Forensic Search for fallen soldier burials from the American Revolutionary War at Kettle Creek Battlefield, Georgia, USA

Daniel P. Bigman[a]*, David Noble[b], Tracy Sargent[c] & Jamie K. Pringle[d]

[a] Bigman Geophysical, LLC, Norcross, GA, USA

[b] Independent Researcher, Atlanta, GA, USA

[c] K9 Search & Rescue Specialists, Inc., Cedartown, GA, USA

[d]School of Chemical & Physical Sciences, Keele University, Keele, Staffs, ST5 5BG, United Kingdom

Email addresses: dbigman@bigmangeo.com (D. Bigman); fishingnoble@gmail.com (D. Noble); trace314@yahoo.com (T. Sargent); j.k.pringle@keele.ac.uk (J. Pringle)

*corresponding author email: dbigman@bigmangeo.com

Abstract

The Battle of Kettle Creek was the only major victory for U.S. forces in Georgia during the American Revolutionary War that took place on February 14, 1779. Around 50 loyalist prisoners were subsequently, and controversially, convicted of treason and 5 hanged. The battlefield site was only identified in 2008 and the land was purchased by the American Battlefield Trust in 2018. This article aims to present results from a forensic archaeological search to answer two questions: (1) was it possible to identify the burial ground(s) for site preservation from this historic battlefield site; and (2), were the fallen soldiers from the battle buried in a mass grave or in individual interments? Search methods included a phased investigation approach of a desk study, then ground searches involving cadaver dogs, geophysics (GPR), and subsequent forensic archaeological excavation and soil analysis (specifically mtDNA and VOC extractions) to recover possible trace evidence of human burials. Results suggest the main battlefield burial area was able to be identified, with 24 cadaver dog alert locations, geophysical and soil anomalies suggesting individual burials where fallen soldiers were interred. Archaeological excavation found contemporary battlefield artifacts, and although human remains were not recovered, the soil analysis showed the presence of mtDNA in these locations. Despite the difficult ground search conditions due to the large search area, 200+ years age of burials, and limited remains, such a focused search strategy has been proven to be an effective approach to detect other historic battlefield burial sites.

Key Words

forensic archaeology, cadaver dogs, ground penetrating radar, geophysics, revolutionary war, decomposition, mtDNA, historic archaeology, American History

Highlights

- Investigating where battlefield burials were located from the Battle of Kettle Creek during the American Revolutionary War.
- Multi-disciplinary investigative approach that includes desk study, cadaver dogs, and geophysics GPR phases.
- Archaeological intrusive investigation and soil analysis subsequently undertaken.
- Results suggest isolated fallen soldier graves rather than a mass grave.

1. Introduction

The Battle of Kettle Creek was the only major American victory in the Georgia Colony during the late 18th Century American Revolutionary War, located near Washington, Georgia, USA (Figure 1). The Battle of Kettle Creek occurred on February 14 ,1779, when more than 50 Loyalist Volunteers and 14 Patriot Militia were killed. A battlefield report by Col. Pickens in 1811 [1] indicates that he negotiated freedom for some Whig prisoners if they buried the dead from the battle. It was suggested by [2] that the fallen may have been buried in a mass grave, but then goes on to note that no evidence to date has been produced to confirm this. The Kettle Creek Battlefield itself was located in 2008 [2]. Upon its discovery, the Kettle Creek Battlefield Association, formed in 2011, has worked to develop, expand, and preserve the 1,600-acre site [3].

Current forensic search methods to detect both isolated and mass clandestine burials of murder victims are highly varied and have been reviewed elsewhere [4], with best practice suggesting a phased approach, moving from large-scale remote sensing methods [5] to ground reconnaissance and control studies before full searches are initiated [6]. These full searches have involved a variety of methods, including forensic geomorphology [7], forensic botany [8], scent-trained search dogs [9-11], thanatochemistry [12] and near-surface geophysics [13-16].

Other forensic searches have identified mass graves from similar historic conflicts (e.g. [17- 20]), including one well documented study of other American Revolutionary war sites [21]. While these researchers provide critically helpful information on optimal procedures and geophysical signatures for identifying historic mass graves, the Kettle Creek battlefield site had some unique challenges. The battlefield may be as large as 500 acres (though much of the fighting likely occurred in an area between 40-80 acres), the topography is highly variable with much of the battle taking place on moderate to steeply sloped terrain (Figure 2), and the environmental conditions, as well as human interventions (clear-cutting, controlled burns, etc.) may have caused rapid decomposition or other burial disturbances. Currently there are no well documented approaches to search for graves in such conditions.

Human remains search dogs (technically known as Human Remains Detection dogs or HRD dogs, and commonly referred to as cadaver dogs) are trained to identify human remains scent from decomposed human bodies using olfactory cues. Decomposed bodies change the physical and chemical properties of the soil they interact with through the release of nutrients and energy [22]. This interaction can possibly alter soil pH, electrical conductivity, and nutrient levels [23,24] which produce an odor that is detectable by properly trained HRD dogs. The odor can remain in the soil or on the surface long after the remains have completely decomposed, and no bone is left [25]. Furthermore, multiple studies indicate that HRD dogs can distinguish between decomposing human cadavers and those of other animals [24,26] since each animal cadaver is composed of a unique set of volatile organic compounds (VOCs) that produce a unique odor [12]. There is some overlap in VOCs found in different animal cadavers, but each species has a unique set. Pigs are often considered the best proxy for decomposition studies [27,28], but pigs and humans only share seven compounds of the 30 that human cadavers contain [26]. Despite the abundance of research showing the capability of dogs to locate human remains, it is still unclear exactly which compounds HRD dogs are using [25]. Thus, the qualifications of the dog handler remain an important factor in determining the success of any search [29].

GPR was used to identify more exact locations of possible burials identified through HRD dog searches. GPR sends electromagnetic pulses to a transmitting antenna at the ground surface which produces a radio wave that travels through the subsurface. Wave velocity depends on the ability of a given medium to transfer energy and when an approaching wave encounters a discontinuity in the physical properties of the soil then some of the wave's energy is reflected. The amplitude, two-way travel times, and polarity are recorded by the GPR antenna [30-33]. These recorded reflection events are what the archaeologist or forensic investigator are using to infer locations of possible clandestine burials. Numerous case studies document the success of GPR for locating unmarked burials [21,34-42].

Forensic archaeology began to be applied to the search, recovery, and identification of human rights victims in the 1980s [43], now common in both forensic research and applied programs searching for victims of war crimes (e.g. [20,44-48], and protest victim sites [17], as well as other "conflict casualties" [49], which include fallen soldiers both defending and oppressing human rights. This work is particularly important when considering topics of closure, identity, and history for the families of victims [50], especially when those descendants may have lived through the violative event [51]. It can be troublesome to investigate conflicts and other humanitarian crises that occurred deeper in history when standard approaches are difficult to deploy, and results are difficult to interpret.

The project under study was set up to answer two specific questions: firstly, was it possible to identify the burial ground(s) for site preservation from this historic battlefield site; and secondly, were the fallen soldiers from the battle buried in a mass grave or in individual interments? To answer these questions, personnel, with uniquely-designed resources, developed an approach that would facilitate the search for graves in such difficult conditions, and that such a multi-resource concept could be used in the future by others working under similar challenges.

2. 1779 Battle of Kettle Creek, Georgia, USA

While the general location of the battle has been known for some time, the first systematic archaeological search wasn't conducted until 2008 [2]. This investigation primarily consisted of reconnaissance survey to identify surface artifacts and architecture, and metal detection survey to identify subsurface artifacts possibly associated with the battle. Limited shovel testing and archaeological excavation was also conducted following survey. The efforts recovered numerous artifacts including ammunition and other arms related artifacts that were diagnostic of the revolutionary war battle. The distribution of artifacts placed a general boundary around area of heavy fighting, though the lead investigator indicated the likelihood that artifacts related to the battle have been removed over the past two centuries by pedestrians.

