older analog maps drafted between the 1960s through the early 1990s. In particular, the project manager was interested in plotting the locations of particular excavations and pedestrian surveys conducted when loci across the southern portion of the Mount were cleared of overlying duff, soil, and leaves and when there was much less tree cover. The project manager then plotted each excavation unit based upon those georeferenced maps, and also plotted loci with assumed function based upon these maps as well. Archaeologist David Starbuck conducted several seasons of archaeological excavation on the Mount, some of which were conducted within its southern portion. As part of those excavations, he drafted very detailed maps of select stone foundations. The project manager also georeferenced and reconstructed as polygon vector shapefiles the majority of those maps. Each of those steps will be explained in greater detail below.

Georeferencing

Using the ESRI ArcMap Georeferencing toolset, the project manager was able to georeference nearly every available survey and excavation map of the southern portion of the Mount (n=17). In order to preserve the internal spatial integrity of each map, they were not "rubber-sheeted" or stretched using ESRI's tools, but rather reduced or expanded in size to match the depicted scale relative to the GIS map's projection. They were then rotated and moved until a fit was achieved. The project manager was willing to discard any map that had significant spatial errors between depicted natural features, elevation contours, culturally deposited loci, or extant rebar datums that were GPS'd in recent years. Fortunately, however, other than slightly misplotted north arrows, all of the analog maps were remarkably accurate given the limitations of angle and distance measurements over large parcels. These maps are certainly a testament to the archaeologists' good work on the Mount in previous years.

Figure 13 depicts a 1968 map drafted by Bowie and Robinson for the southern portion of the Mount overlaying the LiDAR imagery. One can readily see the general good fit of the natural outlines and batteries. Close-up spatial relationships lose some of their integrity, but the map was really not meant to be used at close scale.

Figure 14 depicts a map produced in 1992 as a component of Starbuck's excavation report that year. This map is extremely accurate and matches up well with extant datums and UVM's recent GPS work. Using this map, other maps, GPS coordinates and other benchmarks, other, smaller area maps produced by Starbuck and others were georeferenced as well (Figure 15).

Figure 13. 1968 Bowie and Robinson map of documented features on the Mount overlying modern LiDAR imagery.

Figure 14. 1992 map depicting documented features on the Mount overlying modern LiDAR imagery generated by Starbuck et al.

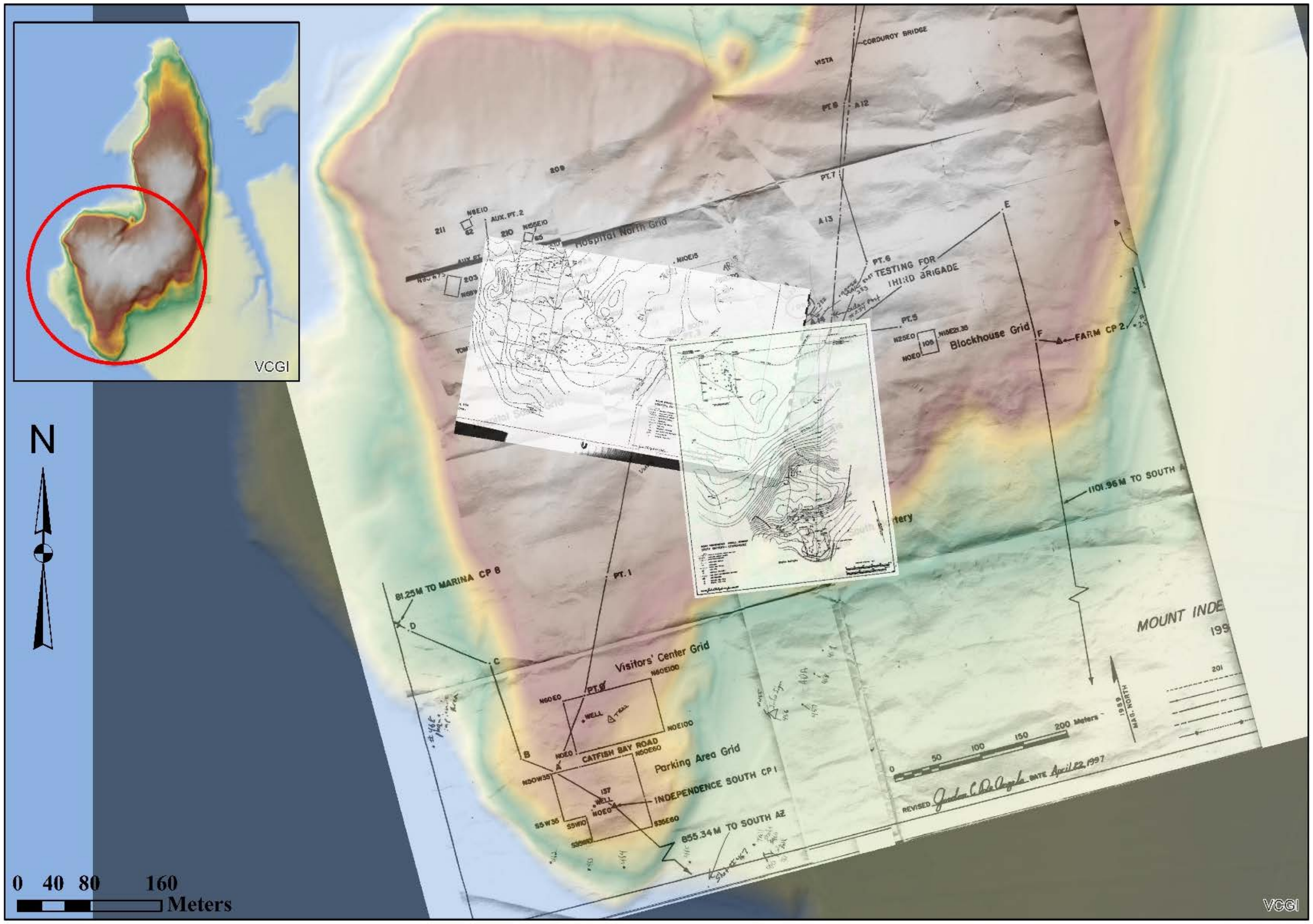

Figure 15. Composite georeferenced maps overlying modern LiDAR imagery of the Mount.

Georeferencing also allowed the project manager to plot individual locus maps with a high degree of accuracy (approximately 1-2 m error range). Starbuck produced a number of very detail maps of certain foundation structures over his three field seasons on the Mount. These mapped foundations stones and other features (except depicted artifacts or artifact clusters) were subsequently transformed into vector polygons. For instance, Figure 16 (Locus 105) depicts the blockhouse foundation mapped in detail by Starbuck (Starbuck et al. 1989) that was subsequently documented by the UVM CAP using photogrammetry. An overlay of the original Starbuck map (Starbuck et al. 1989), the vectorized foundation and fireplace stone arrays (Figure 17). and a hillshade DSM produced using UVM CAP's data are all depicted (Figure 18). Notably, the fireplace feature was covered with soil in an attempt to deter vandalism in 1990. As such, even though the hillshade model depicts the blockhouse foundation with remarkable accuracy, the only record of the fireplace feature is from Starbuck's map. Because it is now depicted as vector polygons, it can be placed over the hillshade layer to get a more complete view of the foundation.

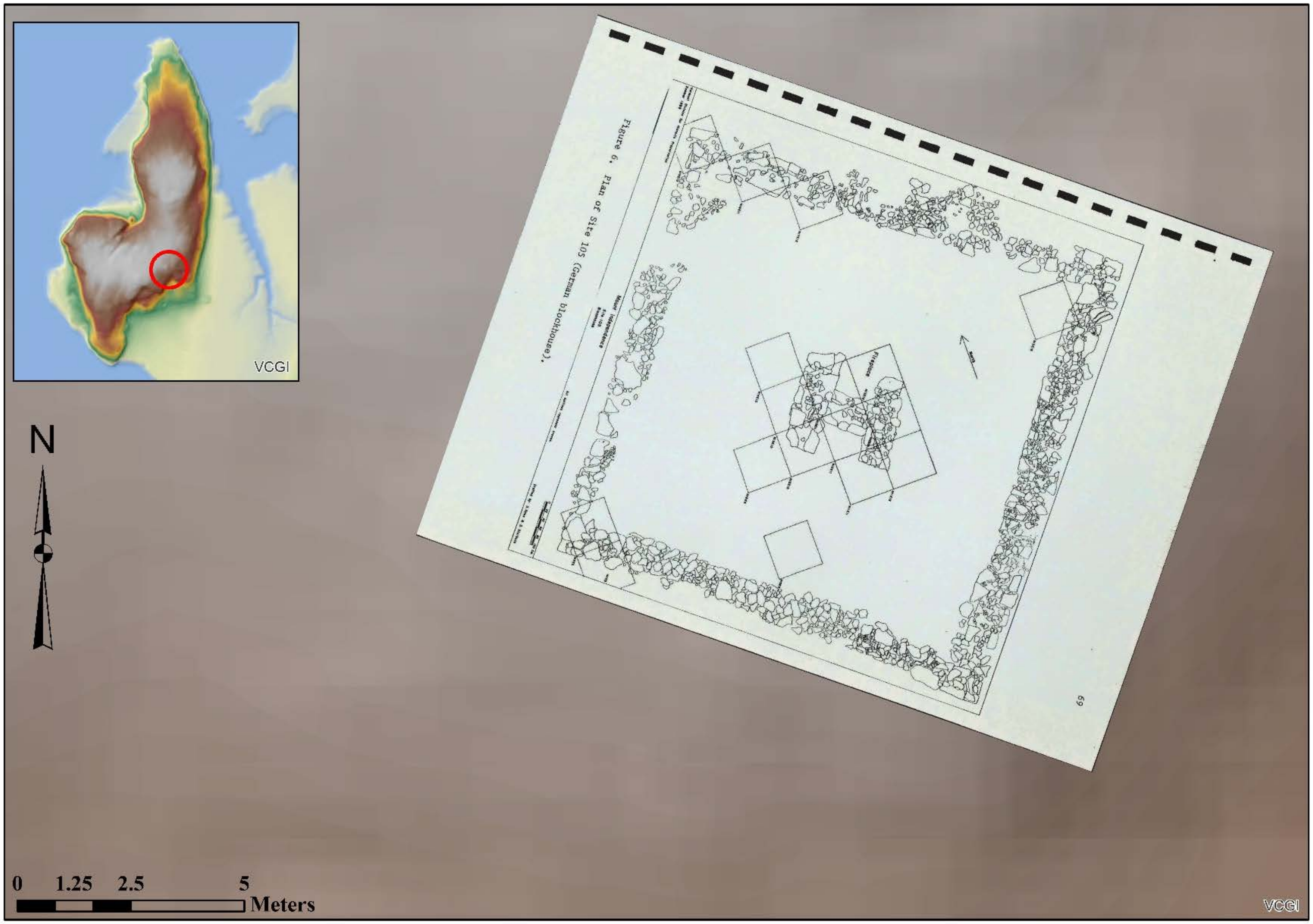

Figure 16. Starbuck et al. (1989) map of blockhouse #3 (Locus 105) georeferenced and plotted in its actual location on the Mount.

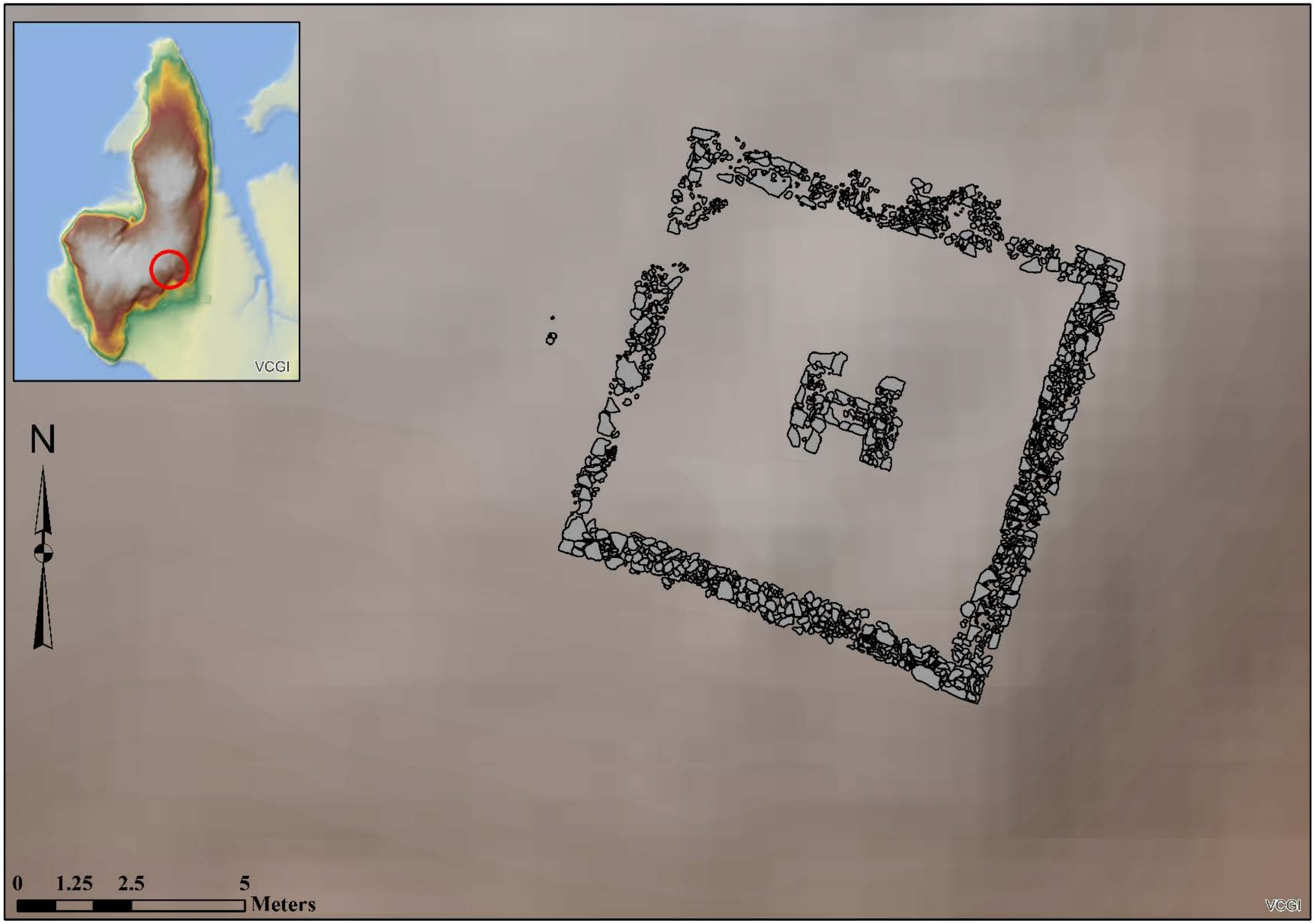

Figure 17. Vector polygon shapes made from the Starbuck et al. (1989) map of blockhouse #3 (Locus 105).

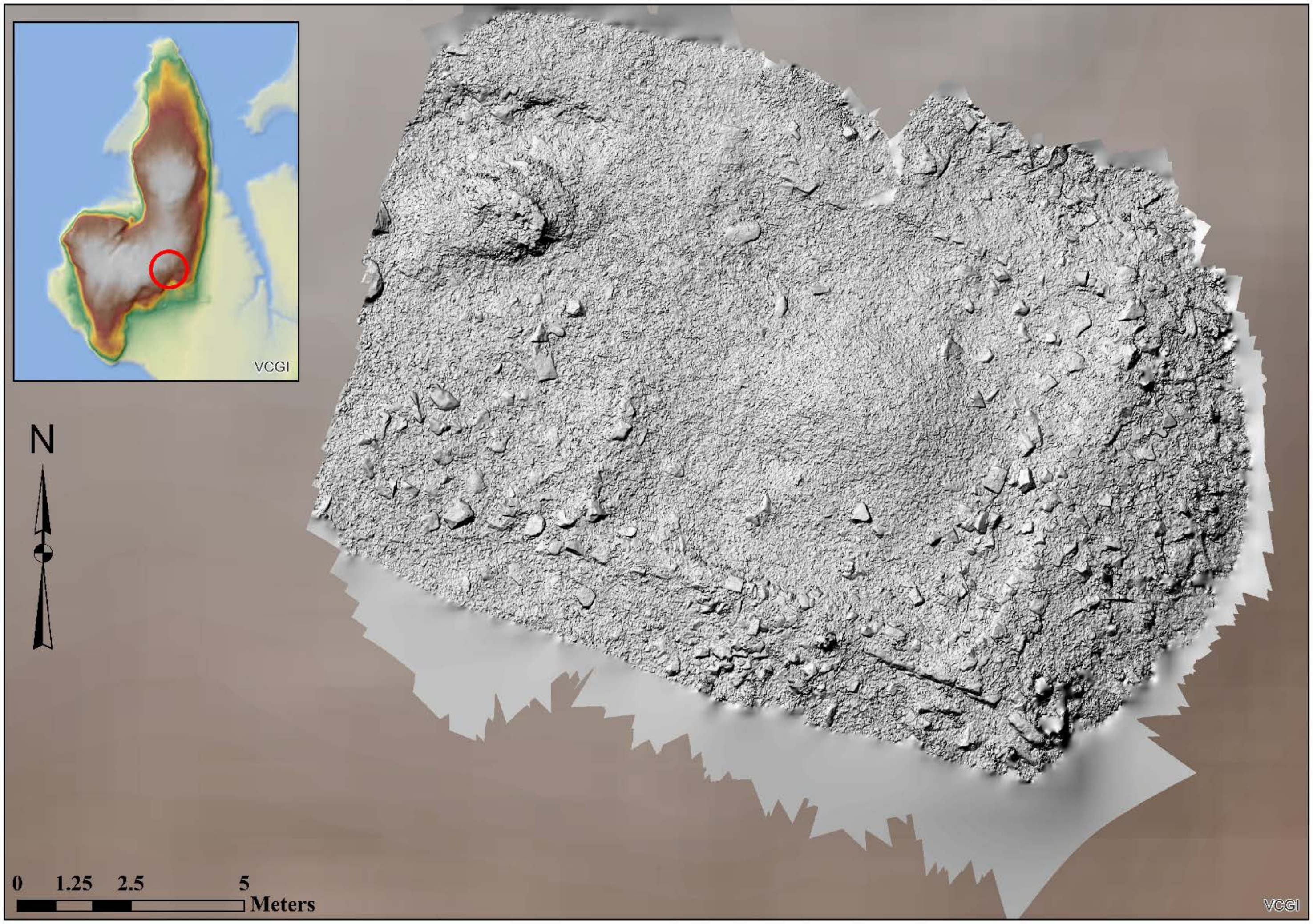

Figure 18. High-resolution, three-dimensional hillshade model of blockhouse #3 (locus 105).