The following battle sequence is summarized from archival research conducted by [52] and [53], and contemporary letters written by [1] about his life and the war and [54] summarizing the battle. During the night of February 13, 1779, ~700 Loyalist soldiers commanded by Col. Boyd crossed Kettle Creek on the Lexington – Crawfordville Road in Wilkes County, Georgia. At 10 am on February 14th, Col. Pickens with 300 Whig Militia arrived at the northern end of the battlefield. Col. John Dooly and 50 GA Militia on horse were on the right flank, Lt. Col. Elijah Clarke and 50 GA Militia on horse on the left flank, Col. Andrew Pickens and 200 South Carolina Militia on horse were in the Center (Figure 3). Col. Pickens and a small advance (7) rode up Old Liberty Church Hill, who were ambushed by Boyd and rode back downhill to their men. Immediately, Col. Clarke started a mounted charge on Settlement Road, reaching Boyd and his men on top of the hill, killing 7 Loyalists with swords and hatchets. Col. Boyd ran downhill 100 yards, was shot, and mortally wounded (Figure 3). Col. Pickens and his men then pushed into a cane break. The remaining Loyalist soldiers ran through the cane break leaving their horses, trying to cross Kettle Creek. Col. Clarke and his men on horse charged downhill, firing pistols and small rifles and killed about 15 Loyalists who were on foot with swords and hatchets. Col. Clarke divided his men in two parts, about ½ rode to both the east and west side of Monument Hill, killing Loyalists with swords. Col. Clarke and the other half of his men followed Settlement Road east and then south to cross Kettle Creek with a swivel gun (cannon). The Battle on the north side of Kettle Creek only lasted ~15 minutes. About 350 Loyalist soldiers under Lt. Col. Moore, already on the south side of Kettle Creek, ran to the top of War Hill to fight Col. Clarke and Col. Dooly (Figure 3). Col. John Dooly had ridden down the right flank with 50 men and crossed Kettle Creek on the west avoiding the cane break. Col. Dooly and his men then rode east to surround War Hill from the west. Col. Clarke and his soldiers surrounded War Hill from the east and south. After a fierce battle, 75 Loyalist soldiers surrendered. The Battle on the south side of Kettle Creek lasted 20 minutes. Casualties were as follows: 47 Loyalists were killed, 75 were captured immediately, 150 were captured later (sent to Liberty Hill Prison, SC), 270 with Major John Spurgeon escaped on horse to fight near Brier Creek, and about 100 deserted. Between 7-14 Patriots were killed, 18 were wounded, and 18 Patriot prisoners were freed. Somewhat controversially for prisoners of war, ~50 prisoners were charged with treason and 5 hanged. This outraged British military leaders who threatened retaliation. Ultimately, they did not retaliate out of fear that other American-held British prisoners might be mistreated.

Following the American Revolutionary War, the Kettle Creek Battle site saw varied land use. Old Liberty Church was a minimal log structure built in 1785 and collapsed in 1798. It was rebuilt one- and one-half miles south of the original site. The top soil layer of the small graveyard associate with the church was bulldozed when the area was used as a timber loading dock, but this location was not included in the current study to distinguish cemetery graves from possible fallen soldiers. The archaeological work conducted by [2] located several farm and homestead sites. Both metal and ceramic artifacts place these sites to the 19th and 20th century. In 1895 the site was a plantation owned by Mr. Henry Slayton and was terraced (see Figure 2) indicating cotton cultivation. A horse barn/house was located on the site using metal detecting with the artifacts dating to 1895-1920. The land has been used for growing timber for the past 75 years. The initial preservation effort began in the 1920's when the Daughters of the American Revolution purchased 15 acres to conserve part of the historic site.

3. Methods

3.1 Overview

This investigation was conducted in three phases. Investigating such a large area required a progression from large-scale search to more localized detection, and ultimately verification through site excavation and soil analysis. First a desk study identified a significant area to be searched. A preliminary ground investigation was then conducted by HRD dogs across the site in 2015, with a follow up near-surface geophysics Ground Penetrating Radar (GPR) survey conducted in 2016 to identify locations of possible burials alerted to by the HRD dogs. Thirdly, another search area was surveyed using the same HRD dogs, then GPR surveys in 2017 before fourth and finally, intrusive archaeological excavation, soil coring, and soil analyses were conducted in late 2017 to ground-truth which HRD dog alerts/geophysical GPR anomalies were probably revolutionary-era burials.

3.2 Human Remains Detection Dogs

It was unclear if HRD dogs could locate 238-year-old burials. Others have used this technique with success in archaeological investigations deeper in history than the current research site [55,56], but the environmental limitations of Kettle Creek were concerning. The acidic soils were expected to decay human remains quickly, and the steep slopes across the site were likely to move burial remains and human cadaver fluids and residue down slope which might confuse the HRD dogs or not leave a significant enough signature for HRD dog alerts.

During the search, the dogs most often worked off lead and were allowed to work independently to search the areas (Figure 4). If more than one dog was available to search the area, another dog also searched the same areas to observe if multiple dogs reacted the same way. The dogs' reactions resulted in either clearing the area with negative results (no human remains scent detected) or performing their trained indication/alert at the same location by sitting (Figure 4), which indicated the dogs' detected human remains scent in a particular area. As the dog searched, the handler observed the dog for any body language changes as well as the dog performing its trained indication/alert to human remains scent. Each dog "hunted" separately, and alerts could be viewed as independent. If multiple dogs alerted within approximately 10 m of each other, those alerts could be considered as coming from the same potential burial since human remains residue may travel this distance. In addition, as environmental conditions change throughout the day, such changes affect the "behavior" of human remains scent; and thus, may affect where the dogs alert in a specific area. The dogs searched over 40 acres (17 ha) in total over the two deployments in 2015 (1 day) and 2017 (2 days).

The dogs used during this study were provided and handled by K9 Search and Rescue Specialists, Inc. Each dog used during this search has been tested and certified as a cadaver/HRD dog by SWGDOG, the Georgia Bureau of Investigation, or both. All have been trained on the full spectrum of humans remains detection including low threshold scent associated with historic graves. One of the dogs is also licensed as a cadaver/HRD dog by the Georgia Office of Homeland Security.

3.3 Ground Penetrating Radar (GPR)

Accurate expectations of various burial anomalies have been developed over the past two decades, including understanding of responses for graves at different points during the decomposition cycle [57,58]. While wood and metal caskets create clear high-amplitude reflective signatures; burial pits and grave shafts, especially with decomposed bodies, might create more faint responses [42] or atypical reflection geometries. Under conditions where the ground surface has been systematically unconsolidated, such as through plowing or in a flood plain where all the soil is unconsolidated, it is difficult to identify graves in this manner. The bottom of burial pits or grave shafts may still contrast with the soil matrix at depth, but historic burials often homogenize with the soil matrix through time. Thus, the signature for identifying historic burial pits can be limited to low amplitude hyperbolic or small horizontal reflections from the bottom of the pit where there is a higher density of organic remains or differentially more water saturation. Finally, decomposed remains might leave void spaces in the pit or grave which could offer a sufficient contrast to the surrounding soil, especially in mineral rich clay conditions such as those found on the slopes of Kettle Creek. In such cases, a polarity shift of the reflected wave would be expected due to the reduction in dielectric permittivity values as the wave transmitted from a slow velocity material (clay) to a fast velocity material (air). Alternatively, if the GPR wave encountered a more saturated and mineral rich material such as decomposed organic residue at the clay/grave boundary then the wave may slow down further as it transmits and the reflected portion of the wave would retain a normal polarity.

A SIR-4000 GPR with a 400 MHz antenna was used during both field deployments to Kettle Creek (Figure 5). This system was integrated with a 3-wheel pushcart for its rugged construction and oversized wheels. This system facilitated data collection in the project site conditions where the instrument had to be pushed up and down steep slopes in sometimes densely wooded areas. Data collection was generally carried out in a grid format where space permitted. These were centered on HRD dog alert locations. Maximum grids sizes where 20 m x 20 m, but sometimes ranged as small as 5 m x 5 m. Individually collected lines were strategically placed in cross patterns when site conditions did not permit set up of formal grids.

Often GPR data only need simple processing methods [59] since there can be diminishing returns when applying more filters, but sometimes additional data processing steps can add value [60]. Though the conditions were problematic and data quality was low overall, some of the responses from expected graves were rather clear and therefore we used a moderate amount of processing on the data collected from Kettle Creek. All GPR data were processed using GPR-Slice v.7 software. A time-zero correction was initially applied to each profile to adjust for ground surface. A background filter was used to remove horizontal banding. Gains were adjusted using an Automatic Gain Curve (AGC) function. A bandpass filter with a low cut of 170 MHz and a high cut of 530 MHz was applied. This lower range was applied since the system experienced some frequency downshift due to the moist clay soils. Finally, a notch filter was used to remove overlapping noise from frequencies between 315 MHz and 350 MHz. While some additional noise was present in the radar profiles, these did not detract from our ability to identify possible graves in a meaningful way.

3.4 Archaeological Excavation and Soil Testing

Five geophysical anomalies that were initially alerted to by HRD dogs were selected for archaeological excavation. These five locations were explored with 2 m x 2 m excavation pits to document the structure and state of possible graves and record any human or cultural remains. The archeological test units were excavated with standard archaeological techniques, by natural strata not exceeding 10 cm, using shovels and trowels, maintaining vertical control with a line level and rule, screening soil through quarter-inch hardware cloth, and treating stains and anomalies as potential cultural features. Each naturally occurring stratigraphic layer was considered one temporal unit but broken into sub-units at 10 cm increments unless a new naturally occurring stratigraphic layer was encountered. While recovery of human remains was unlikely, there was no plan to fully exhume remains if encountered. Excavation was primarily a tool to evaluate the effectiveness of the chosen search techniques under these difficult conditions. With the purchase of the land for conservation, the likely protection of these remains was high. Metal detectors were used at all excavation sites to try and detect bullets, buttons, boot nails or other metal objects. Soil samples, approximately one pint in volume, were recovered from features identified in excavation units or from the bottom of excavation units if no features were present.

In addition, soil core samples were taken from 3 additional geophysical anomalies with associated HRD dog alerts and a control sample was taken 30 m from any GPR anomaly or HRD dog alert. The control sample was extracted from a rocky hillside where it would have been difficult and impractical to inter a grave. Core samples were recovered using a 3 cm diameter soil auger. About 100 ml of soil was collected of which 30 ml was immediately placed in a 40 ml sterile tube for testing and remainder placed in a quart sized zip lock bag.

Soil samples collected from archaeological excavations were labeled as 1, 3, 4, 5, and 7 while those collected with cores were labeled 2, 6, and 8. All samples were tested for two specific indicators to infer if dog alerts and GPR anomalies were recorded from actual human burials. This was specifically designed with the idea that possible burials may no longer contain human remains beyond residue due to depth of time, acidity of soil, slope/runoff, displacement, bioturbation, or animal scavenging. First, a soil sample from all eight contexts were sent to the University of Georgia Soil Laboratory in Georgia, USA to test for VOCs. VOC samples were prepared in accordance with [12] using gas meter accessible lids on 30 mL vials. Second, soil samples from all contexts were sent to Lakehead University Paleo-DNA Laboratory in Ontario, Canada to test for human mitochondrial DNA (mtDNA) using standard test and control methods [61,62]. In this paper we argue that archaeological excavations which reveal prepared pits and/or presence of unique indicators of human burial such as VOCs or mtDNA would be strong enough evidence to label a GPR anomaly a probable grave even if no remains are present.

4. Results

4.1 HRD Phase

Overall, the HRD dog search across the large area yielded successful results. The HRD dogs alerted to 11 different locations during the first deployment in 2015, and 13 locations during the second deployment in 2017 which were characterized as 12 possible burial locations based on proximity (Figure 6). In a span of 3 days total (1 day during first deployment, 2 days for second deployment) the HRD dogs were able to complete full coverage of over 40 acres and help localize high probability sites for further geophysical investigations. The distribution of HRD dog alerts suggests that fallen soldiers were likely buried at or near the location of death. The total number of HRD dog alerts suggests an individualized burial strategy of fallen soldiers rather than a single mass grave or aggregated cluster of graves as described by others.

Due to the age and condition of the site, a quality control experiment was conducted to test the repeatability and reliability of HRD dog alerts based on the soil samples collected from the 24 alert locations at Kettle Creek. The same HRD dogs that searched the Kettle Creek Battlefield areas were also utilized during the quality control experiment. The HRD dogs were provided with seven different soil samples to smell. Each soil sample was placed on individual paper plates, separated by approximately one meter, and oriented linearly. Five of the plates contained sterile soil, one plate contained a sample from Kettle Creek which was suspected to be from a soldier's burial, and one "control source" which contained 3 1/2-year-old soil from a homicide victim's gravesite, was utilized for the comparative test by the HRD dogs. The modern gravesite soil was obtained with permission by law enforcement in charge of the homicide investigation. The permission was restricted to sampling soil where the homicide victim's remains were recovered. No human remains were in the soil sample. The soil was obtained with permission as a “training aid” to be used for the training and maintenance of HRD dogs. This sample was considered a good training aid since human remains scent was absorbed by the soil, because the homicide victim’s remains remained in the soil for approximately two weeks, which allowed the soil to be saturated with cadaver fluids and human decomposition material. The sterile soil was taken from various locations where no human remains were believed to have been placed. And to confirm no human remains scent were present in these locations, the HRD dogs searched these areas to confirm negative results, which indicated that no human remains scent was present in the sterile soil samples. Sterile soils were stored separately from the training sample and the Kettle Creek sample.

The handler was not informed whether the Kettle Creek samples were obtained from possible solider gravesites, or from some other location. Two dogs were “run” through the samples to test identification. A sample was classified as positive only if both HRD dogs alerted to the Kettle Creek sample. Soil samples 1, 4, 5, 6, 7, and 8 from Kettle Creek all had positive alerts by both dogs. Neither dog alerted to samples 2 or 3. There are three possibilities for this: first, the possible burials were shallow and soil samples were taken from a depth below the grave; second, the soil sample may not have been taken from the densest part with human remains scent; or third, the scent from the soil sample may have dissipated from the time it was collected, to the time the experiment was conducted.

4.2 GPR Phase

The results from the GPR investigation were useful in locating subsurface features which were used as locations for excavation and/or soil sampling (Figure 6). All of the 11 HRD dog alerts investigated during the Phase 1 of GPR work, except for one, had a corresponding GPR anomaly. Six of the twelve alerts investigated during Phase 2 had corresponding GPR anomalies. Of these six, GPR recorded a single reflection at 3 of them, two reflections at two of them, and three reflections at one of them. This phenomenon might be the results of multiple burials where the dogs only alerted to the strongest scent, disarticulated burials, or a single burial with additional non-burial discontinuities in the subsurface that present like burials. An example would be an uprooted tree whose scar is now filled in through soil runoff and deposition.

Most of the GPR reflection anomalies indicative of a possible burial occurred within 1 m to 2 m of a HRD dog alert and all GPR anomalies were generally recorded uphill from the HRD dog alerts as expected. GPR 2D reflection responses varied in geometry (see Figure 7 for examples) suggesting variability in burial method, rates of deterioration, or current burial condition. The GPR recorded a polarity reversal in some instances suggesting a possible void space left from the decomposed body where the burial pit has not collapsed in (Figure 7). This signature has been observed in modern simulated clandestine graves beneath a domestic patio (see [63]) and occurs because the GPR wave is reflecting off a change in material where the transmitted portion of the wave increases in velocity (from a decrease in dielectric permittivity) when crossing the barrier from clay into air. GPR waves move at the speed of light in air and thus a polarity reversal is expected for voids in every circumstance. The soils in the burial pit might homogenize with the surrounding soils, leaving little contrast between the burial pit and the general soil matrix. A burial pit in these situations would be difficult to detect with GPR and may only leave a faint signature (Figure 8). It is likely that not all responses were from burials. Shallow bedrock veins, large tree roots, and other subsurface discontinuities could also present as hyperbolic reflection geometries similar to graves. The GPR was effective overall, but recorded some well-defined reflection events, some poorly defined reflection events, and no reflection events in some instances. Cases where the GPR did not record an anomaly associated with an HRD dog alert did not suggest a false-positive, or no burial being present. It likely means that any burials were only identified by one technique, the remnant scent left by a decomposing human body which is detectable by the trained HRD dogs, but the location of a burial pit could not be always successfully recorded with GPR.