Excavation Units and Locus Designations

The next task the project manager undertook was to draft excavation units as shapefiles using the georeferenced maps as a guide (Figure 19). Nearly all units depicted on Starbuck's maps were 1 x 1 m squares. The project manager divided the excavation units by year. This work has never been done in detail before for the Mount and is a critical tool to understanding where and when particular artifacts were recovered and to the site's stewardship in general. As noted above, the maps generally have a 1-2 meter error range across the studied section of the Mount as checked through reference to recently generated GPS points of benchmarks and other features.

It should be noted that certain excavations that were undertaken on southern portion of the Mount could not be depicted. Bowie and Robinson (1968) conducted some test excavations at various locations on the Mount, but no detailed record of their locations or grids now exists (see Bowie 1966; Robinson 1968). While Starbuck was normally very assiduous in his mapping of excavation locations, there was unfortunately no excavation map included of his survey of the southernmost area of the Mount. Those excavations were undertaken at the request of VDHP in anticipation of a parking lot being placed there. Finally, there was a 2001 excavation of certain areas of the southern portion of the Baldwin trail for ADA compliance, but unfortunately, there is no excavation map or plotted locations contained within that report either. It should also be noted that numerous excavations have taken place in the more northerly portions of the Mount. These were outside of the project scope, however, and were not plotted, but certainly could be in the future.

From the excavation unit locations, georeferenced maps, and GPS point data, among other data sets, the project manager was then able to assign loci for each of the mapped or excavated features across the southern portion of the Mount. The project manager utilized a numbering system that was established by Bowie and Robinson in 1968 (Figure 20 and below), which was subsequently modified by Starbuck and others, including the project manager. Specifically, the interpretations of features by Bowie and Robinson were changed as excavations or subsequent surveys revealed data that changed the interpretation of the presumed function of the feature. The project manager also refers to them as loci rather that sites, as Bowie and Robinson did, to conform with modern VDHP convention. Finally, with the exception of the batteries and hospital, the locus polygons generated by the project manager and depicted in Figures 20 and 21 are only rough approximations of the size of the visible remnants of each locus. The center of each polygon was placed in the center of each feature as currently understood. The numbered labels are described below.

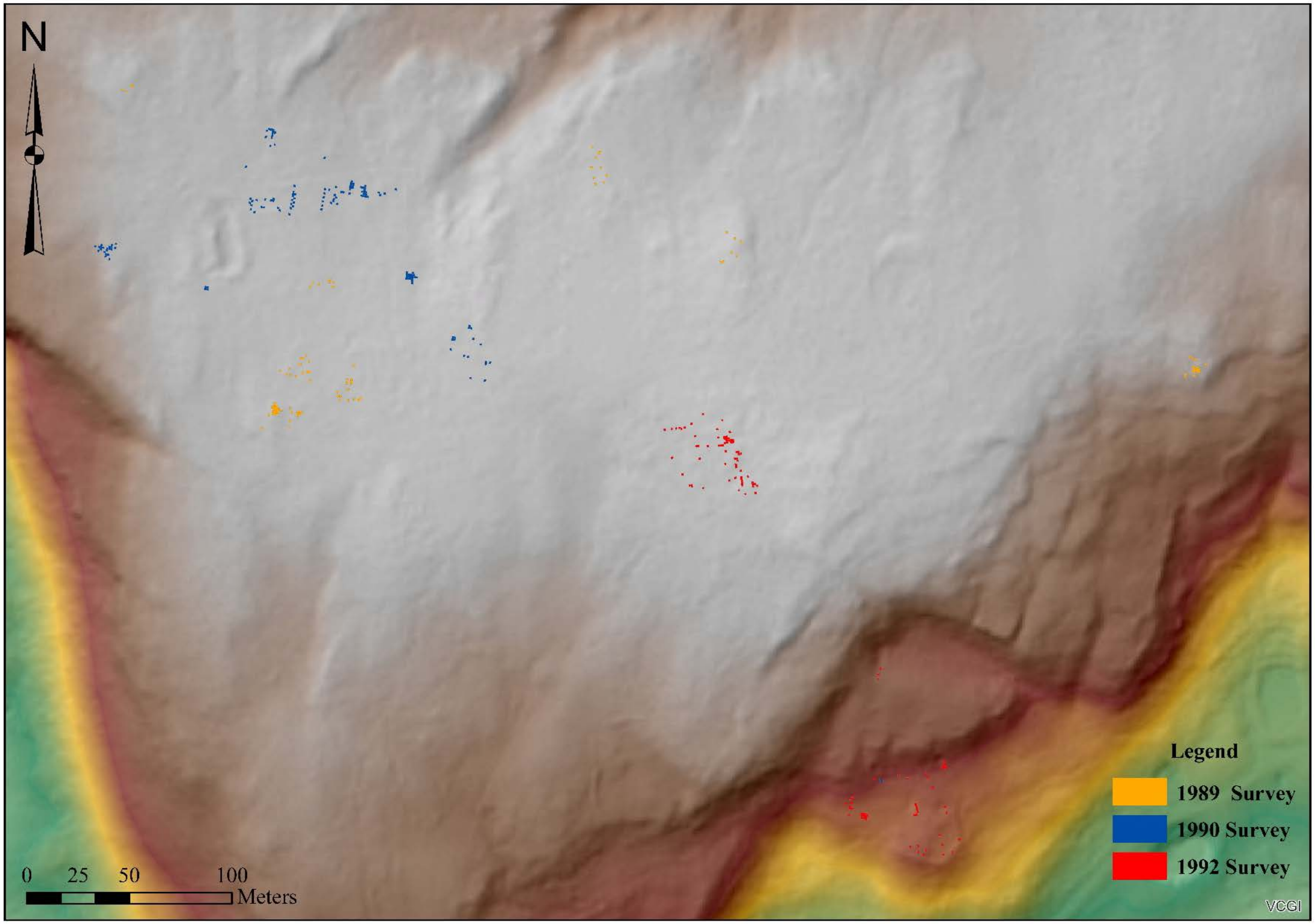

Figure 19. Locations of Starbuck's excavations from 1989-1992. Polygons are depicted as fixed, one by one meter squares rather dynamic points so they appear quite small at this resolution.

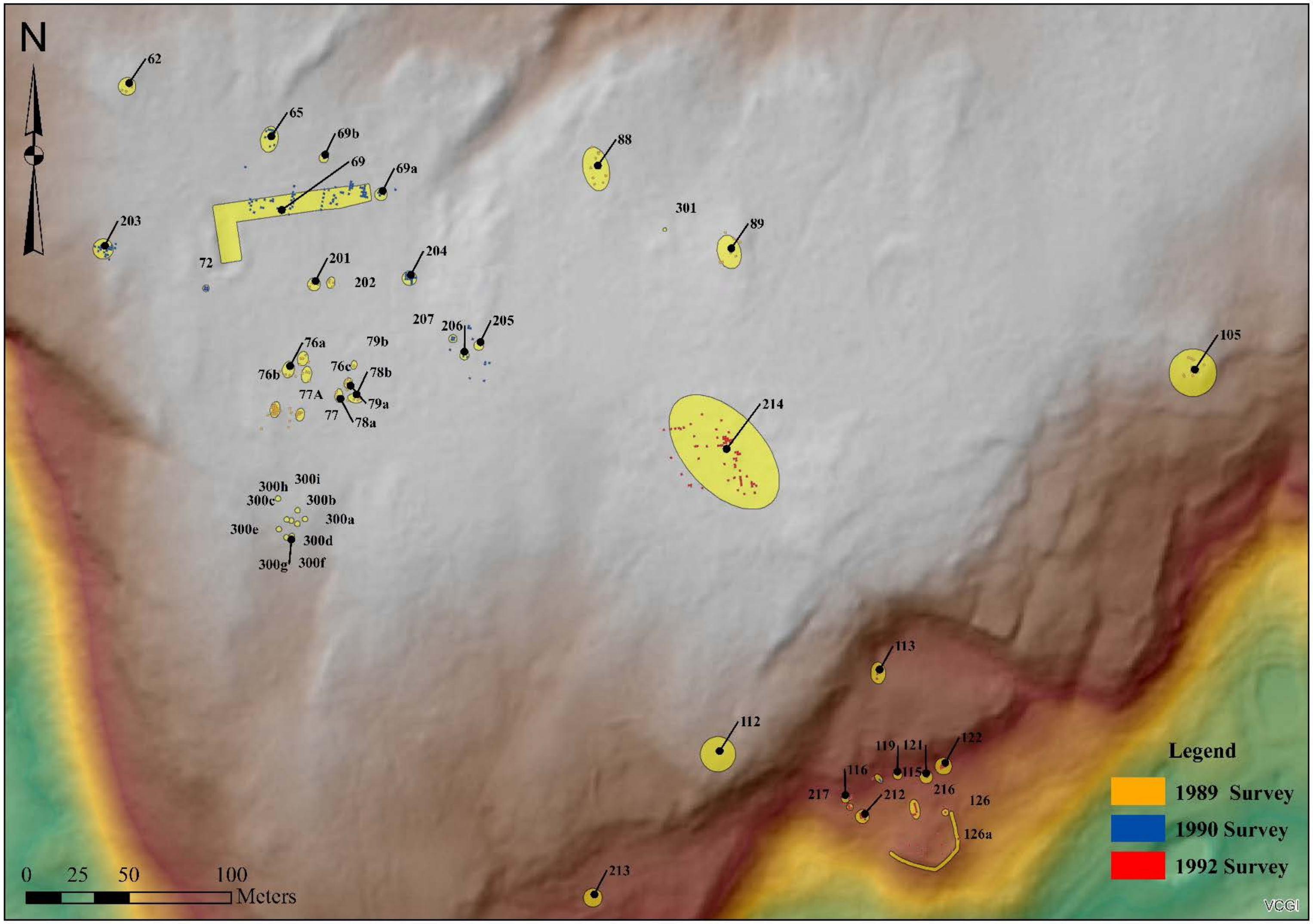

Figure 20. Locus designations based upon Starbuck's excavations from 1989-1992 and other pedestrian surveys across the Mount.

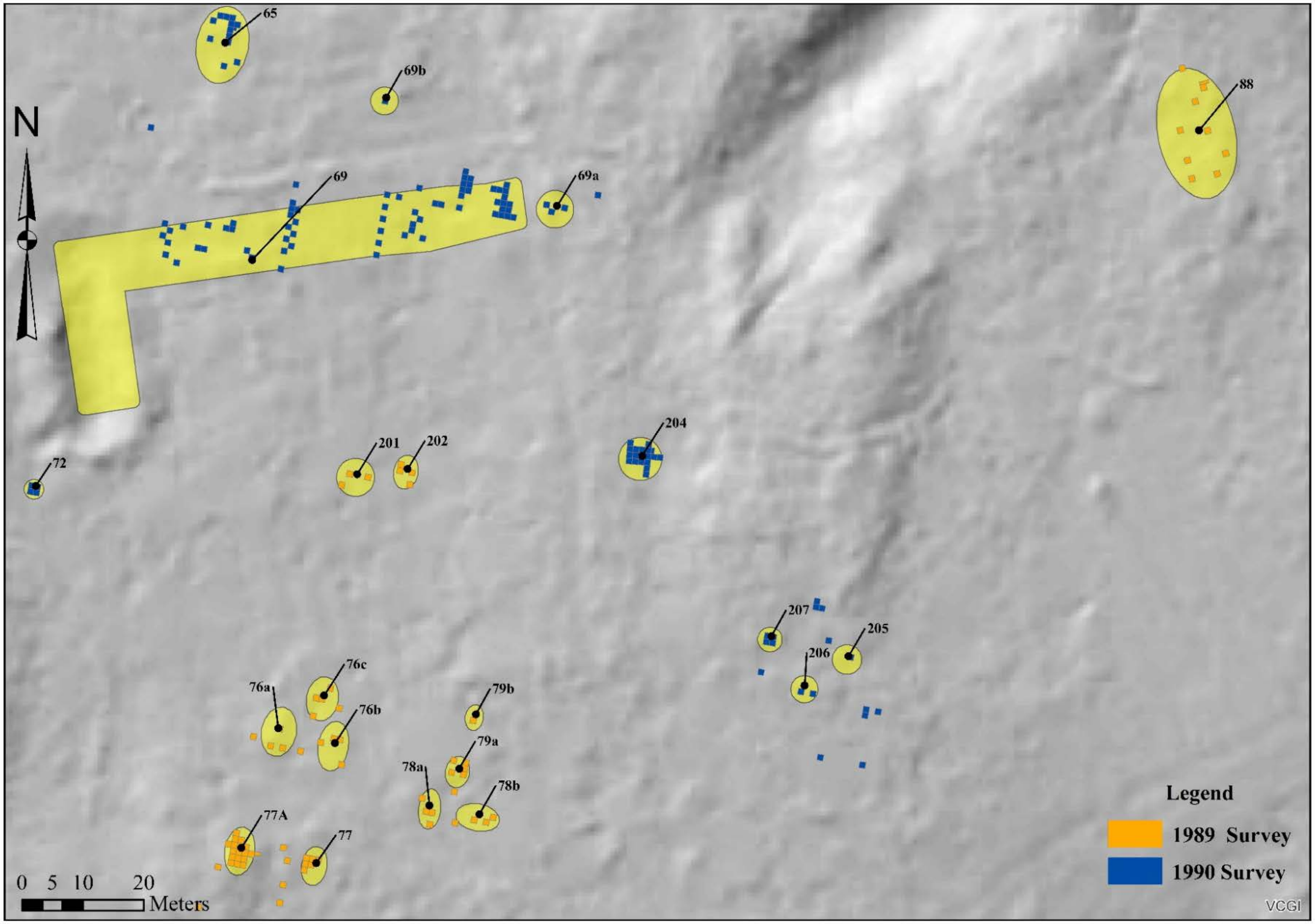

Figure 21. Close-up view of locus designations and excavation units in the area around the archaeological remnants of the hospital (locus 69).

Locus Numbers and Presumed Functions

Table 1 below lists all the loci mapped during the course of this project. Their presumed functions as currently understood also listed. The note field records pertinent information as generated during previous or current surveys. The coordinates indicate the centroid of each locus, which the project manager aligned to the center of each locus as currently understood. They are presented in Vermont State Plane NAD 83 (meters) format, which is the projection that that VCGI uses for all of its data due to its accuracy within the state of Vermont. Numbers beginning with 300 were designated during this survey. All numbers below 300 were designated during earlier surveys.

Function	**Locus Number**	**Notes**	**VT_NAD83_E Coordinates**	**VT_NAD83_N Coordinates**
Storehouse	214	50' LONG 12' WIDE FOUNDATION WITH 3 OR 4 PARTITIONS; SURROUNDING DEPRESSIONS AND STONE SCATTERS	428929 m	147230 m
Probable Power Magazine	113	FOUNDATION AT BASE OF SLOPE ~300 FEET NORTH OF SOUTHERN BATTERY	429004 m	147123 m
Depression Behind Battery	216	POSSIBLE DUMP IN DEPRESSION BEHIND SOUTH BATTERY	429022 m	147056 m
Excavated Pit	126a	PIT PLACED IN DEPRESSION BEHIND (NORTH OF) BATTERY	429037 m	147055 m
Possible Officer's Dwelling	122	POSSIBLE OFFICER'S HUT LOCATED AT EASTERN END OF LINE OF HUTS, ABOUT 40-50 METERS NORTH OF SOUTH BATTERY	429036 m	147077 m
Building w/ Fireplace	212	BUILDING WITH FIREPLACE, NORTHWEST AND UPSLOPE OF SOUTH BATTERY	428996 m	147053 m
Cellar Hole	217	CELLAR HOLE ABOUT 40 M NORTHWEST OF SOUTH BATTERY	428990 m	147057 m
Soldier's Dwelling	121	HUT SITE APPROXIMATELY 50 METERS NORTH OF SOUTH BATTERY	429028 m	147072 m

Soldier's Dwelling	119	HUT SITE, DEPRESSION IN THE ROCKS ALONG NORTHERN EDGE OF SOUTH BATTERY, ~52M N OF SOUTHERN BATTERY	429014 m	147073 m
Dwelling	116	HUT ABOUT 40-50 METERS NORTHWEST OF SOUTH BATTERY	428988 m	147061 m
Dwelling	77A	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428710 m	147251 m
Dwelling	77	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL; POSSIBLY AN OFFICER'S CABIN	428722 m	147248 m
Battery #2	126		429032 m	147035 m
Dwelling	115	HUT SITE ~150 FEET NORTHWEST OF SOUTHERN BATTERY	429004 m	147071 m
Dwelling	78a	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428741 m	147258 m
Dwelling	78b	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428749 m	147256 m
Dwelling	79a	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428745 m	147264 m
Dwelling	79b	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL, CONTROL PIT PLACED OUTSIDE HUT FEATURE (SITE 79A)	428748 m	147273 m
Dwelling	76a	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428716 m	147270 m
Dwelling	76b	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428725 m	147268 m
Dwelling	76c	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428723 m	147276 m
Dwelling	202	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428737 m	147313 m

Dwelling	201	PART OF A CLUSTER OF SOLDIER'S HUTS SOUTH OF HOSPITAL	428729 m	147312 m
Hospital	69		428711 m	147347 m
Possible Dump	69a	POSSIBLE DUMP AREA ABOUT 15 FEET EAST OF HOSPITAL FOUNDATION	428761 m	147356 m
Possible Dump	69b	POSSIBLE DUMP AREA ABOUT 50 FEET NORTH OF HOSPITAL FOUNDATION	428733 m	147373 m
Dwelling	204	HUT SITE ~125 FEET SE OF HOSPITAL FOUNDATION, HEARTH (HEARTHSTONE IS N0E0)	428775 m	147315 m
Human Burial	72	IDENTITY UNKNOWN	428676 m	147310 m
Bone pit and rubble pile	65	BONE DISPOSAL PIT ABOUT 100 FEET NORTH OF HOSPITAL FOUNDATION, "BONE PIT"	428707 m	147383 m
Dump	203	DUMP ON STEEP DOWNHILL SLOPE WEST OF THE GENERAL HOSPITAL	428625 m	147329 m
Grave 1	300a	MARKED HUMAN BURIAL	428724 m	147197 m
Grave 2	300b	MARKED HUMAN BURIAL	428720 m	147195 m
Grave 3	300c	MARKED HUMAN BURIAL	428717 m	147197 m
Grave 4	300d	MARKED HUMAN BURIAL	428715 m	147197 m
Grave 5	300e	MARKED HUMAN BURIAL	428711 m	147193 m
Grave 6	300f	MARKED HUMAN BURIAL	428715 m	147188 m
Grave 7	300g	MARKED HUMAN BURIAL	428718 m	147189 m
Grave 8	300h	MARKED HUMAN BURIAL	428720 m	147202 m
Grave 9	300i	MARKED HUMAN BURIAL	428711 m	147207 m
Dwelling	206	NOT IN CATALOG; USED BAG LIST	428802 m	147277 m
Dwelling	205	HUT SITE ~300 FEET SE OF HOSPITAL FOUNDATION	428809 m	147282 m
Possible Dwelling	207	POSSIBLE HUT SITE ~250 FEET SOUTHEAST OF HOSPITAL FOUNDATION	428796 m	147285 m
Cabin	62	HUT SITE ~40 METERS NORTHWEST OF HOSPITAL	428637 m	147408 m

Possible Barracks	88	POSSIBLE BARRACKS ~380 FEET EAST OF HOSPITAL FOUNDATION	428866 m	147368 m
Possible Barracks	89	POSSIBLE BARRACKS OR WAREHOUSE	428931 m	147328 m
Well	301		428900 m	147339 m
Blockhouse	112	BLOCKHOUSE #2	428926 m	147083 m
Blockhouse	105	BLOCKHOUSE #3	429158 m	147269 m
Possible Soldier's Dwelling	213		428865 m	147013 m
Battery	302	3RD BATTERY	429260 m	147208 m
Battery	302	3RD BATTERY	429240 m	147215 m
Blockhouse	58	BLOCKHOUSE #5	429318 m	147463 m
Battery	138	1ST BATTERY	428883 m	146822 m

Table 1. Locus designations functions and coordinates for the southern portion of Mount Independence.