4.3 Probe Investigation Phase

The apparent burials of fallen soldiers from the Revolutionary War were generally shallow, usually not exceeding 0.6 m deep, although some occurred as deep as 1 m. This was probably deeper than the original burials for those located near the creek since soil would have accumulated over the past 200 years or more, but probably shallower for those located on slopes since soil erosion might strip cover from graves. The accumulated soils in the areas near the creek were generally unconsolidated, which made it impossible to utilize the metal push probe to verify the locations of possible burials identified with the GPR. It did however help rule out some hyperbolic reflections as possible burials since the probe was able to penetrate the soil and detect large, deep tree roots. The single occurrence during Phase 1 where the HRD dogs alerted to scent, but the GPR did not record a response, was on a slope with a thin layer of organic humic buildup overlaying compact clay. A soil probe was also able to penetrate this to add support for the HRD dogs alerting to an actual grave in this location. The probe identified an area of softer, unconsolidated soils immediately uphill from the HRD dog target. This area measured 0.7 m by 1.5 m, or approximately the size of a human grave if placed horizontal or with a slight flex. The probe penetrated more than 0.6 m into the subsurface when pushed in the soft soil, but only 0.15 m in the undisturbed soil.

4.4 Archaeological Excavation Phase

The five GPR anomalies selected for test excavation were all located on upland (non-alluvial) landforms, and all were on sloping ground surfaces. Two excavation units (1 and 3) were near the crest of a ridge on which the ca. 1780s Liberty Church was once located, two (4 and 7) were at the western foot of War Hill next to Kelly Branch, and one (5) was on the northeast slope of War Hill (Figure 6). All were in areas of heavy fighting where [2] recovered numerous bullets and battle artifacts. Four of the excavation units (all but unit 5) encountered very rocky soils from just below the ground surface. Units 1 and 3, on Old Liberty Church Hill, contained north-south trending veins of bedrock at just 6 to 15 cm below surface. In units 4 and 7, next to Kelly Branch, soils were naturally rocky from just below the humus zone.

Test unit 7 contained the most compelling evidence for a burial pit. A dense, oval-shaped rock cluster which occupied most of the unit was exposed approximately 10 to 15 cm below surface (Figures 9 and 10). This concentration of rock also coincided with slightly darker soils (Munsell color 7.5YR4/4) than the surrounding matrix (Munsell color 7.5YR5/6). This poorly defined, oval-shaped feature of rock and soil was labeled Feature 2 and was seen to be about 25 cm thick and possibly extending the width of the 2 x 2 m unit. It extended to about 45 cm below the sloping ground surface (Figure 10). This feature is the most convincing evidence we encountered of a possible burial pit, but it is not clear that it is indeed a 1779 burial. It appears that the concentration of rock is not a purely natural feature, and that the feature is sufficiently deep to have contained a body.

Based on the HRD dog alert and subsequent positive testing of the soil sample from this unit (see next sub-section), we conclude that Feature 2 is more likely than not to be a burial from the Kettle Creek battle. We can interpret it as a 45- to 50-cm deep, somewhat ovular pit, in which a body with no durable objects was placed and covered with a layer of naturally occurring rocks. The lack of a bullet could be explained by the soldier having been stabbed to death rather than shot, or by a prior round of metal detecting having removed a bullet from this feature.

All the test units lacked compelling evidence of burial objects (buttons, buckles, bullets) and visible human remains, but four test units contained artifacts (Figure 11). There is a possibility that the recovery efforts by [2] removed bullets from apparent burial locations. Also, there is strong evidence in the historic record to suggest that many died from horse-back cavalry charge and were killed by sword (see Section 2 for a summary of the battle). This would also reduce the likelihood of finding bullets in burial pits. The metal artifacts themselves contained little diagnostic evidence for age or function; they may have been utilized during the battle, but this conclusion is tentative until additional tests are conducted on the artifacts.

Excavations from Unit 1 recovered three metal artifacts. One was a piece of iron that is triangular in cross section, is 38 mm long and weighs 20.0 g (Figure 11a). The other is a curved piece of iron that is round in cross section, is about 30 mm long and 8 mm in diameter, and weighs 7.5 g (Figure 11a). We do not know what either of these pieces are. A third artifact was a burned cut nail (Figure 11a). Recovery efforts from Unit 3 produced ten artifacts including stoneware, fragments of glass bottles, and a cut nail (see Figure 11b for a selection). The single most chronologically diagnostic piece is the fragment of amethyst bottle glass (Figure 11b), a type of glass that was manufactured from the 1880s to about 1918, during World War I, which post-dates the event of interest. Excavations from Unit 4 also recovered three metal artifacts. Two of the recovered pieces are round in cross section (6 mm diameter), about 8 cm long, and slightly curved at their ends (Figure 11c and 11c). The third piece is squared in cross section, tapered in thickness, curved, and about 7.5 cm in length (Figure 11c). Finally, a projectile point made of dark red-colored jasper and two small quartz flakes were recovered from Unit 5 (Figure 11d), but these pre-date the American Revolutionary war activity.

4.5 Soil Analysis Phase

Seven of the eight soil samples tested positive for mtDNA (only sample 1 returned a negative result). Possible modern contamination of the samples could not be absolutely ruled out. Degradation of human mtDNA has a "half-life" of 521 years so calibrating age of a specimen is not possible, and thus identifying contamination based on mtDNA age also remained difficult. Since sample 1 returned a negative reading, it was believed that the results were likely from ancient DNA (aDNA) rather than modern contamination. Although “negative extraction and PCR controls do not ensure lack of contamination” [62], it reduced the likelihood of contamination in this circumstance.

1. The control sample had 1 out of 3 extractions test positive. In only the last extraction did the control sample exhibit weak DNA, and as indicated by the laboratory “showed extreme damage

and degradation." Being very weak and having extreme damage and degradation might indicate very old blood. There is a low probability that samples from Kettle Creek won't contain any aDNA. Traces of blood from wounded soldiers probably splattered and leaked across the site, dispersing trace aDNA throughout the battlefield. This phenomenon was likely exacerbated from both fleeing soldiers and post-burial residue migration.

2. Soil samples 2, 6, and 8 all tested positive for mtDNA and had the best chance of not being contaminated since they were taken with cores and not during excavation (Figure 6). Sample 8 is also the only sample to test positive for VOCs, with the largest concentration being acetone (0.071 mg/kg).

3. Soil samples 3, 4, 5, and 7 all tested positive for human mtDNA, but had the highest possibility of contamination because these were collected during excavation. Since sample 1 showed no human mtDNA, it was definitely not contaminated. This indicates a high probability that all the excavated soil samples were not contaminated.

4. Soil sample 2 had 2 out of 2 mtDNA extractions test positive. Sample 8 had 2 out of 3 extractions test positive. Samples 3, 4, 5, and 6 had 1 out of 2 extractions test positive. Sample 7 had 1 out of 3 extractions test positive.

In summary, six out of eight samples had higher positive extraction rates than the control, including one (sample 8) which also tested positive for a human VOC marker of acetone. The soil analysis proved critical for our conclusions, since the archaeological excavations recovered no human remains, bullets, cloth, buttons, etc. Table 1 contains a summary of the results from the soil analysis and corresponding results from other phases of investigation.

5. Discussion

After a phased investigative approach for this American Revolutionary War battle and burial site, it was reasonable to confirm from the results that burial sites were able to be identified from this 200+ year old conflict, which looked to be isolated rather than a mass grave as per the study objectives. Feature 2 uncovered during excavations in unit 7 is the best candidate of a grave from the Battle of Kettle Creek since it was identified by HRD dog searches, was then identified by GPR, was positive for mtDNA, and was characterized as an oval shaped pit filled with a high density of rock. While this is the most compelling example, it is likely that other targets recognized during the search are also burials. Target 8 for example was identified by HRD dog searches and GPR and tested positive for both mtDNA and VOCs. Not every alert or anomaly of interest could be proved or excavated, but the distribution of probable burials was consistent with a pattern of individual burial not a mass grave (see Figure 6 for distributions of alerts and anomalies).

Much of the Kettle Creek battlefield consists of shallow bedrock, and field burials are often excavated and placed quickly following battle. The burials at Kettle Creek were thus expected to be shallow graves and may have been shallow enough to easily become exposed from soil erosion. Bodies in shallow graves are more susceptible to scavengers that could feast on exposed corpses or remove bodies completely from burial pits and drag them across the landscape [64]. Generally, deeper internments will preserve bodies better while those buried in shallow graves are more accessible to insects [64,55], especially in warmer weather, which is associated with increased biological activity and chemical reaction rates [65].

It has been noted that clothing might slow down decomposition [66], but material type will determine the ultimate effect. Synthetic fibers might slow down decomposition and encourage adipocere formation, but [66] recorded a lack of adipocere formation on a body buried in cotton clothing. This may be a result of rapid disintegration of natural fibers which could completely disintegrate in less than 10 months [67]. Uniforms worn by both Loyalist and Whig soldiers primarily consisted of natural materials. Prior to burial, soldiers might be stripped of boots, coats, hats, belts, etc, and would therefore not be buried with these items. The shirts worn by soldiers that fought in the American Revolution were generally made from cotton or linen. The rapid disintegration of these materials may contribute to putrification.

Bones tend to preserve better in soils with neutral or slightly alkaline pH than in acidic soils where leaching of calcium from the soils may increase rates of chemical weathering and speed up dissolution of biological apatite [68]. Kettle Creek primarily consists of acidic clay soils with pH ranging from 5-6.5. It rains in the area roughly 115 cm per year, contributing to the elevated levels of acidity and leaching of calcium. Remaining decomposition residues could also washout from shallow graves or migrate downslope through groundwater movement. This might relieve burial pits of all visible evidence or make it difficult for search techniques to clearly identify graves. However, aDNA can absorb into the soil matrix [69] leaving trace evidence of human remains. While the acidic soils on site may degrade the aDNA, much of the site is covered in forest which could encourage persistence of aDNA by bridging onto humic substances [69].

It was chosen to approach the investigation with a series of investigative techniques that could produce evidence which could be independently used as proxies for burials. If multiple lines of evidence indicate a possible burial, then the probability of a given detection representing an actual grave would increase. The investigation began with HRD dog searches across a large area. Next, HRD dog alert locations were identified, which were then surveyed using GPR to help pinpoint potential locations of burial sites. These areas were then probed, excavated, and cored to identify possible causes of GPR reflection events and to recover any potential human or cultural remains. Soil samples of interest were then tested by HRD dogs in a controlled comparative test. Finally, soil samples were presented for laboratory testing of human mitochondrial DNA (mtDNA) and volatile organic compounds (VOCs).

Project limitations included the limited historical information on the battlefield site itself as well as the subsequent burial sites, which made this study harder than it would otherwise be on better documented historical conflict sites. Other remote sensing techniques could have been utilized if available and time permitted. The distribution of graves and human remains scent at this site might have confused the HRD dogs during search and hindered their ability to distinguish multiple closely spaced graves. For the geophysics, GPR was the only geophysical method utilized to locate anomalous positions for subsequent intrusive investigations. Other geophysical researchers have used other geophysical search methods to locate such targets, including bulk ground conductivity [13, 14,17], electrical resistivity [15, 41] and magnetics [17, 42]. Other researchers have used more densely collected GPR datasets [18-20] although [21] evidenced that 2D surveys were optimal to locate such historical grave targets. For the intrusive investigations, other anomalous areas could have been targeted but weren't due to the lack of survey time. Other evidence types also could have been being analyzed, for example forensic botany [8] and soil water conductivity [23] but was thought unlikely to be useful due to the long burial time in this study. Finally, the mDNA analysis does not provide information on date of deposit. The subsequent use episodes of the site may have contributed additional remnant mDNA to the soils and it would not be possible to correlate which use episode the mDNA extractions date to. Much of our analysis and interpretation leverages the strong associations between data sets to overcome some of the previously mentioned limitations which increased our confidence in the overarching conclusions regarding burial pattern.

6. Conclusion

The Battle of Kettle Creek was the first American victory in Georgia, USA during the American Revolutionary War. This study is the first to describe a forensic investigation into locating potential burial sites of fallen soldiers from this battle. A careful multi-resourced, multi-phased investigation was conducted over three years to identify prospective high areas of interest. Trained HRD dogs identified 24 potential burial sites in an area over 40 acres in size before 400 MHz GPR surveys were undertaken which mostly showed geophysical anomalies at these locations. Subsequent careful soil coring was undertaken and archaeological excavations did not reveal physical remains, but soil samples taken from targeted burials were recorded as positive for human DNA. It was concluded that the identified old grave locations, with no human remains, were identifiable in the archaeological record and could be labeled as such with a high degree of confidence.

The workflow detailed in this study of HRD dog searches, geophysics, soil testing, and excavation proved efficient in the search for and archeological study of historical battlefield sites. It is suggested that other researchers working on historic sites or situations where buried homicide victims are disinterred and moved could use this process. HRD dog searches might help identify locations and GPR could help characterize the subsurface. Soil testing for DNA, VOCs, or other signatures may suggest the likelihood of a previous burial even if excavation does not recover any additional human remains or paraphernalia.

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Table 1. Summary of results from each phase of investigation at 8 soil sample sites.

Sample #	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Control
HRDD	Alert (2/2)	Alert (2/2)	Alert (2/2)	Alert (2/2)	Alert (2/2)	Alert (2/2)	Alert (2/2)	Alert (2/2)	Negative
GPR	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	N/A
Arch	Possible	Core Extraction	Possible	Probable	Possible	Core Extraction	Probable	Core Extraction	Core Extraction
HRDB	Alert	Negative	Negative	Alert	Alert	Alert	Alert	Alert	N/A
GC-MS	Negative	Nevative	Negative	Negative	Negative	Negative	Negative	Acetone	Negative
mtDNA	Negative (0/0)	mtDNA (2/2)	mtDNA (1/2)	mtDNA (1/2)	mtDNA (1/2)	mtDNA (1/2)	mtDNA (1/3)	mtDNA (2/3)	mtDNA (1/3)
Legend									
HRDD	Human Remains Detection Dogs Alert								
GPR	Ground								
Arch	2x2 Meter Pit Dug								
HRDB	Human Remains								
GC-MS	Gas Chromatogy-								
mtDNA	Human mtDNA detected in multiple extractions LakeHead University Paleo DNA Lab. Ontario Canada								