Data Synthesis

On November 8th, 1777, following Burgoyne's surrender at Saratoga, the remaining British and German troops stationed on the Mount were ordered to retreat to Canada. The soldiers took all the worthwhile supplies they could aboard their vessels and then burned every building and destroyed the majority of the cannons (Wickman 2017). Due to those actions, no post-war maps, paintings, or other documentation could be made of the structures on the site, and therefore relatively little exists to assist in the reconstruction of the fortifications and structures once upon it apart from archaeology. Arguably the best extant reference is British draftsman Charles Wintersmith's (1777) map depicting the state of the fortifications and structures on the Mount after St. Clair's abandonment. Nevertheless, from the data generated or synthesized and aggregated over the course of the project, various aspects of the field of battle and the structure of the fortifications, barracks and other dwellings on top of the Mount have been revealed.

Specifically, the hospital (Locus 69 and sub-numbers) is well-mapped by Wintersmith. He even documents with a dotted line the unfinished state of the L-wing (Starbuck 1990). Its location relative to the contours of the Mount is also quite accurate. The storehouse located to the east of the Mount is also depicted quite accurately, but another large structure (Locus 89) near to it is missing. Similarly, another storehouse nearer to the southern edge of the Mount is also not depicted on the map (Locus 214), and neither are the possible dwellings near to it. The potential dwelling sites were located recently by UVM CAP and a previous pedestrian survey as depressions with concentrations of stones in several cases. Because no excavations were conducted on any of them and duff, trees and other detritus were not cleared away to conform with the non-disturbing aspect of this project, their function or their exact number cannot be confirmed at this time. Nevertheless, it is possible that they may represent tent sites or structures that were more make-shift or of lower quality than the ones nearer to the hospital. The dwellings nearer to the hospital were depicted by Wintersmith, although their number and orientation appear to have been quite impressionistic. Starbuck et al. (1989) note differences between several of the excavated cabin sites in that area, which likely reflect military status. It is currently unclear why Wintersmith did not depict some of the larger features. It is certainly possible that they were constructed after the British took over the Mount, but that doesn't seem logical given the relatively small number of troops stationed there relative to the American population at its height.

Turning to the southern defenses that were the site of the 1777 American attack, this project has revealed significant new information relative to the extant historical sources. Comparing the Wintersmith map to the archaeologically excavated and mapped features along the southern ridge, there are several notable features that have not been identified. Obviously, the abatis that formed the first-tier defense on the southern portion of the Mount and the log lines that formed the edge of the third-tier are no longer extant, and may have not even been in place during the Americans' attack. As noted previously, the abatis and log lines may have been dismantled and burned for heat. No remnants of the "log houses" depicted by Wintersmith (designation k on his map) near to the southern edge have been identified either. It is possible they were dismantled and burned as well or that they were built with an earthfast construction that did not leave obvious above-ground traces.

The number and orientation of the blockhouses along the southern edge of the Mount has been a recurring question among archaeologists and historians examining the Mount. Wintersmith depicts five blockhouses on his map, but also indicates that several of these were under construction. The archaeological remnants of blockhouses #2, #3, and #5 have been securely documented and plotted during this survey. As noted above, Blockhouse #3 has been subject to previous excavation and photogrammetric mapping for this project. Bowie and Robinson (1968) identified a loose concentration of stones that they indicated might belong to blockhouse #1, but subsequent pedestrian survey and previous excavations have failed to find these remnants in the southernmost portion of the Mount where Wintersmith depicts it. Similarly, detailed pedestrian survey in and around the area of the 3rd battery for this project failed to identify any foundations for blockhouse #4. While it is possible that these blockhouse foundations remain hidden under accumulated colluvium or cultural fill, or that they were made using unorthodox construction techniques that did not require foundation stones, it is much more likely that they were never completed or potentially even begun.

While Wintersmith depicts the second battery as a single feature, previous and current surveys have revealed that it actually contains numerous cultural loci, including artilleryman's' dwellings, a probable powder magazine, and a dump feature (Howe et al. 1994). Similar structures may exist in and around the other two batteries, but if so, they are far more obscured or ephemeral relative to those around the second. Previous and current pedestrian surveys have failed to identify them.

One of the more dramatic outcomes of UVM CAP's close inspection of drone and LiDAR data, and subsequent ground truthing, was the identification of intentional landscape modifications including zig-zag cuts modifying the natural landform at the height of the southern edge of the Mount, above built “terraced” platforms formed with stone retaining walls, overlooking the higher defensive walls associated with the 2nd and 3rd batteries (Figure 22). These features evince remarkable modification of the landscape. Some interpretations of these modifications will be offered below.

Figure 23 depicts general demarcations of space elucidated through the grant-sponsored work and a synthesis of the data by the project manager. The top of the southern portion of the Mount appears to have largely been divided between living areas and support areas (hospital, storehouse(s), and cemeteries). Judging by the locations and a close analysis of the LiDAR imagery, the Americans appear to have chosen the highest and most level spots for their durable infrastructure. Surely, however, tents and make-shift dwellings were probably placed all across the Mount’s expanse during the fall of 1776 when 12,000-13,000 people occupied it.

The first tier’s position as depicted in Figure 23 is largely conjectural, but is based upon Wintersmith’s map and an evaluation of terrain from the LiDAR and DSM imagery. As noted previously, the first tier consisted of abatis that may or may not have been present during the 1777 American attack. The second-tier batteries were able to be mapped much more accurately based upon slope and terrain analyses, the presence of Revolutionary War loci and earthworks, and the modifications of the landscape documented by UVM CAP. The third-tier defenses, defined most notably by the positions of the blockhouses, were also able to be mapped quite accurately.

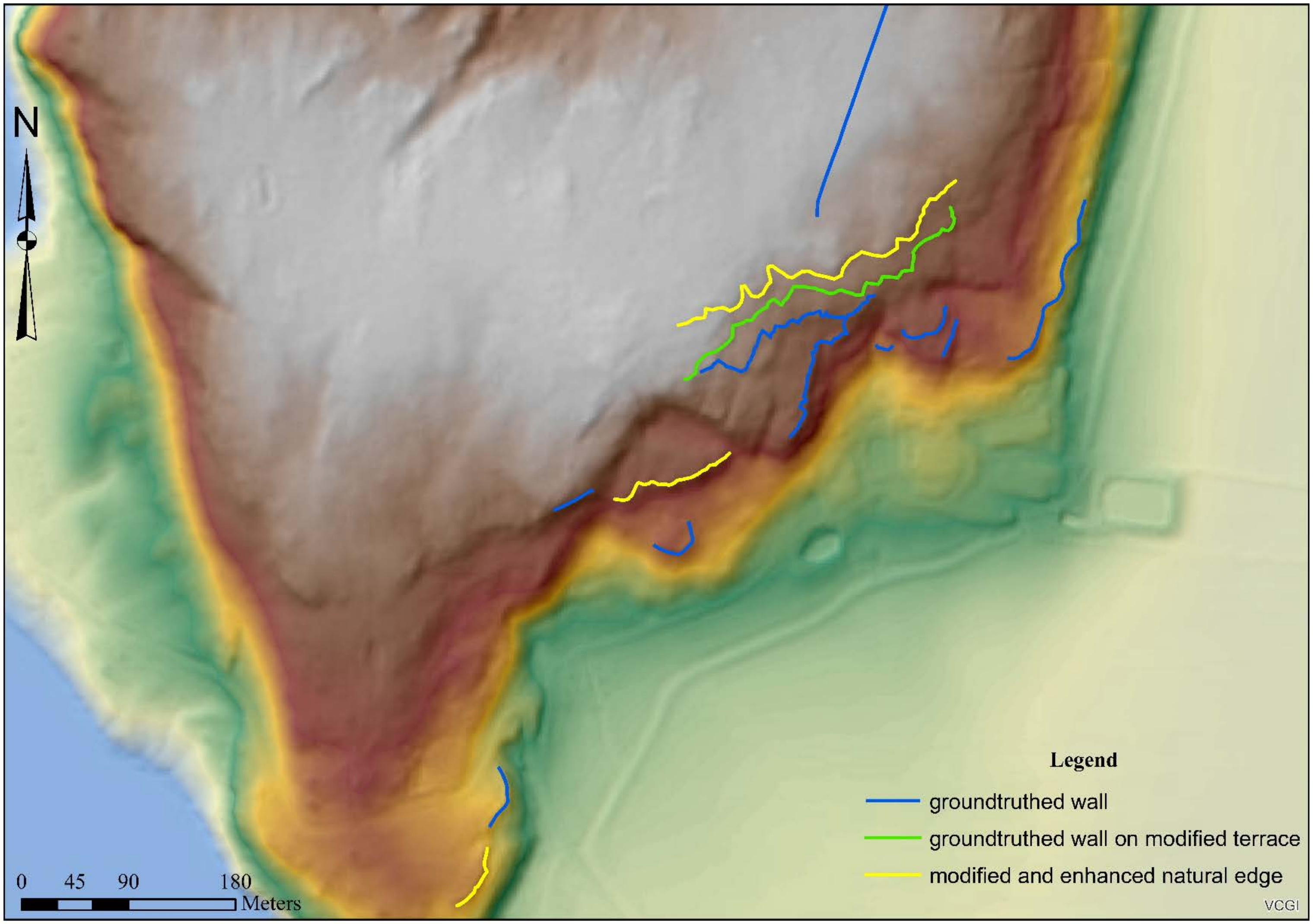

Figure 22. Mapped stone walls, walls on modified earthen terraces and modified and enhanced natural edges. The northernmost wall depicted in this image is likely a post-Revolutionary War farm wall.

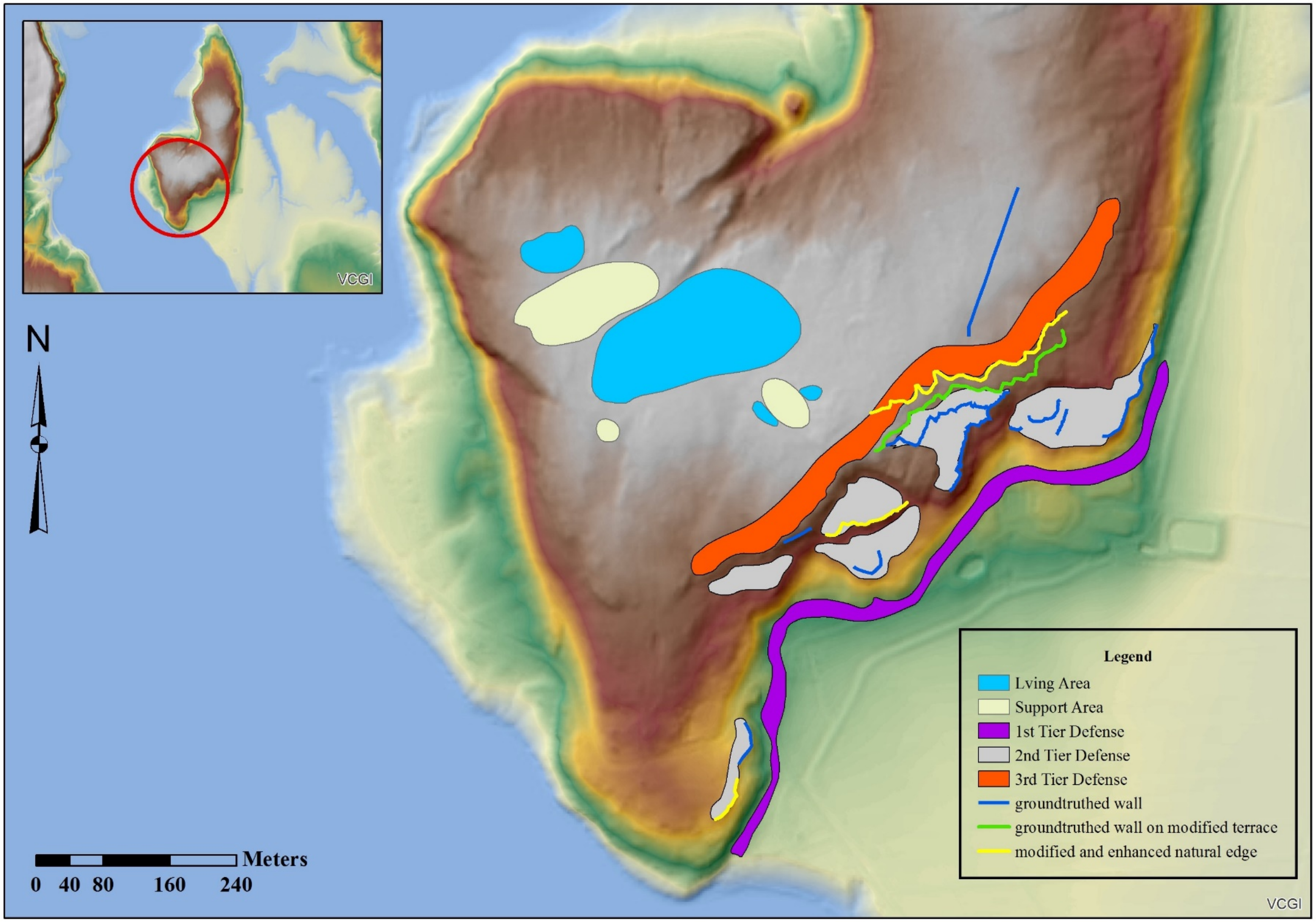

Figure 23. Inferred spatial arrangements and functions of the southern portion of Mount Independence.

Interpretations

Lieutenant August Wilhelm Du Roi, a German in the service of the British, remarked upon seeing Mount Independence after it was captured, that:

> [The Mount] had been cleared of the wood, and a wooden fort had been erected there, strengthening the whole with trenches and batteries. They had called this mountain on account of its location and their own intentions 'Mount Independence.' The whole was well done and showed no lack of clever engineers among the rebels (Du Roi 1776-1777, quoted in Wickman 2017:77).

Du Roi further described the Great Bridge as "a piece of work which …does honor to human mind and power. It is only regretted that the work was commenced for fighting purposes. It therefore, will hardly be completed as it deserves." (Du Roi 1776-1777, quoted in Wickman 2017:77). Indeed, the infrastructure and defenses designed and constructed by the American forces on the Mount in 1776-1777 evince remarkable ingenuity. While the construction techniques of many buildings have yet to be detailed, their arrangement over the Mount and their ability to make efficient use of the natural topography of the southern edge is very impressive. It appears that the American engineers Baldwin and later Kosciuszko favored subtle landscape modifications and the efficient use of natural topography to extensive stone or earthen constructions.

Indeed, UVM CAP remarked to the project manager that the batteries and landscape modifications may have been constructed so as to channel or at least oversee not only the field spreading south from the Mount but also the intermittent steep draws within which formal fortifications could not be constructed. The Americans' knowledge of these natural and artificial features may have aided them significantly in their nighttime raids against the second and third batteries without incurring casualties. Moreover, it was likely their knowledge of the relative impregnability of the Mount when approaching from the south that caused them to adopt the strategy that they carried out in September 1777.

Conclusions and Recommendations

The 2017 geospatial mapping of landward side archaeological features at Mount Independence produced or synthesized a great deal of data that moves the 240-year effort to document the site significantly forward. One of the most remarkable lessons of the project is the site's level of preservation, despite centuries of logging, farming and looting. Many of the site's landscape features and culturally produced loci lend themselves to the use of non-invasive techniques such as those employed in the present study. The work has created a central geographic database that can be used to integrate additional past efforts with future studies. Indeed, recent recataloging and data entry of all of the artifacts from Starbuck's excavations will allow us in the near future to link that database to the mapped excavation units so as to document where each artifact was recovered.

The geospatial data contributes another perspective that can be employed in the ongoing interpretation of the site's military history and offers a centralized archive to help manage and track the archaeological resources within a dynamic, mainly forested natural environment.

The ground-based pole camera and hand-held photogrammetry proved to be an excellent way to capture smaller areas and archaeological features, at least when conditions were right. This economical method can produce curated maps of sites and 3D models that can help aid structural reconstruction and interpretation.

Overall, this data will offer scholars and interpreters a great deal of new data to understand not just the American presence on the Mount, but their later attempt to recapture it. It will also greatly assist VDHP in the stewardship and preservation of this remarkable National Historic Landmark.

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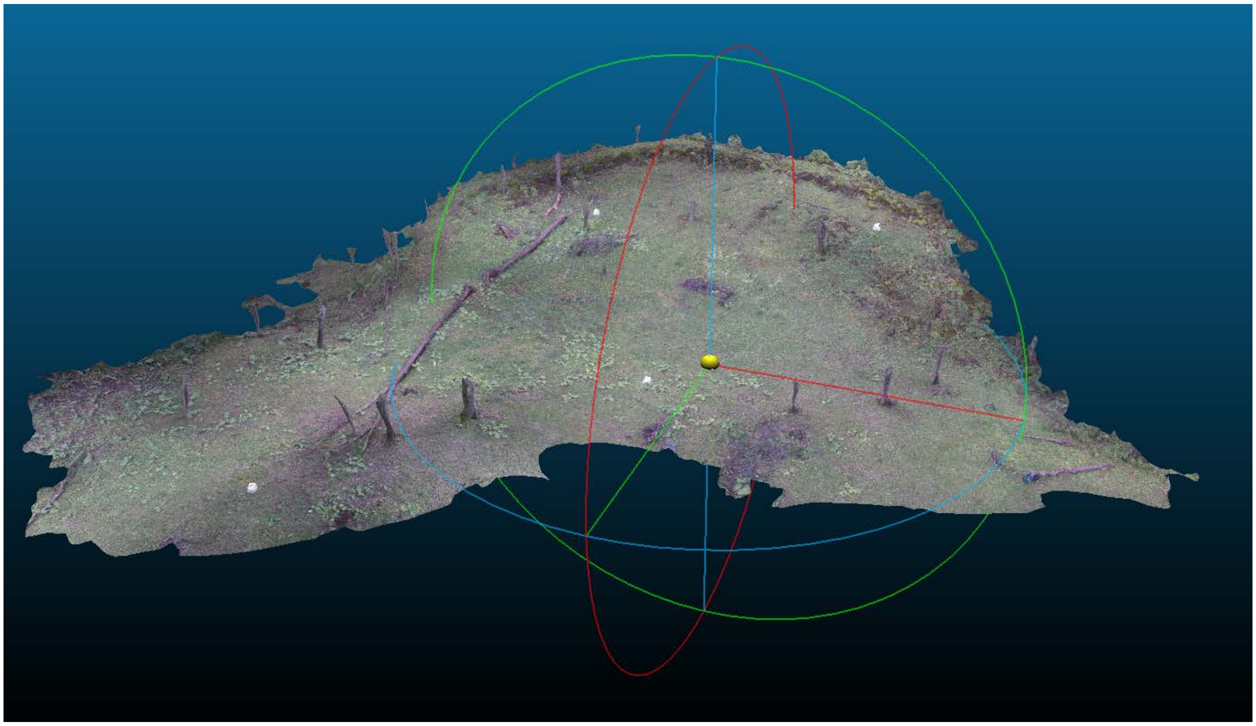
Appendix A: Geospatial Mapping of Archaeological Features along the Landward Section of Mount Independence, Vermont (ABP P Grant # GA 2287-16- 020), University of Vermont Consulting Archaeology Program Technical Report

Geospatial Mapping of Archaeological Features along the Landward Section of Mount Independence, Vermont (ABP P Grant # GA 2287-16- 020)



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UVM CAP Report No. 1112

Geospatial Mapping of Archaeological Features along the Landward Section of Mount Independence, Vermont (ABPP Grant # GA 2287-16- 020)

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Geospatial Mapping of Archaeological Features along the Landward Section of Mount Independence, Vermont (ABPP Grant # GA 2287-16- 020)

Introduction

This report summarizes the geospatial mapping of archaeological features conducted in 2017 along the eastern, landward side of Mount Independence, a Revolutionary War era National Historic Landmark located on the eastern side of Lake Champlain in Vermont. This work was supported by a grant from the American Battlefield Protection Program (ABPP #2287-16-020) to the Vermont Division for Historic Preservation (VDHP). The goal of the project was utilize remote sensing technology and traditional survey methods, along with previously collected data to accurately document the geospatial location of archaeological features along the eastern side of Mount Independence, a critical concentration of American and later British defenses during the American Revolution. The 2017 mapping efforts also were designed to capture the relationship between archaeological features and the subtleties of local topography, acknowledging that the interrelationship between two is critical to understanding the strategic choices made throughout the site's military history. This report accompanies digital outputs from the project, archived in Geographic Information System (GIS) format.

Brief Historic Background and History of Mapping Efforts

Mount Independence is a roughly 250 acre elevated outcrop on the eastern, Vermont shore of Lake Champlain, opposite Fort Ticonderoga in New York (Figure 1). The site represents one of the largest and best preserved Revolutionary War archaeological sites in America and was listed as a National Historic Llandmark in 1972. At present, 114 acres of the northern end of Mount Independence is owned by Pell / Fort Ticonderoga Association (purchased in 1911) while the southern portion of the landform and historic site is owned by the State of Vermont (start of purchases in 1961). In association with Fort Ticonderoga across Lake Champlain to the west, the Mount played a vital role in the American Revolution, especially in the Northern Campaigns of 1776 and 1777. The Mount was mapped during and following the war on several occasions by different parties with different emphases and different degrees of accuracy. Due to the limits of mapping technology, the varying expertise of the surveyors and cartographers, and the military defensive focus of the mapping efforts, the historic maps are schematic and lack many details. Missing from all of the maps, for example, are details such as the number of individual soldier huts, the extent and location of breastwork constructions, and the true dynamics of the topographic features so critically important to the Mount's defenses. While some of these details may never be known, the locations of defensive constructions in relation to the natural contours of the Mount is one of the exciting outcomes of the present project.

Each map makes very valuable contributions, however, to understanding the timing and extent of constructions and helping to interpret the archaeological record. As part of the present project, historic maps were georeferenced, approximately, in ArcMap 10.4 to be able to relate their contributions to archaeologically visible remains and the timing of their construction. For example, the Trumbull map of “Ticonderoga and its Dependencies, August 1776” though it has geographic inadequacies, illustrates the locations of American brigades, the northern battery, and “works intended” including the batteries on the landward side which are the focus of the present mapping project (Trumbull 1776)(Figure 2). The “Plan of Mount Independence at the time of the American Retreat of July, 5, 1777” from the court marital of General St. Clair in 1778 shows that the landward batteries and breastwork had been constructed a year later, described on the map as “Line, with three new made batteries, for 1500 men, and not less”(Anon. 1881)(Figure 3). Perhaps the most accurate geographically is the map “Surveyed & Drawn by Lieut. Charles Wintersmith Assistt Engr. By Order of Lieutenant Twiss Commandg. Engineer” (Wintersmith 1777). This map shows the three landward batteries and locations of blockhouses and other constructions. In addition, it more accurately portrays the natural prominences upon which the batteries were built and the topography on the landward side in relation to the open terrain east of the Mount (Figures 4 and 5). Together, the historic maps each provide details that help anchor dates of construction, interpret the spatial relationships between archaeological features, understand their functions, and help reconstruct the development of the Mount’s defenses and the strategy behind it.

In addition to the historic mapping efforts, there are numerous early accounts that also provide useful information documenting post-abandonment conditions at the Mount in the century following the Revolutionary War. These establish the site’s remarkable and long preservation history, despite the site’s notoriety, and the historical trends of lakeside agriculture and development. The Mount has long attracted day visitors interested in observing the topographic and military features of the site, and collecting artifacts associated with the American Revolution. A number of notable individuals have visited, each making their own “discoveries” across the property. Unfortunately the vast majority of these efforts did not include systematic mapping or recording and identified features were left to “rediscovered” by someone else years later.

One of the earliest visitors was Alden Partridge, the founder of Norwich University, who made a trip through the Lake Champlain Valley in 1820 and made topographic observations. He afterwards wrote: “I completed my observations at Ticonderoga at 1 ‘o’clock, PM and immediately crossed over to Mount Independence, in order to examine its position, and the remains of the works which had been erected…A breast-work extended around the base of the hill, near the water’s edge, from the east, on the norther, to the west side, the remains of which are distinctly to be seen. About half way to the summit, on the north side, are the remains of a half-moon battery, which effectively commanded the lines below. On the summit, which is table land, was a large stockade work, in form of a star fort, which enclosed a large area. Nothing now remains to denote either the figure or former existence of this work, except a shallow trench, and a few decayed and broken palisadoes (sic)." (*National Intelligencer*, Washington DC, August 5, 1820, p. 4).

In 1846, a description of the Mount noted that: Directly opposite {Ticonderoga}, on the Vermont side of the lake stands Mount Independence, covered with forts and redoubts, but all hid from traveler's view by trees and shrubs which cover it (*Christian Journal*, Exeter New Hampshire, November 12, 1846, p. 2).

In an article about the Hand's Cover Chapter of the DAR's meeting in 1904, it was noted that, on Mount Independence: "numerous traces of the redoubts and lines of entrenchments in various directions are yet visible. The old parade ground, surrounded with piles of stone which once served as fireplaces for their camps can be plainly marked out (*Burlington Free Press*, February 4, 1904, p. 4).

A large portion of the archaeological complex changed ownership in the early 20th century and the new owner also acknowledged the historical significance of the property. Stephen H. Pell, a New York City banker/broker bought 113 acres of the north end of the Mount in 1911. In 1912, it was reported that "Mr Pell has found rifle pits and piles of stone erected in the course of the Revolution on the point occupied by Mount Independence, some of which have not been disturbed apparently, since the war, having been hidded in the woods and in all probability forgotten until discovered by him" (*Bennington Banner,* February 5, 1912, p. 3).

These amateur accounts were followed by the first archaeological investigations focused on Mount's significant Native American history. In the 1930s, Prof. Godfrey J. Olsen of the New York Museum of the American Indian Godfrey reportedly excavated 52 Native American burials on the former McCrea farm (then owned by John Pell) near the mouth of East Creek, opposite Fort Ticonderoga. At least one burial also was reported on the farm owned by J.M. Stevens in Orwell in 1916. Also an "Indian Hatchet" was found on the T.S. Arthur farm on the shores of Lake Champlain, near the Mount, in 1930.

Archaeological investigations focused on the Revolutionary War remains continued through the late 1950s, into the1960s, 1970s, 1980s and into the 1990s. Among these efforts are Tom Daniels artifact collecting 1958-1959 and Richard Fifield's excavations in the 1960s-1970s (Seidel et al. 1997). As the State of Vermont prepared to take over part of the Mount, the Wintersmith map was used to identify 45 sites in 1965 and a survey was conducted in 1966-1967 of more than 140 possible foundations. Mills and Morse created a list of sites in 1965, mapping and pedestrian survey was conducted by Chester Bowie and David Robinson in 1966-1967 (Robinson 1968), and Richard Fifield and J. Robert Maguire conducted a cemetery investigation in 1972 (Seidel et al. 1997). Offshore surveys were conducted by the Lake Champlain Maritime Museum and State of Vermont in 1983, Ronald F. Kingsley surveyed and mapped a low area to the east of the Mount from 1987-1995 (Seidel et al. 1997), and Dr. David Starbuck conducted excavations as part of UVM field schools in archaeology in collaboration with VDHP in 1989-

1990 (Starbuck et al. 1990; 1991; 1993). Later, as part of the State's efforts to interpret the site and improve access, an archaeological survey of the Baldwin Trail was conducted by Sheila Charles in 1991. Dr. David Starbuck VDHP and Castleton College conducted additional mapping in 1992 (Starbuck and Murphy 1994) and, the same year, additional offshore mapping was conducted by the Lake Champlain Maritime Museum (Cohn 1995b). The first comprehensive look at the whole property was conducted in 1997 by Goodwin and Associates ~~who~~ produced a Cultural Resources Management Plan for the property (Seidel et al. 1997). This was followed by mapping and spatial control by the University of Maine at Farmington Archaeology Research Center/Northeast Archaeology Research Center in 2003 and 2008.

2017 UVM CAP Mapping Project

In an effort to map the archaeological features and natural topography of the landward side of Mount Independence in the greatest detail possible, the UVM CAP chose to utilize available remote sensing technologies, in addition to more traditional surface survey and ground-truthing methods. The goal was to build a GIS dedicated to the various data layers contributing to the natural and cultural elements that comprise the southeast portion of the National Historic Landmark. This work was conducted in multiple phases and included the use of an Unmanned Aircraft System (UAS) "drone," a high grade Global Positioning System (GPS), close analysis of airborne LiDAR coverage, and ground-level photogrammetry. The composite of data collected was viewed and archived within ESRI's GIS platform (ArcMap 10.4) in conjunction with existing spatial datasets.

Unmanned Aircraft System Flights

The UVM CAP collaborated with the UVM Spatial Analysis Laboratory (SAL) to utilize their UAS to develop a digital elevation surface model (DSM) for the property. A licensed pilot from UVM SAL flew the project area using the *senseFly eBee RTK* UAS on May 4, 2017. Six 25 minute flights were conducted over the project area at an average elevation of 399 ft above ground level in overlapping parallel and perpendicular flight lines. All flights were completed in compliance with FAA Section 333 exemption and FAA Part 107 UAS regulations.

The data gathered during the aerial survey was then processed by UVM SAL using *Pix4D* to generate overhead imagery in a 3-band, true color, GeoTIFF format, orthorectified in NAD 1983 StatePlane Vermont, survey meters. The resulting imagery has 5cm maximum pixel size, and horizontal accuracy +/- 10cm or better (hard ground surfaces)(Figure 6). A photogrammetrically derived point cloud was then generated in LAS (3-D point cloud interchange format) with image matching key points from all photos with vertical accuracy of +/- 10cm or better (hard ground surfaces)(Figure 7). A photogrammetrically derived raster surface model was then generated from the point cloud. A Digital Surface Model (DSM) was subsequently produced in GeoTIFF format (Figures 8 and 9).

The digital surface model was the goal of the UAS flight and some great elevational detail was obtained for more open portions of the property. Unfortunately, by the time the flight took place in early May, 2017, leaves had begun to sprout and this caused a great deal of reflection in the imagery and a lack of desired detail closer to the ground surface (see Figure 9). It may be possible to achieve better results in the early or late winter under no leaves and no snow conditions.

The digital point cloud was found to have high value, however, particularly when rotated using software such as CloudCompare which allows manipulation of three-dimensional point datasets. In particular, the imagery provides a dynamic perspective on the landward approach, not available with two-dimensional imagery (Figure 10). Using software such as CloudCompare, the user can change perspective and zoom in and out looking at the Mount from the perspective of a military approach and in relation to defenses (Figure 11). The color point cloud also can be used to geolocate specific features, including individual trees, which can be helpful in identifying, on the ground, specific archaeological sites and landscape features.

Airborne LiDAR and GPS

Immediately prior to preparing the proposal for the present project, the State of Vermont's Center for Geographic Information (VCGI) released LiDAR datasets for the portion Addison County, Vermont, that includes Mount Independence. While the UAS flights are based on photographic imagery, LiDAR, or light distance and ranging technology is laser based. With some correction to eliminate the tree canopy, point clouds generated from airborne LiDAR can penetrate to the ground level and generate "bare earth" digital surface models and other models such as hillshade models that provide dramatic representations of even subtle topographic relief. The LiDAR coverage for Mount Independence is astounding in its identification of anthropogenic constructions associated with the archaeological site (Figures 12 and 13). The second phase of the present project utilized the LiDAR data to identify likely and possible archaeological features along the landward portion of the Mount and then during subsequent visits to the field, these features were sought out and then GPS'd using a Trimble Geo7X hand held unit with sub-meter accuracy.

While some of these features had previously been mapped during earlier projects using traditional survey equipment, these earlier data are limited in that they represent points along alignments and do not, for example, capture the height or dimension of constructions such as defensive walls. One of the more dramatic outcomes of close inspection of the LiDAR data, was the identification of intentional landscape modifications including zig-zag cuts modifying the natural landform at the height of the southern edge of the Mount, above built "terraced" platforms formed with stone retaining walls, overlooking the higher defensive walls associated with the 2nd and 3rd Batteries (Figure 14). These features, some of which had been partially mapped previously, were groundtruthed in the field and GPS'd to confirm that all were artificial constructions and not simply natural phenomena that happened to be utilized for defense (Figure 15).

What the LiDAR data provides is a more complete map of the features along the landward side of the Mount than ever could be accomplished on the ground using traditional survey equipment. It may be possible in the future to get even higher resolution LiDAR that specifically targets Mount Independence with the goal of getting more of the Mount's archaeological features mapped in three dimensions, and in their topographic context. It is the context and interrelationship of the cultural and natural features that is the most compelling result of the use of these data. For example, it becomes readily apparent when one looks at the orientation of the tiered defenses and their orientation that they were designed not only to protect the length of the landward flank of Mount Independence, but also to defend and perhaps invite particularly likely avenues of approach up natural corridors (Figure 16).

Using software such as ArcScene and CloudCompare, the three-dimensional geospatial data provide exciting opportunities to evaluate the site's military engineering, defensive and offensive scenarios, and also provide a new appreciation for the labor involved in the construction of Mount Independence's archaeological landscape. Based on the historic maps, much of the earthwork, battery and breastwork construction likely was accomplished by American's prior to their abandonment of the Mount and the British occupation. Clearly the formidable defenses constructed by the Americans and their knowledge of the inherent traps associated with attacking from the landward side contributed to their strategies that favored harassment over reoccupation.

Ground-level Photogrammetry

The final technique employed during the 2017 field season was the use of hand held and pole-camera photogrammetry in attempt to improve upon the three-dimensional resolution provided by the airborne LiDAR data. The work included a selection of three archaeological features/complexes that were relatively open in terms of vegetation coverage and therefore were more accessible to pedestrian photogrammetry. These included the 2nd Battery, the storehouse and a blockhouse located above the 3rd Battery. The images were taken using a Canon SLR EOS Rebel T6 24 megapixel camera for the hand-held images, and a GoPro 5 Black for the pole and shot-stick images. The imagery was processed using *Pix4D* licensed to UVM SAL and Agisoft software licensed to the Department of Anthropology at UVM.