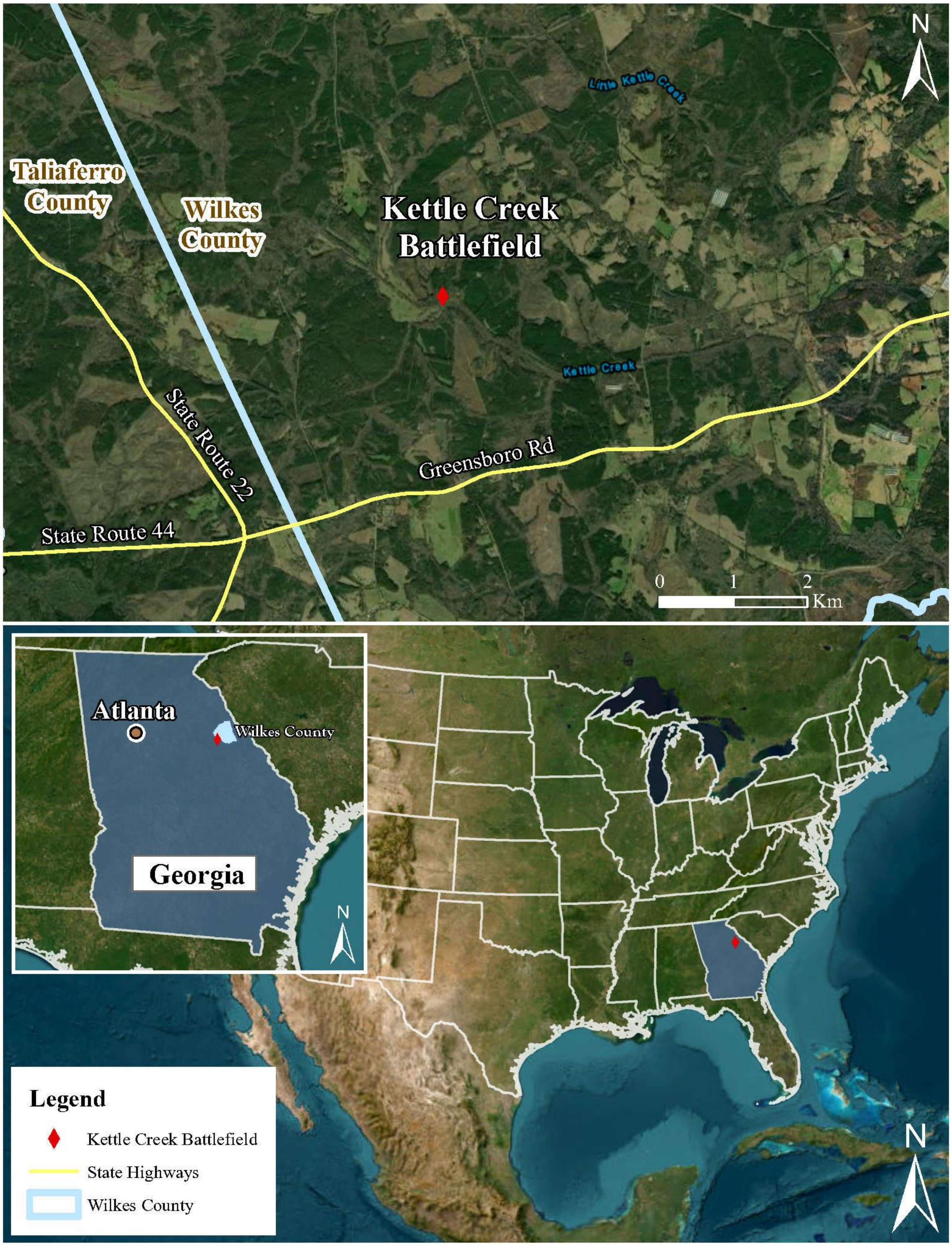

Figure 1. Location maps of the 1779 Kettle Creek Battlefield site, Georgia, USA.

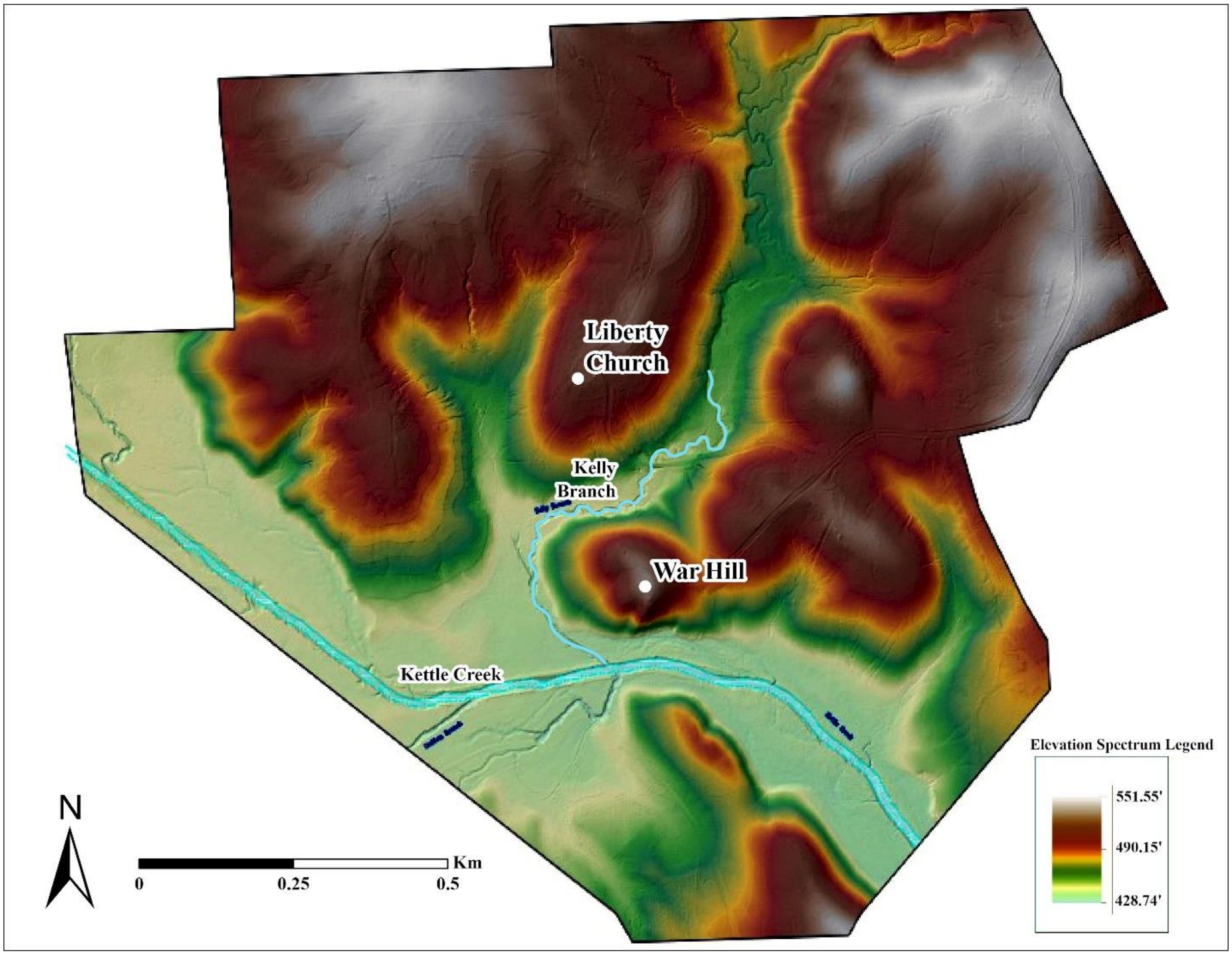

Figure 2. Topographic map of the study area produced from aerial Lidar

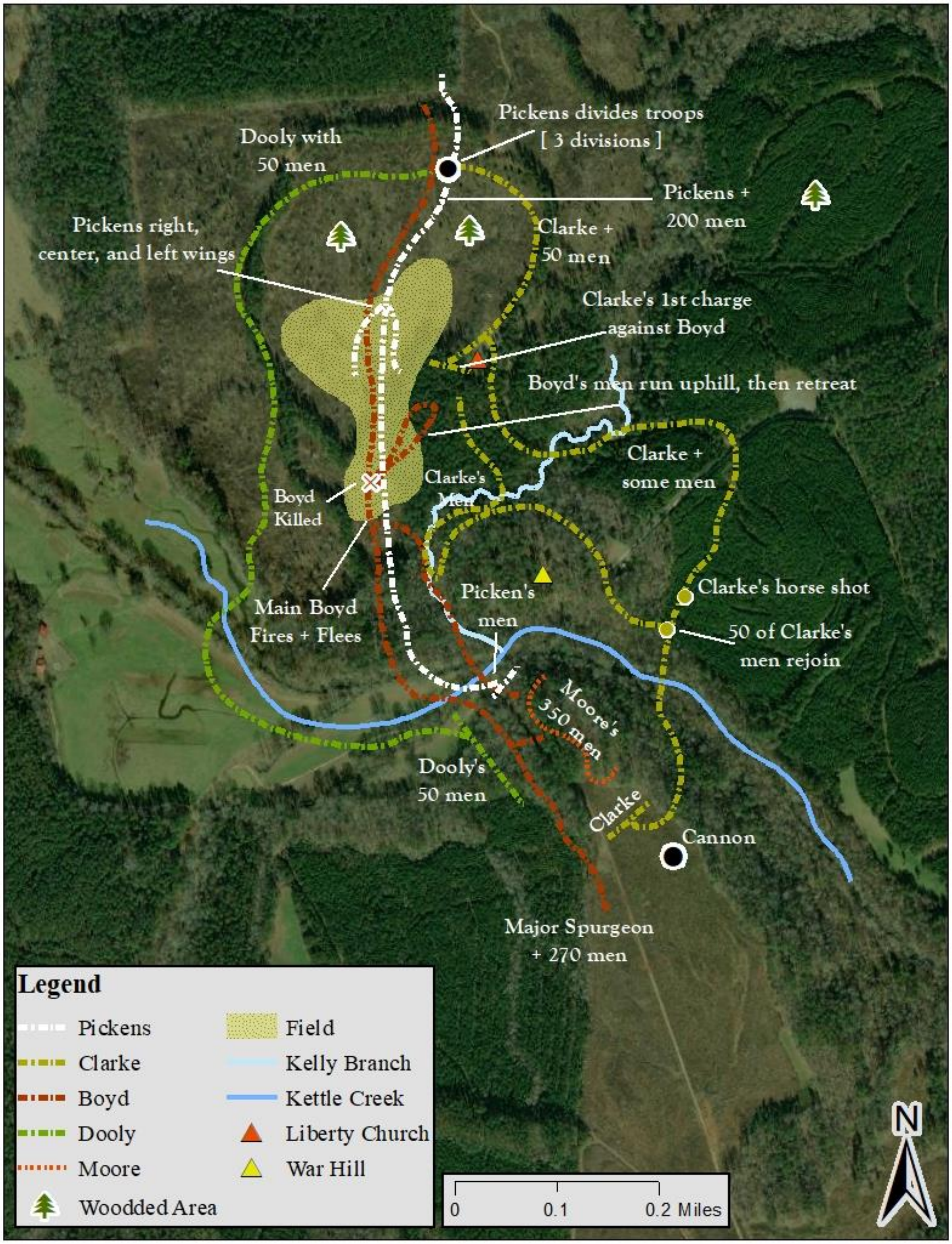

Figure 3. Site map indicating the 1779 Kettle Creek battle sequence (see text for details).