The process included systematic photography of stone wall features and associated landscape in parallel lines or arcs so that individual images overlapped sufficiently to allow for alignment and "meshing" by the software. In the same way the drone images were combined through photogrammetry to create a 3D model point cloud and a digital surface model of the landward side of the Mount, the ground-based images were combined to produce 3D models and digital surface models of individual archaeological features/complexes. These individual outputs were then georeferenced and placed in the GIS.

The first test of this technique at Mount Independence included the area of the 2nd Battery which is one of the more studied areas on the landward side of the Mount. To record the locations of excavations in this location conducted in 1993, the area was surveyed and mapped in some detail by DeAngelo (Howe et al. 1994). The DeAngelo map is incredibly accurate, with excellent representation of the battery's topography as seen when it is georeferenced in relation to the aiborne LiDAR (Figure 17).

On August 24, 2017, the 2nd Battery was photographed using a pole-mounted GoPro (Figure 18) in systematic arcs across the terrace landform. The arcs were GPS'd to record the paths used to cover the area (Figure 19). Cardboard box "targets" were placed across the landform and GPS'd to provide ground control and enable subsequent georeferencing of the models that were generated (see Figure 18). The imagery was later processed by UVM SAL using *Pix4D.* The 8/24/17 imagery produced a photorealistic model of the Battery including the defensive wall and the landscape of the terrace battery (Figure 20). However, a significant number of data points were out of alignment and appeared on different three-dimensional planes in the model (see Figure 20).

The data error was interpreted as a likely product of differential sunlight and glare in imagery taken on 8/24/17 which did not allow for proper matching and alignment of photographic blocks (see Figure 18). Rather than attempt to digitally stitch the offset parts into the base model, we resolved to reshoot the area under better conditions. To correct for the lighting issue, we waited for an overcast day and returned to the site on September 8, 2017, to repeat the process. The results, when there was more even lighting across the ground surface, were demonstrably different and yielded a remarkably realistic model of the archaeological complex, including the defensive wall and Battery terrace (Figure 21). Further processing of the model into a textured mesh provides even more detail as the software interpolates in between the points in the cloud (Figure 22). When manipulated with CloudCompare software, different rotations and zoom levels reveal other features as well including walled platform, likely a gun placement, in addition to topographic depressions in the area of excavations conducted in 1993(Figure 23). The model also enables measurement of individual stones, alignments and features, and also provides the ability to change the perspective and look at the battery from a defensive or opposing offensive perspective. The rendering provides a dimensional quality to the archaeological record that is impossible in a two-dimensional format, even when as accurate as the DeAngelo map. Finally, the model was georeferenced using the box targets and incorporated into the GIS (Figure 24).

Ground-based photogrammetry also was used to capture two other archaeological features on the southern, landward side of the Mount to evaluate the technique as a method for future documentation. The first, the storehouse located on the level plateau above the 2nd Battery, was done using a hand-held digital SLR camera with images taken across and around the foundation remains of the storehouse. The imagery was then processed using Agisoft software to produce a photogrammetric point cloud and a textured mesh. An image field was exported from the software and georeferenced using GPS points taken on foundation corners in the field (Figure 25). The level of detail recorded is excellent and, as in the case of the 2nd Battery data, easily rotated and manipulated to change perspective, execute measurements, etc. This particular model was accomplished with only minimal field time prior to a longer period devoted to laboratory processing.

Finally, the third area where ground-based photogrammetry was used was on a blockhouse foundation above the 3rd Battery. Here a shorter shot stick was used to elevate the remote-controlled GoPro camera. Images were taken across the foundation and around its perimeter. These images were then processed in Agisoft to generate point clouds and textured meshes. A digital surface model also was generated in georeferenced geotiff format (the GoPro images are all geotagged and therefore have embedded coordinate data). The geotiff of the blockhouse shows excellent relief associated with the foundation walls, as well as a mound in the center of the foundation, reportedly covering the area of the chimney and a prior excavation (Figure 26). This type of output, when integrated with the airborne LiDAR can be built upon over time to enhance detail in and around archaeologically significant areas.

Conclusions and Recommendations

The 2017 geospatial mapping of landward side archaeological features at Mount Independence produced highly useful data that moves the 240 year history of mapping at the site to yet another level. One of the most remarkable takeaways from the project is the site's incredible level of preservation, despite centuries of logging, farming and looting, and how the site's landscape features and stone constructions lend themselves to the use of non-invasive techniques such as those employed in the present study. The work has created a central geographic database that can be used to integrate past efforts with newly added and future detail. In particular, the geospatial data contributes another perspective that can be employed in the ongoing interpretation of the site's military history and offers a centralized archive to help manage and track the archaeological resources at a well-visited significant site within a dynamic, mainly forested natural environment. Additional LiDAR coverage would be ideal, taken in low-vegetation seasons either flown by plane or drone, or by using ground based LiDAR units, perhaps aided by the use of a lift in some areas. Capturing the LiDAR and processing of the data is a more expensive route, though the equipment and processing software is becoming much more accessible. Ground-based LiDAR units can provide millimeter accuracy over a great distance and, even working around trees could provide exciting results including revealing subtle archaeological features and associations between them that are not visible from the ground.

The airborne photogrammetry yielded mixed results. The drone-collected imagery, while extremely interesting has limitations mainly imposed by the level of tree cover across the Mount. The point cloud generated showed the viability of this method for producing excellent results in more open areas, and certainly the value of manipulating the data to gain different perspectives on the Mount, its defenses and possible approaches. Additional flights in late winter would likely produce more detailed imagery of the ground surface that might approach the level provided by the airborne LiDAR.

The ground-based pole camera and hand-held photogrammetry proved to be an excellent way to capture smaller areas and archaeological features. This economical method can produce curated maps of sites and 3D models that can help aid structural reconstruction and interpretation. The integration of elevation models generated from the more feature-specific photogrammetry with the other elevational data such as the airborne LiDAR is a powerful way to add to what could become a true 3D model of Mount Independence. Evaluating these non-invasive techniques and there outputs will allow the State of Vermont to gauge the level of effort necessary to pursue more extensive mapping at this incredibly well-preserved National Historic Landmark.

Figures

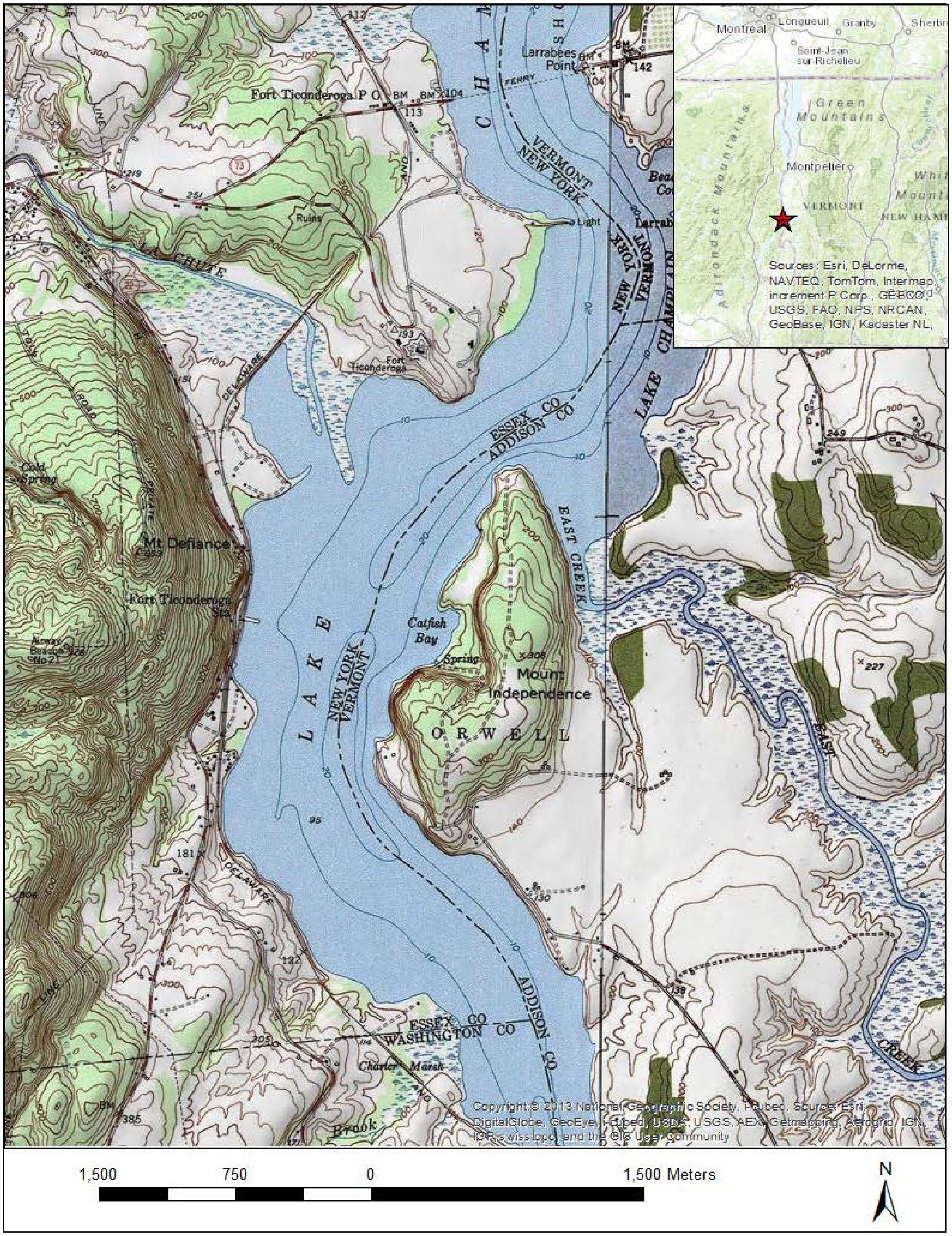

Figure 1. USGS map showing the location of Mount Independence on Lake Champlain, Orwell, Vermont.

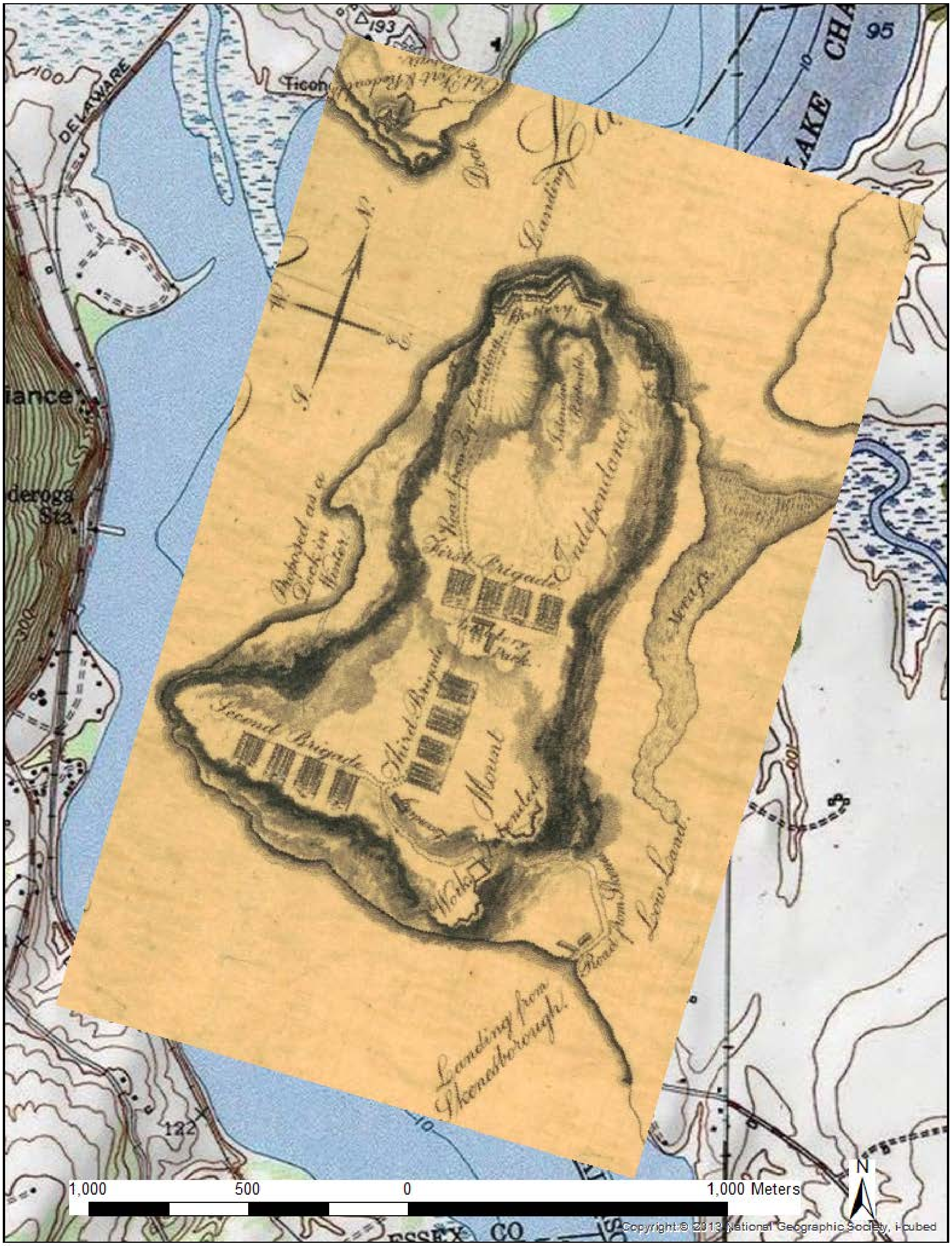

Figure 2. Georeferenced (approx.) Trumbull *Ticonderoga and its dependencies, August, 1776,* on USGS topographic map.

Figure 3. Georeferenced (approx.) of *Plan of Mount Independence at the Time of American Retreat*, from the Court Martial of General St. Clair, 1777 on USGS topographic map.

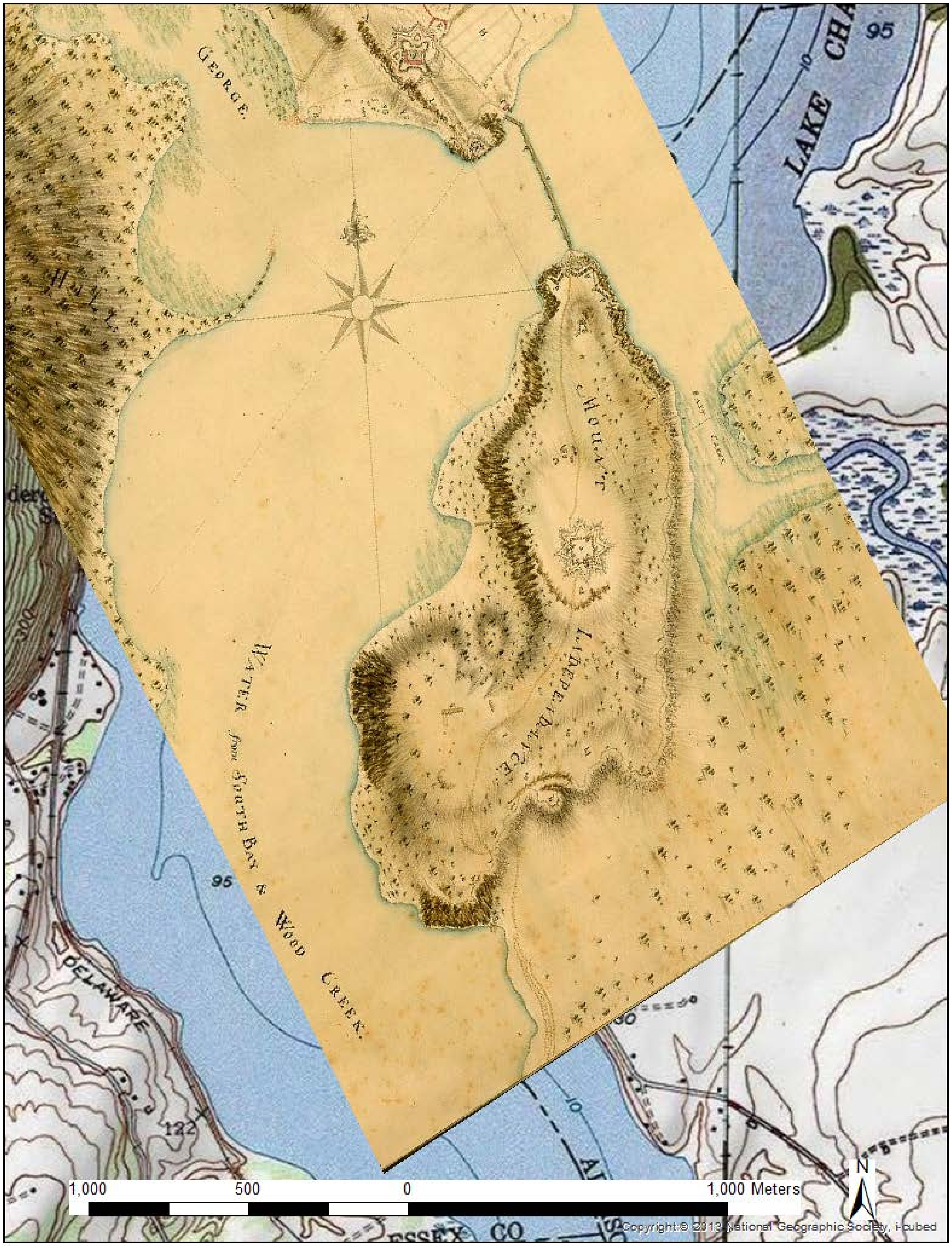

Figure 4. Georeferenced (approx..) Wintersmith *Conditions 6 July 1777* map (John Carter Brown Library, Brown University), on USGS topographic map.

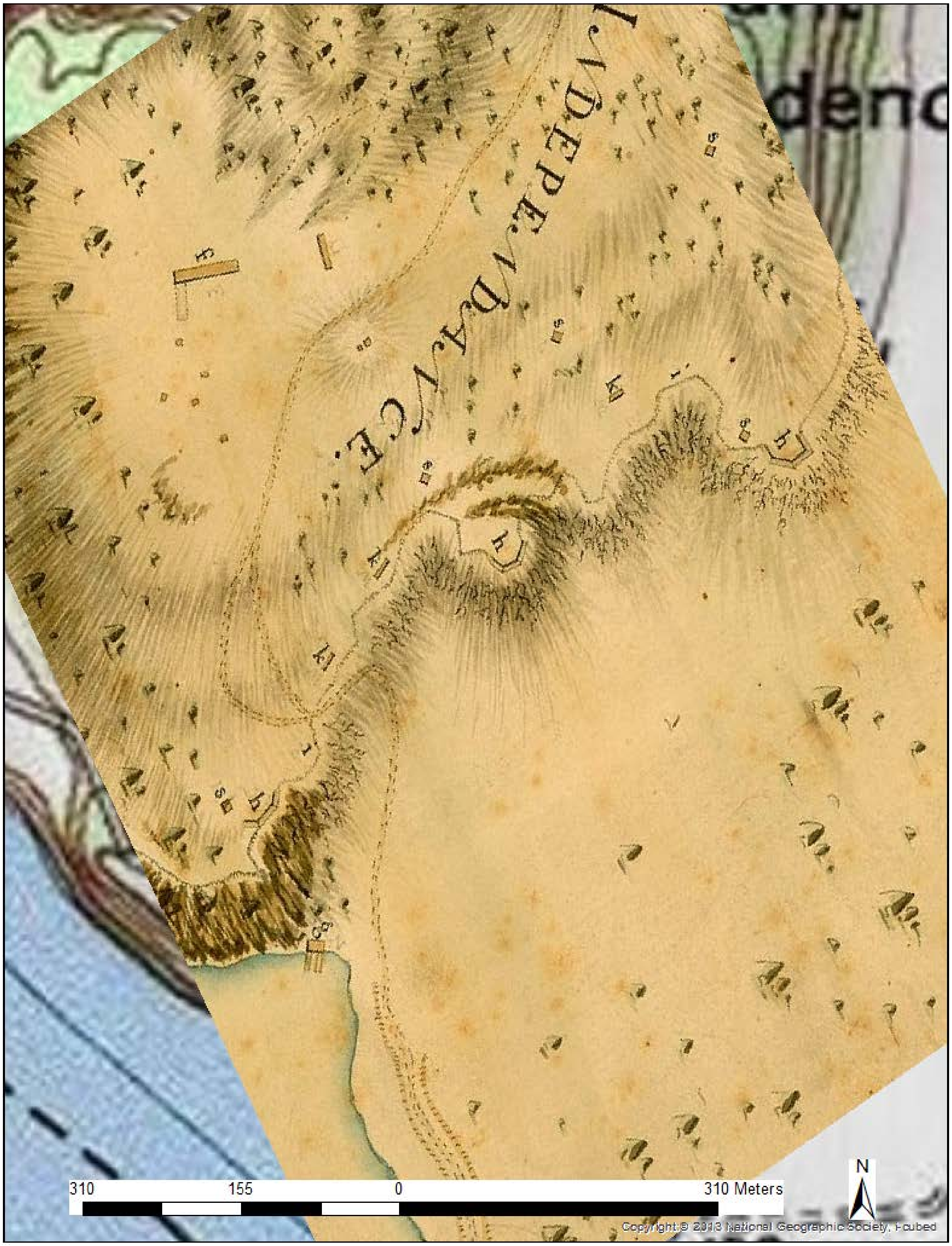

Figure 5. Georeferenced (approx.) closeup of Wintersmith *Conditions 6 July 1777* map (Wintersmith 1777), on USGS topographic map. Note the location of the three landward batteries ("h") on prominences and topographic features along the southern edge of the landform.

Figure 6. Orthophoto generated from UVM SAL's unmanned aircraft system's flight, May 4, 2017.

Figure 7. Photogrammetrically derived “point cloud” generated from imagery taken by UVM SAL’s unmanned aircraft system.

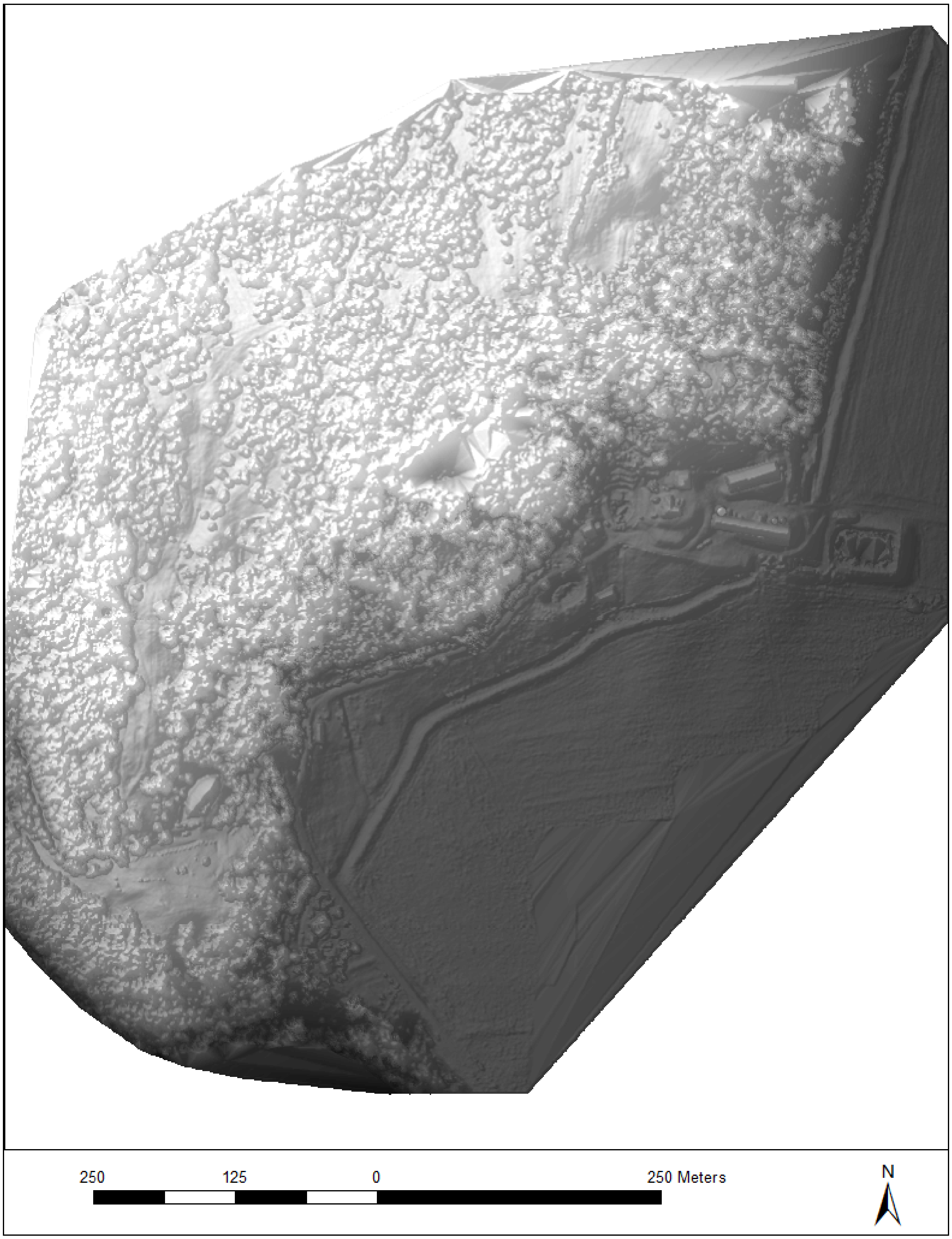

Figure 8. Digital surface model (DSM) generated from the photogrammetrically derived point cloud collected during the May 4, 2017 UAS flights.

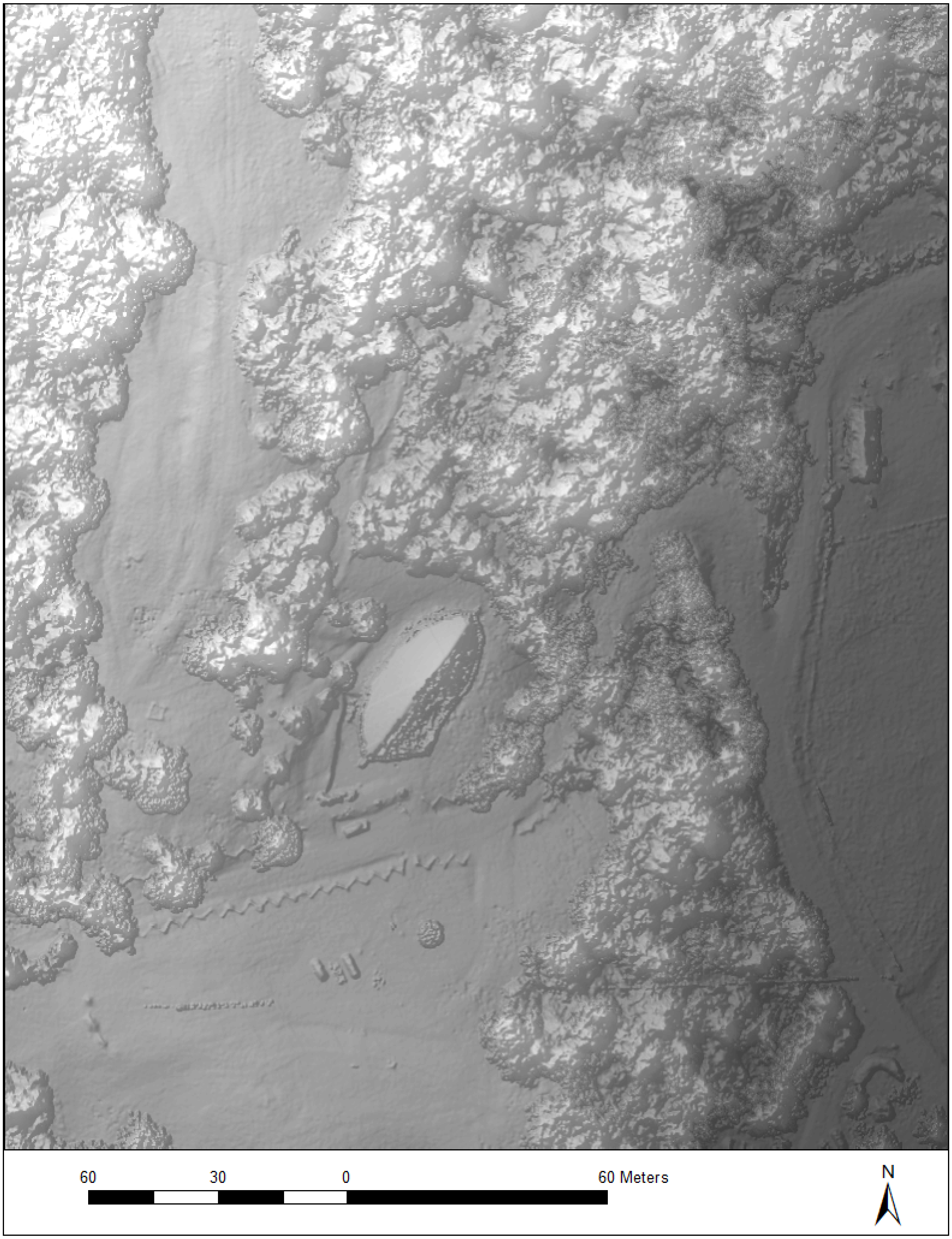

Figure 9. Close-up of digital surface model (DSM) generated from imagery collected during UAS flights May 4, 2017. Note "boat-shaped" Mt. Independence Museum and Visitor's Center, wooden zig-zag fence along parking area at bottom, and bright reflection of tree canopy.

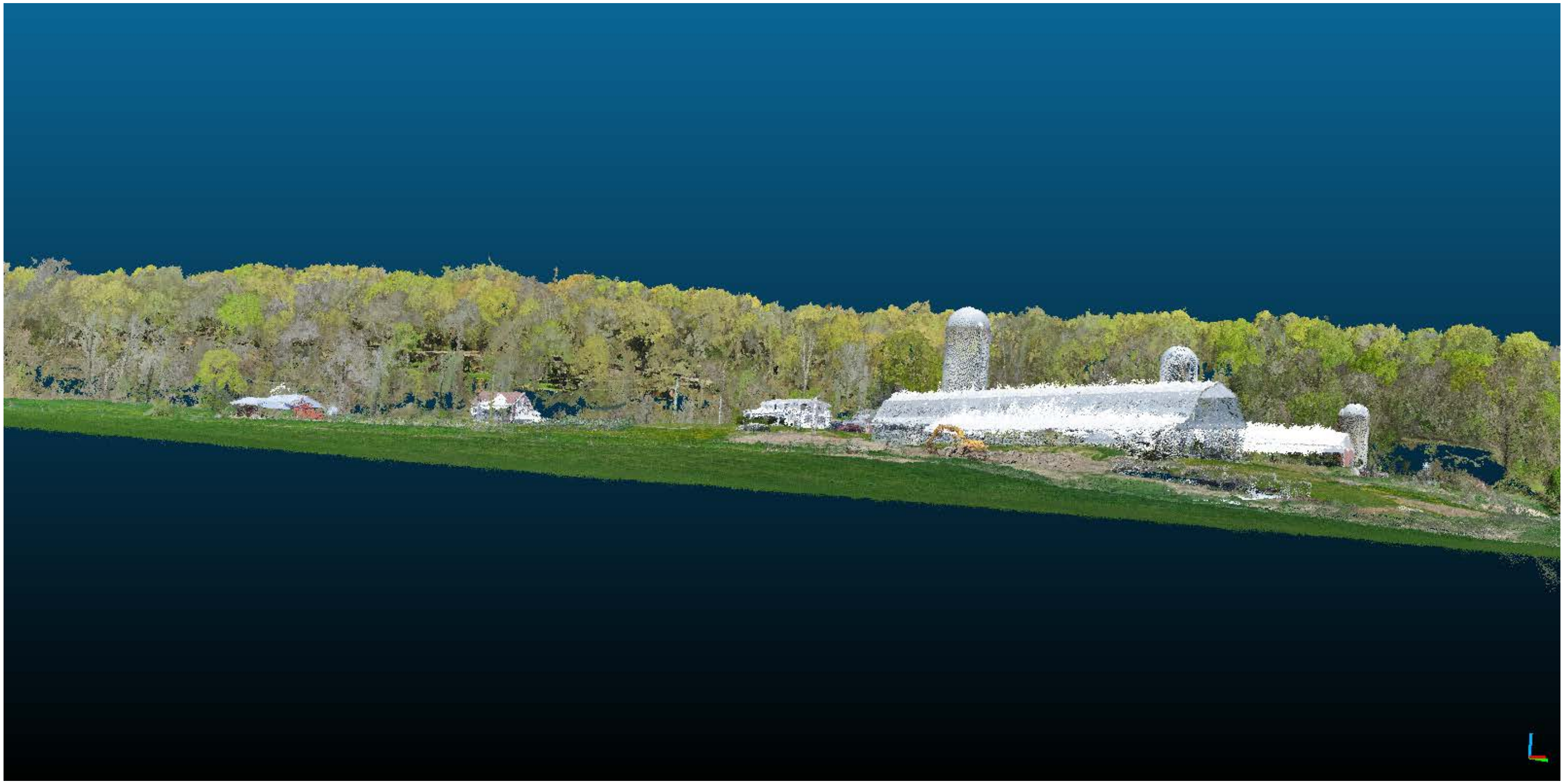

Figure 10. Photogrammetrically derived “point cloud” generated from imagery taken by UVM SAL’s unmanned aircraft system, facing west from landward approach.

Figure 11. Close-up of Photogrammetrically derived “point cloud” generated from imagery taken by UVM SAL’s unmanned aircraft system, facing west from landward approach. Note farm in foreground and approximate location of 2nd battery on the Mount above.

Figure 12. LiDAR image of the landward side of Mt Independence (source: VCGI EGC_services\IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1). Note easy discernable cultural features, including roads below, walls along the ridge, and manure pits by farm at center right.

Figure 13. Close-up showing the location of of 2nd Battery in LiDAR image of Mt Independence (source: VCGI EGC_services\IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1). Note relief representing defensive wall around the battery.

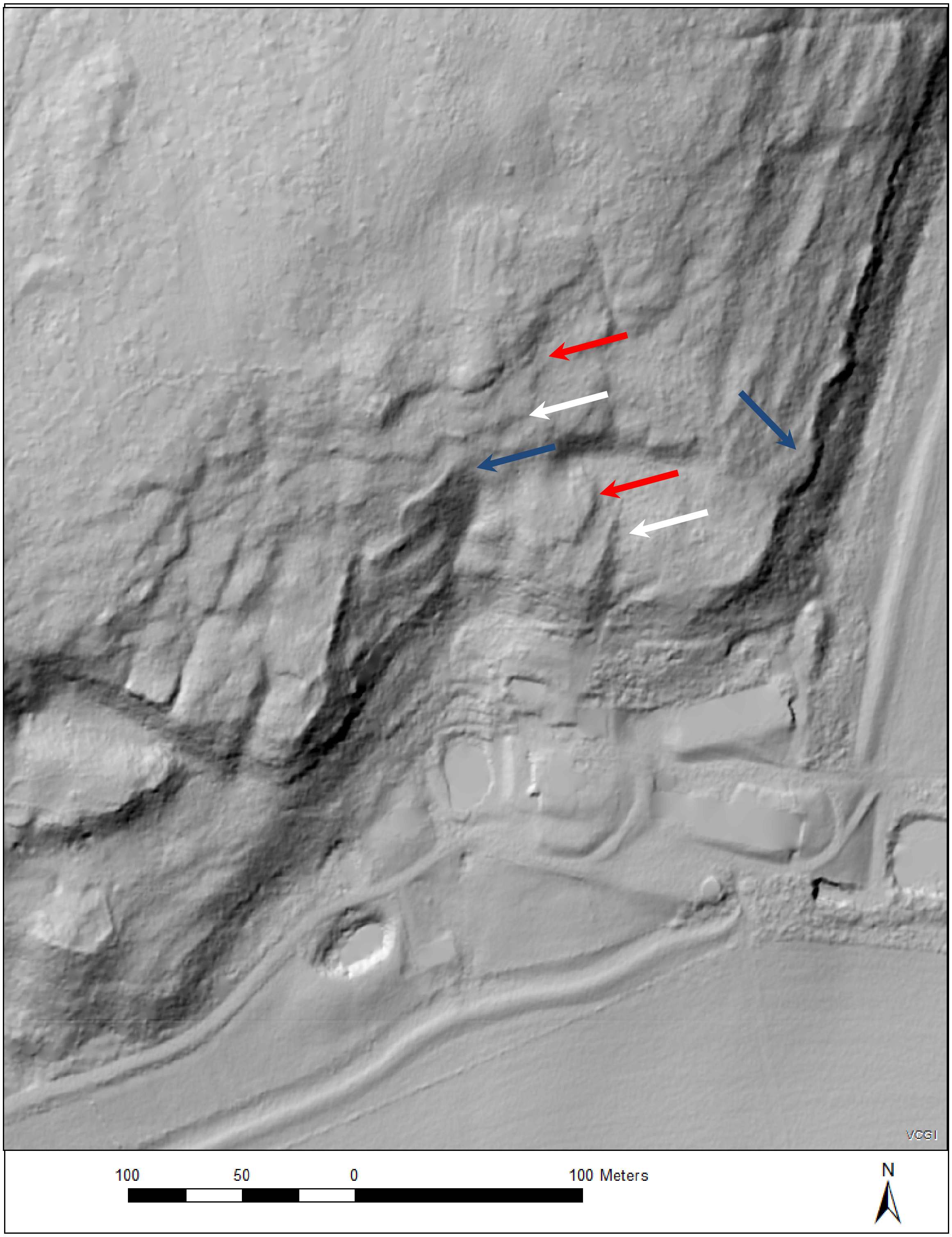

Figure 14. Close-up of LiDAR showing the archaeological features near the 3rd Battery (source: VCGI EGC_services \IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1). Note walls and terracing.