Figure 4. (Top) Photograph facing north showing HRD dog searching independently off lead; (Bottom) Photograph showing HRD dog alerting to human remains scent.

Figure 5. Site photograph facing east showing a SIR-4000 GPR with 400 MHz antenna being pushed up slope on the southside of War Hill (see Fig. 2 for location). Note colored flag indicates location of an HRD dog alert that is being tested with GPR.

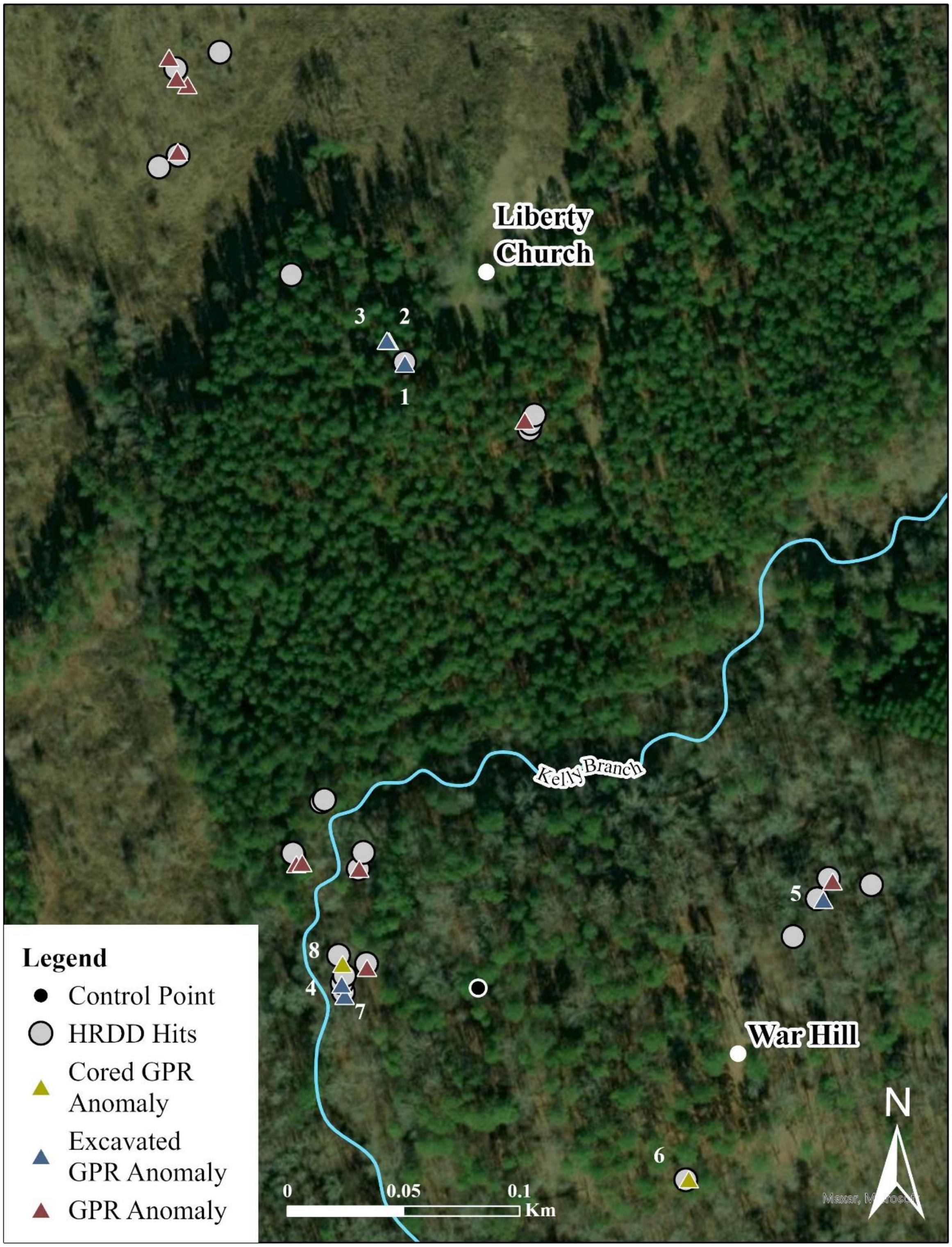

Figure 6. Aerial photograph of the Kettle Creek battlefield site indicating locations of HRD dog alerts, GPR anomalies with no intrusive investigations, with soil core extractions, and with archaeological excavations. Numbers indicate soil sample label.

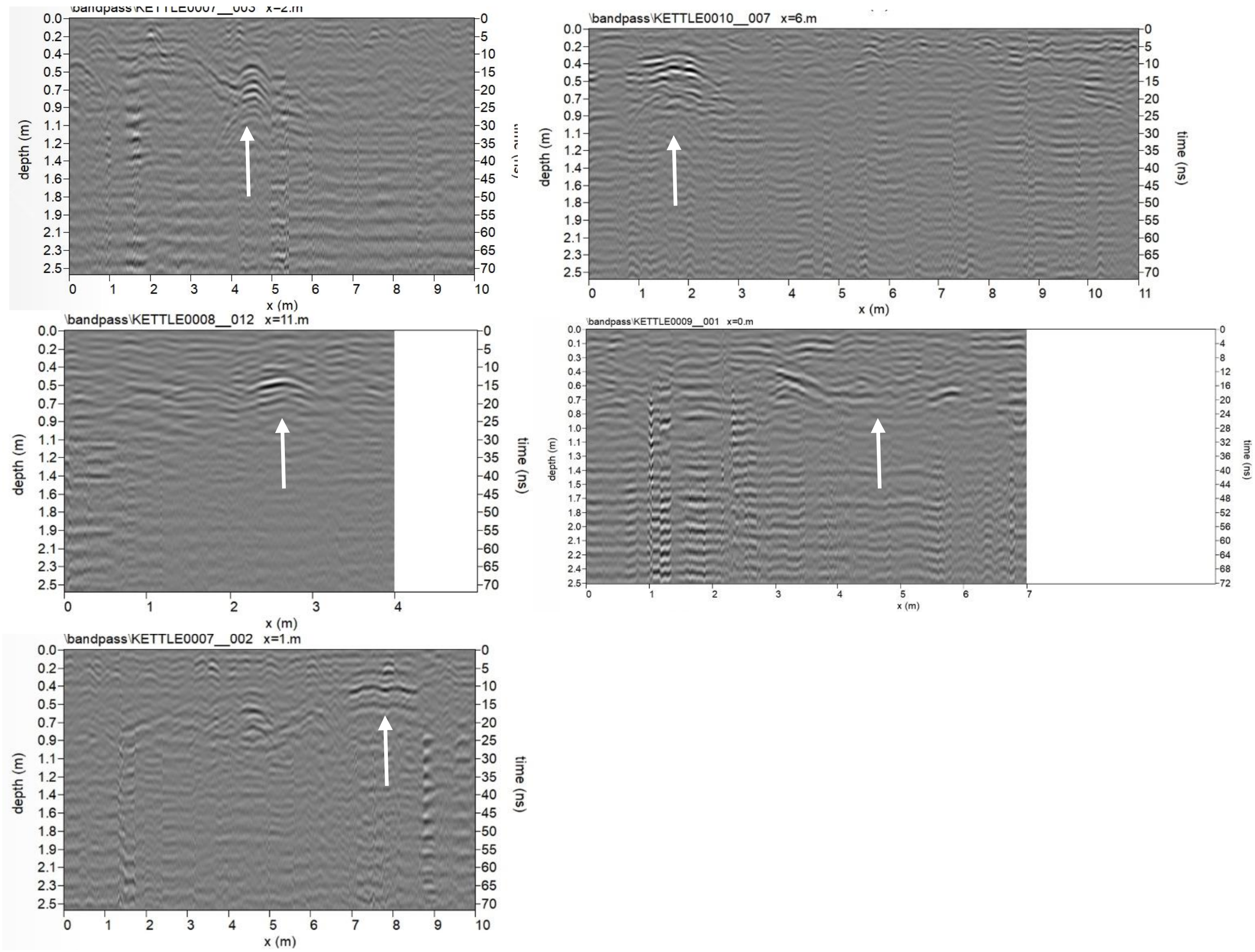

Figure 7. 400 MHz GPR 2D profiles indicating various reflection geometries including (Top Left) hyperbolic, (Middle Left) hyperbolic with multiples, (Bottom Left) horizontal, (Top Right) inconsistent geometry, and (Middle Right) pit shaped (all arrowed). The horizontal response in the bottom left section has a polarity reversal, suggesting a possible void.