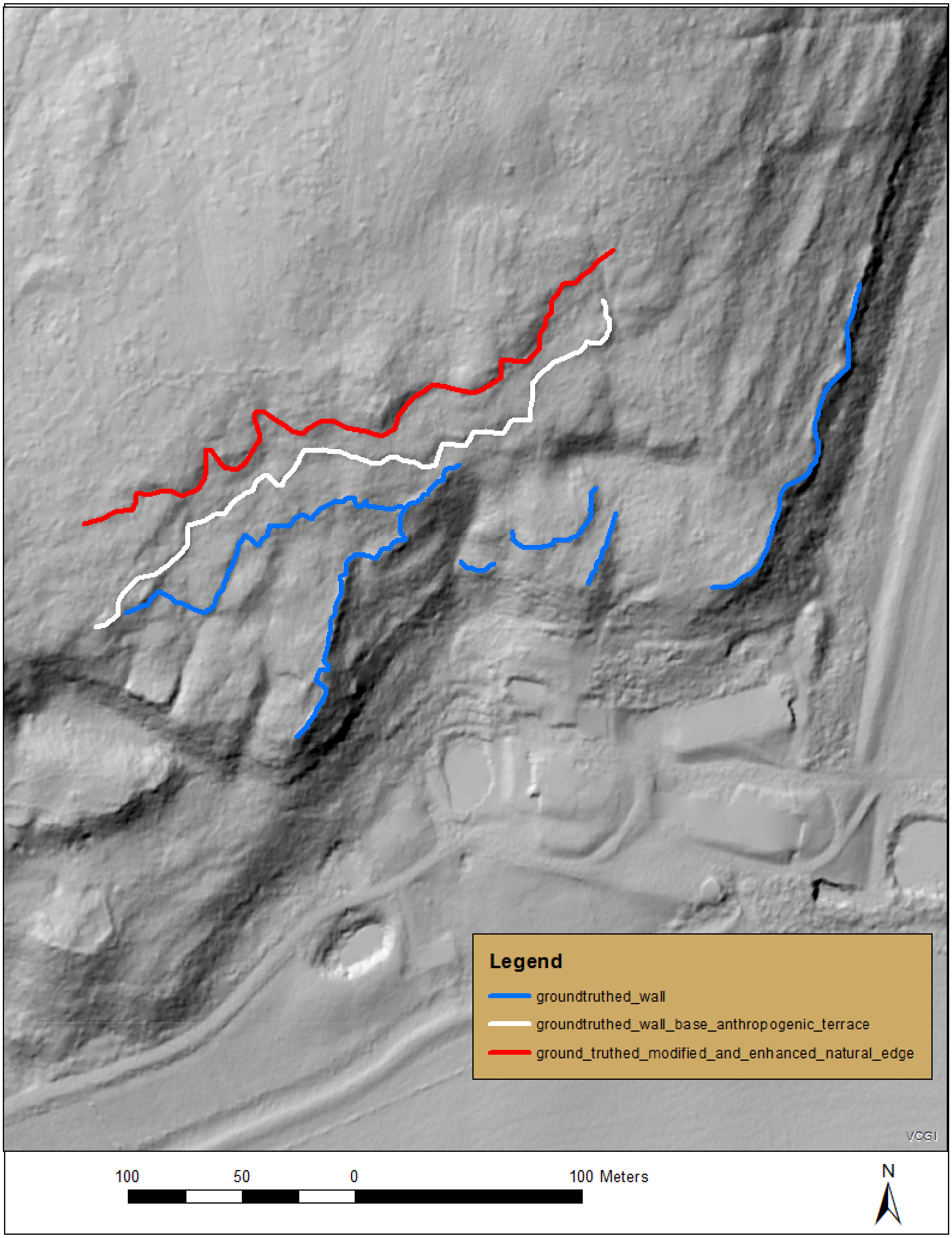

Figure 15. Close-up of LiDAR showing groundtruthed archaeological features near the 3rd Battery (source: VCGI EGC_services \IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1).

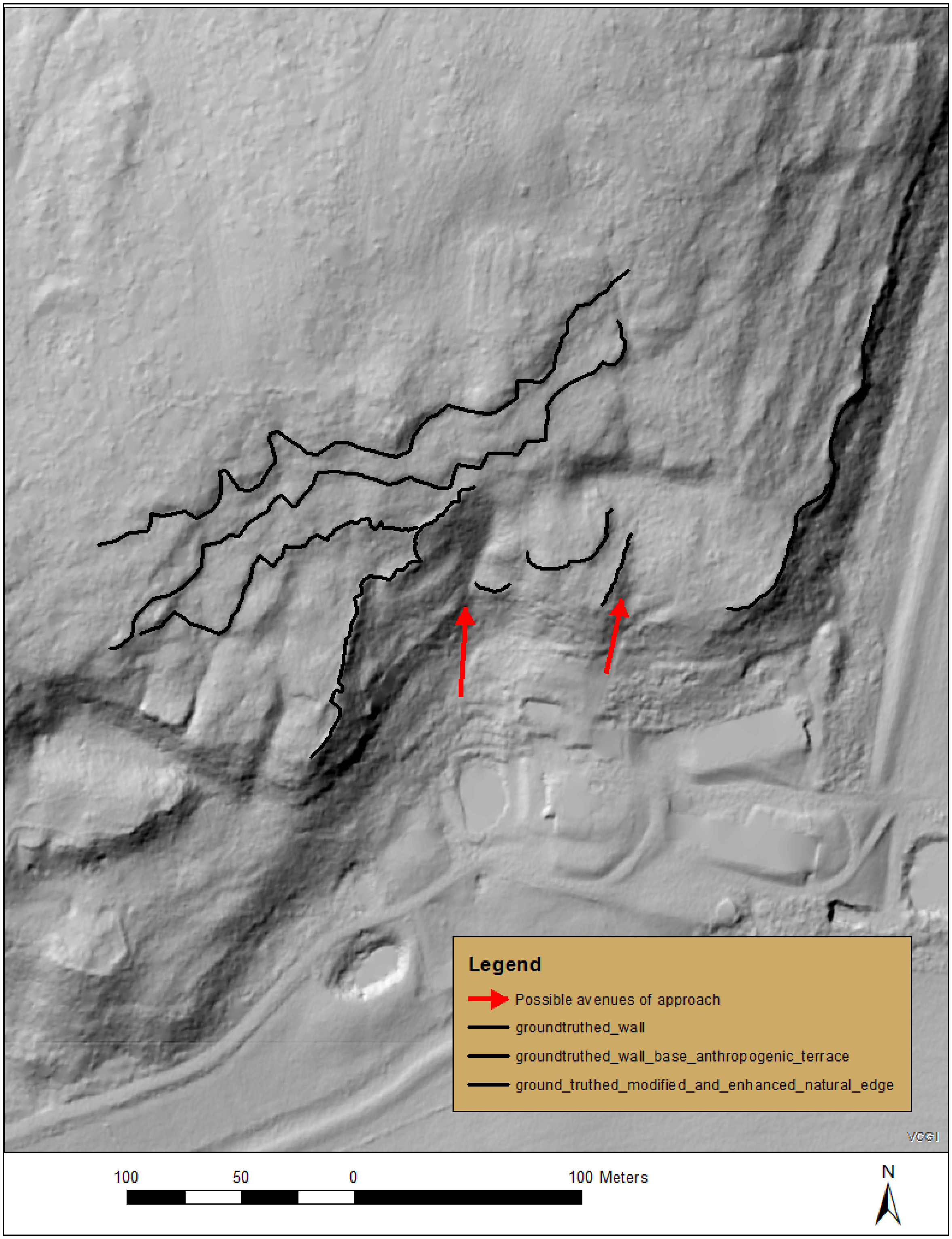

Figure 16. Close-up of LiDAR showing groundtruthed archaeological features near the 3rd Battery and possible avenues of approach up natural corridors (source: VCGI EGC_services \IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1).

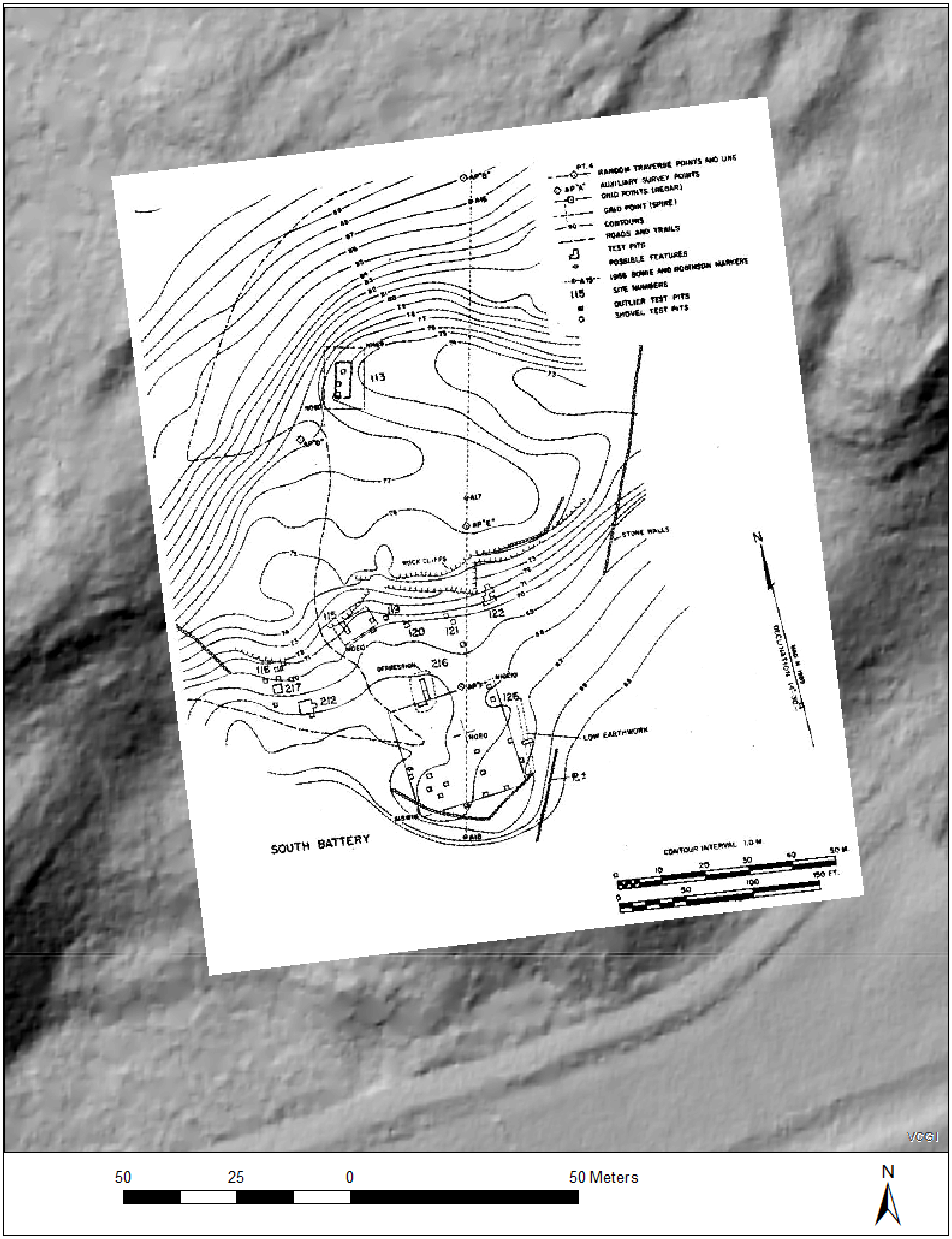

Figure 17. LiDAR imagery overlaid with georeferenced copy of the 1993 “South Battery Excavations” map by DeAngelo (Howe et al. 1994).

Figure 18. Photography in progress at the 2nd Battery using a pole-mounted GoPro 5 Black. Note cardboard box “target” in background used to geo-locate the composite imagery later on. Note “patchy” nature of sunlight across the ground surface.

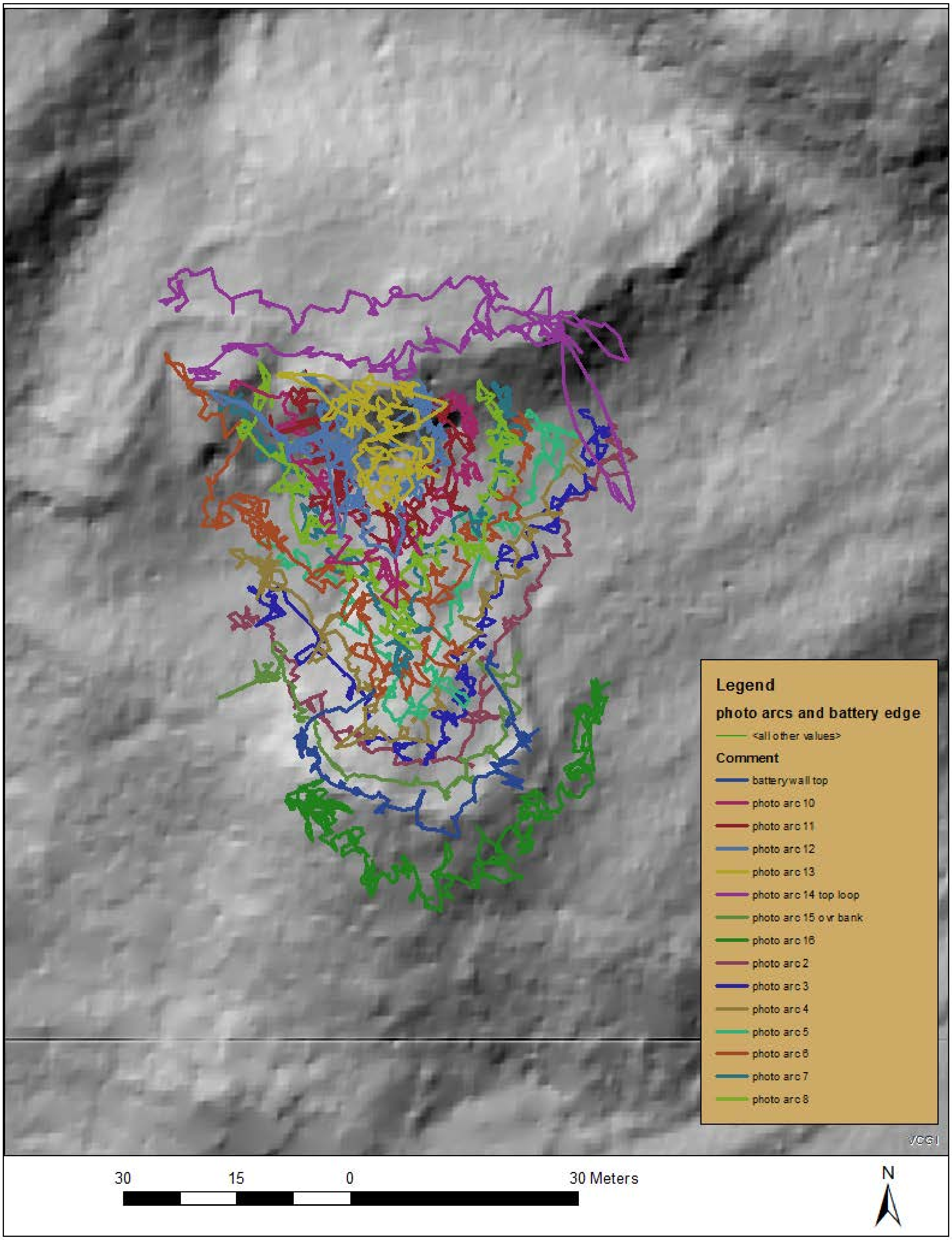

Figure 19. Close-up of 2nd Battery in LiDAR image of Mt Independence with photogrammetry "arcs" (source: VCGI EGC_services\IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1).

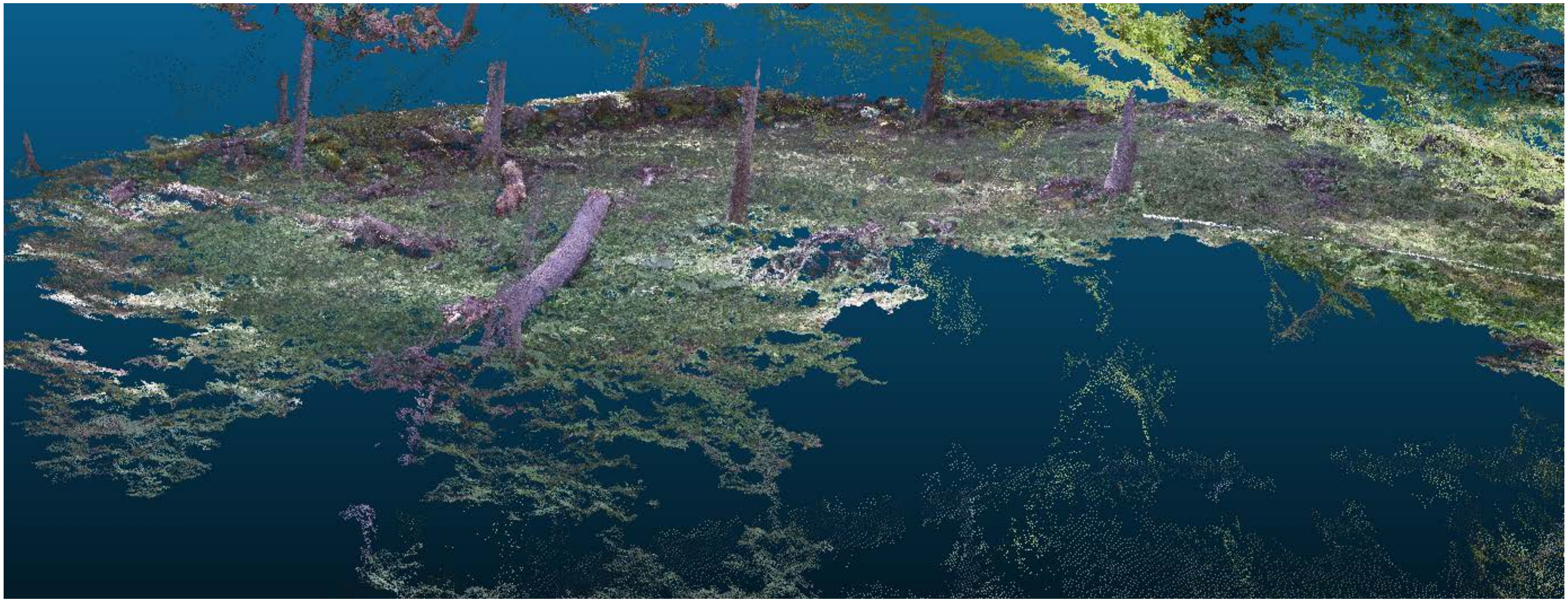

Figure 20. Point cloud mesh of 8/24/17 photogrammetry at the 2nd Battery, Mount Independence. Note battery's defensive wall in background and data points on different three-dimensional planes likely resulting from variability in sunlight and glare on the day the images were taken.

Figure 21. Photo, above, of the 2nd Battery, Mount Independence, and photogrammetric point cloud, below, rendered from the 9/8/17 pole-camera imagery.

Figure 22. Photogrammetric textured mesh of the 2nd Battery, Mount Independence, rendered from 9/8/17 pole-camera imagery.

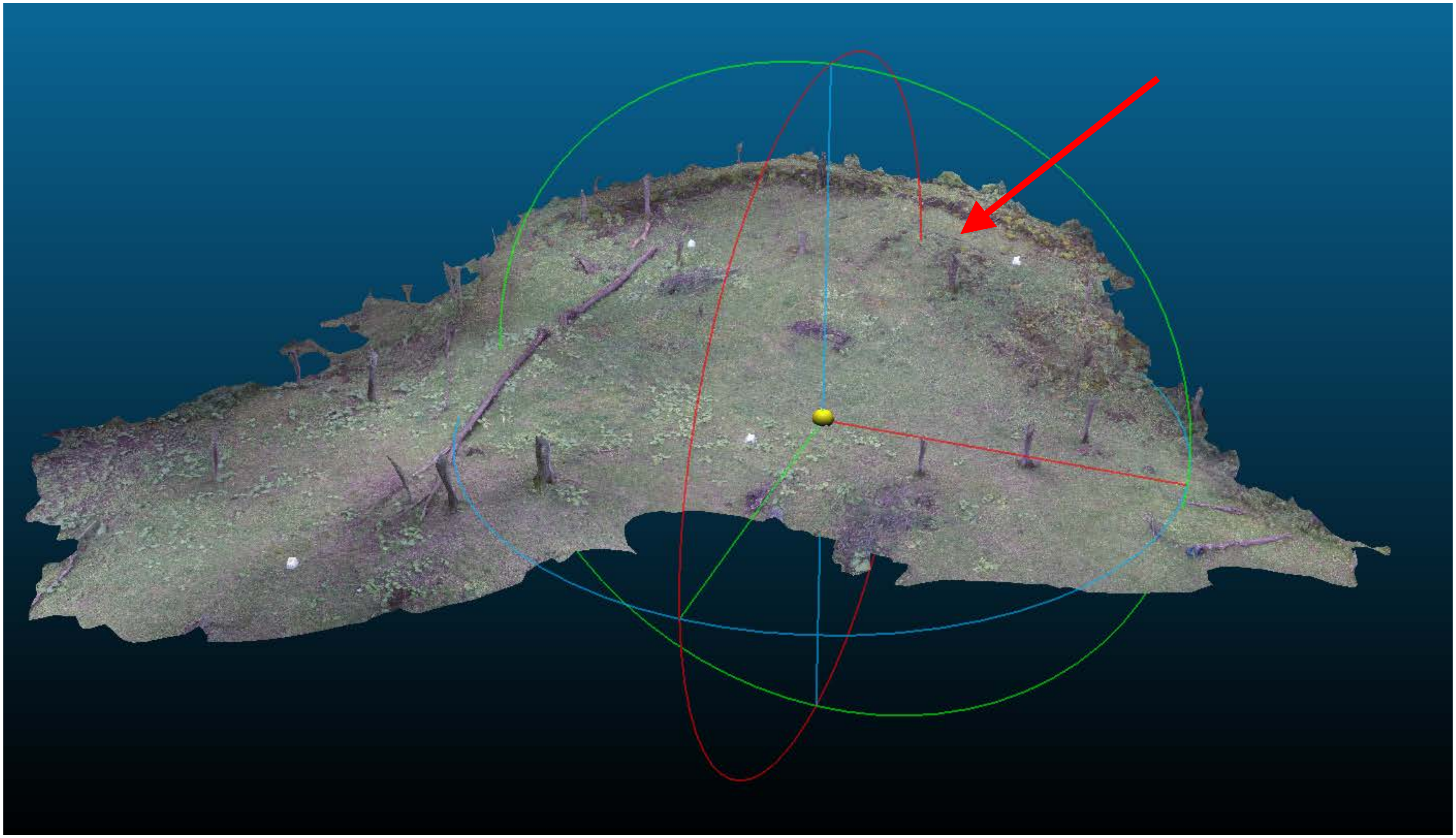

Figure 23. Screen shot in CloudCompare software showing the rotation of the textured mesh rendering of the photogrammetric model of the 2nd Battery at Mount Independence. Note arrow pointing to stone alignment feature (gun emplacement?) not depicted on the 1993 archaeological survey map.

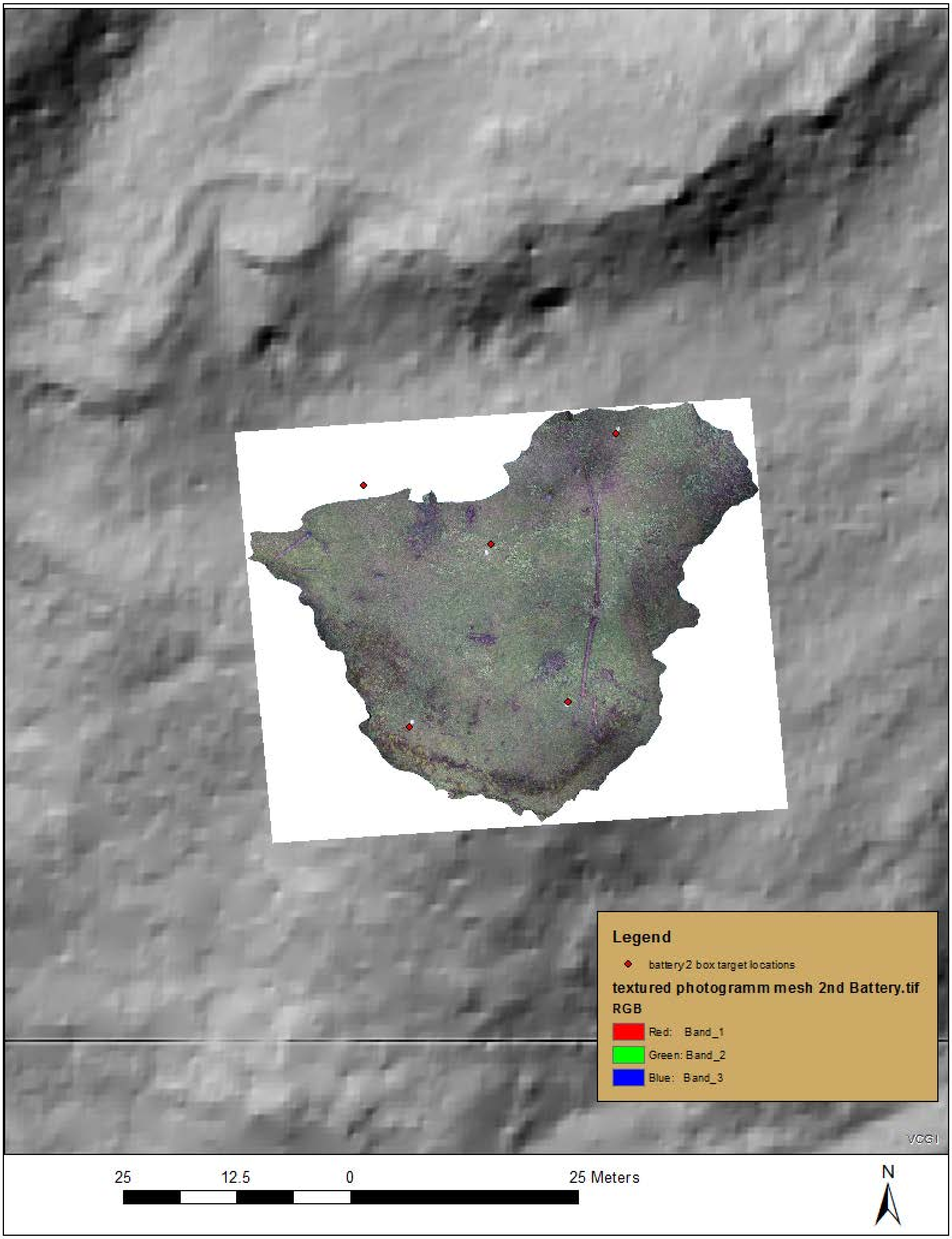

Figure 24. Georeferenced photogrammetric mesh of the 2nd battery overlaid on LiDAR (source: VCGI EGC_services\IMG_VCGI_LIDARHILLSHD_WM_CACHE_v1).

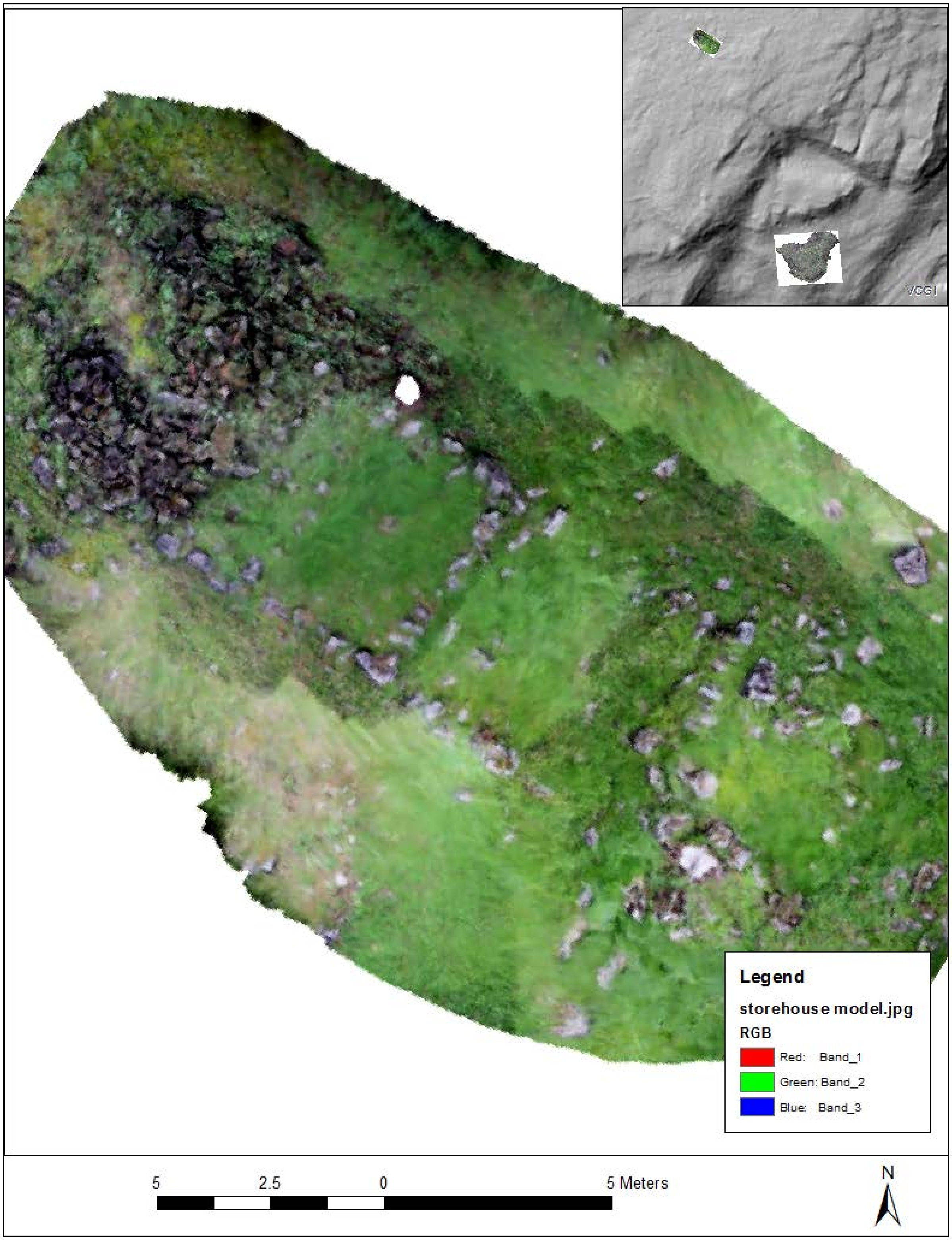

Figure 25. Plan view of photogrammetric textured mesh model of Mount Independence storehouse rendered from hand-held digital SLR imagery. Inset shows storehouse on LiDAR imagery in relation to 2nd Battery.

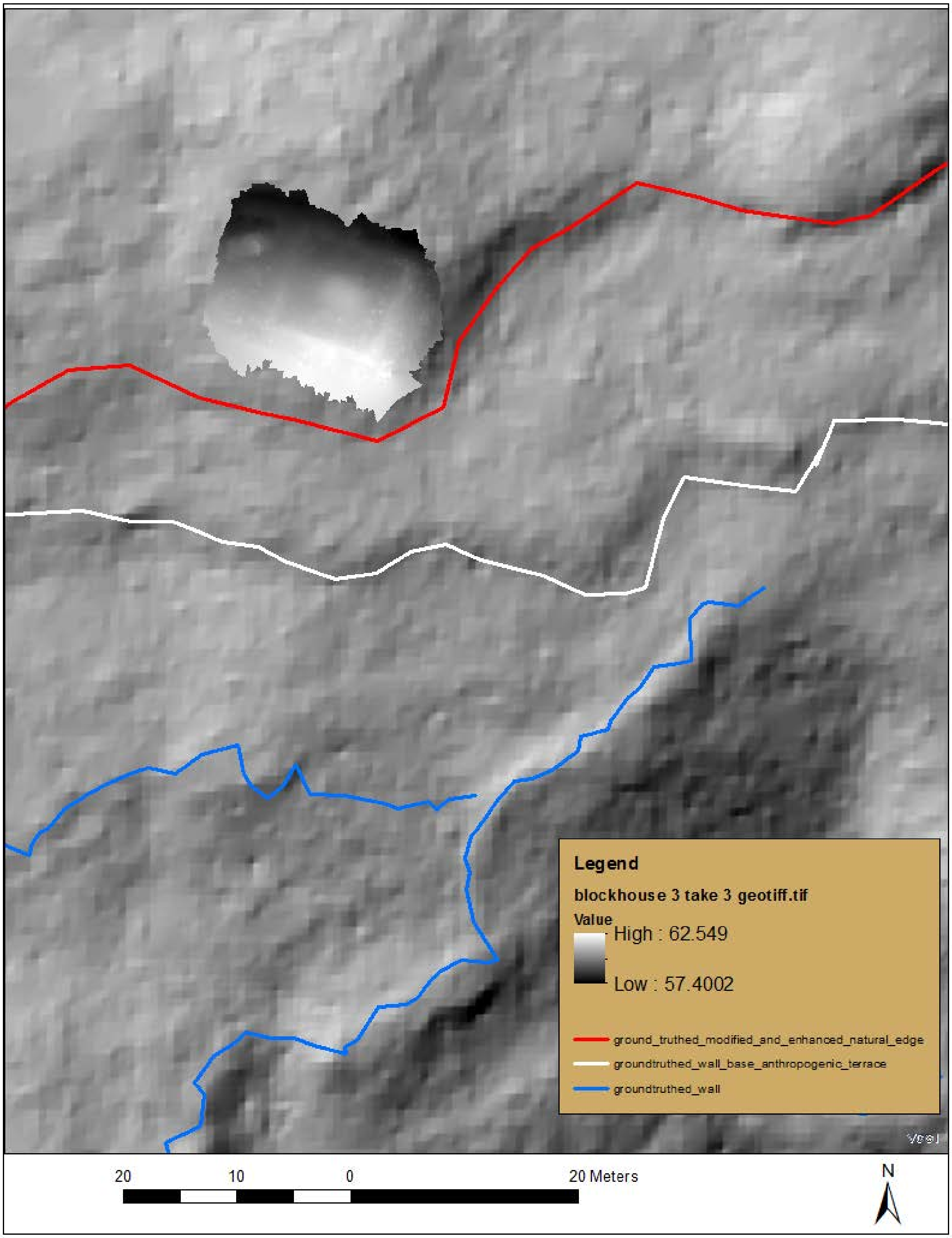

Figure 26. Geotiff of photogrammetric digital surface model of blockhouse foundation above 3rd Battery at Mount Independence on LiDAR imagery. Note blockhouse wall elevations, rise in center of foundation marking prior excavation location, and relationship of blockhouse to landscape and wall features.

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