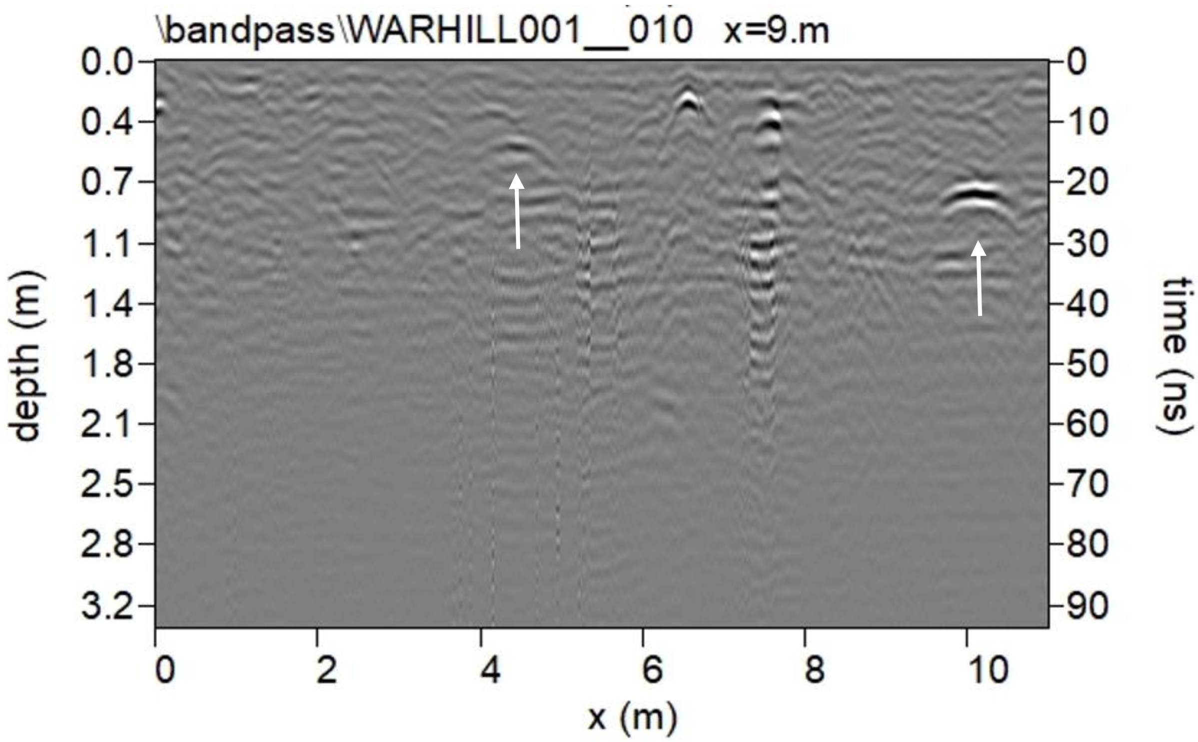

Figure 8. GPR profile indicating two hyperbolic responses with one (left) low amplitude and the other (right) a moderate amplitude.

Figure 9. Photograph of Target 7 (see Fig. 9 for location) with Feature 2 half excavated, indicating stained soil and concentration of rock in oval-shaped pit. Photograph is oriented north.

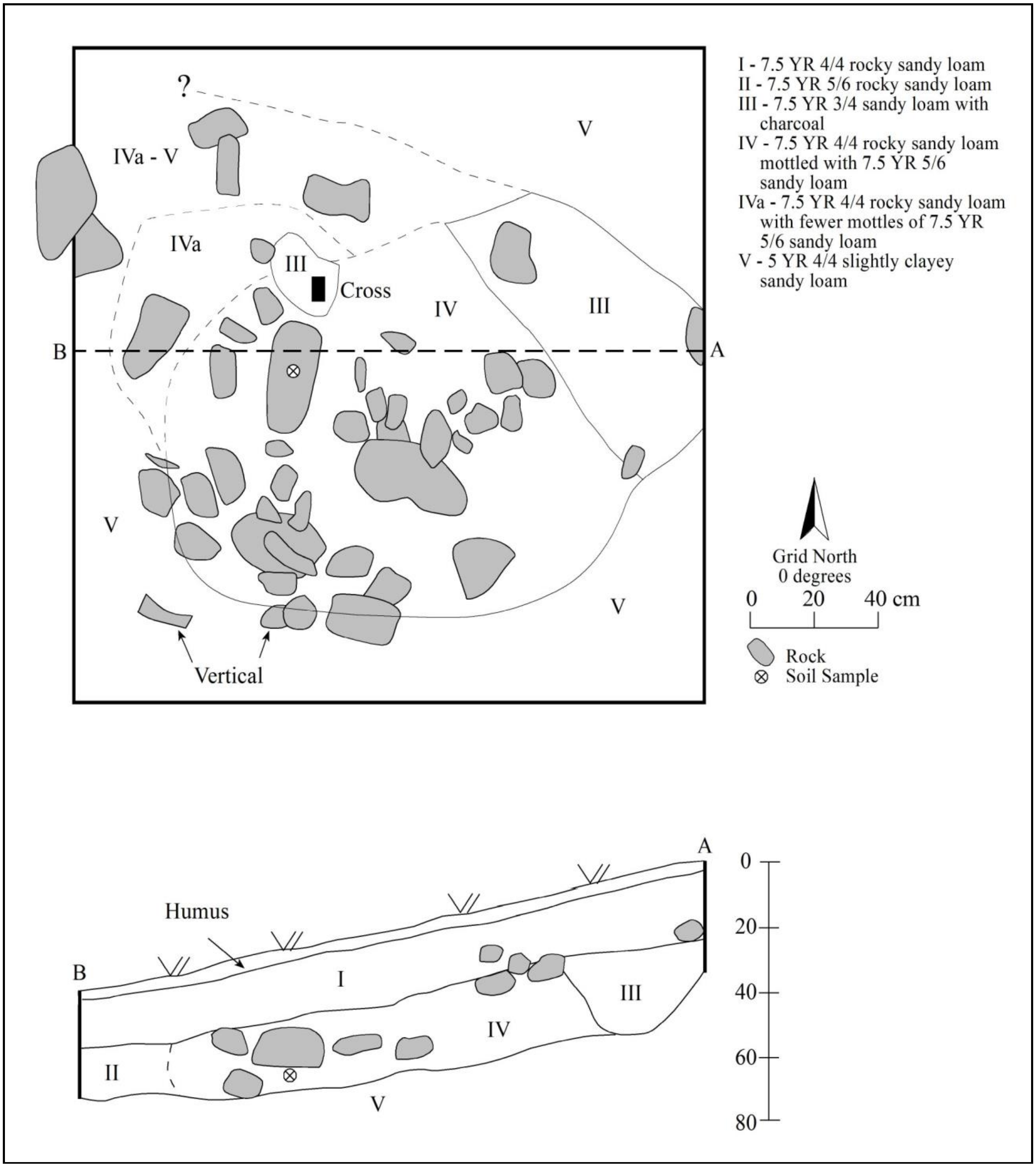

Figure 10. Plan view and profile schematic drawings of Feature 2 in Target 7 shown in Fig. 10. Numerals indicate soil variations (see key). Cross indicates location of a recorded GPR reflection anomaly.

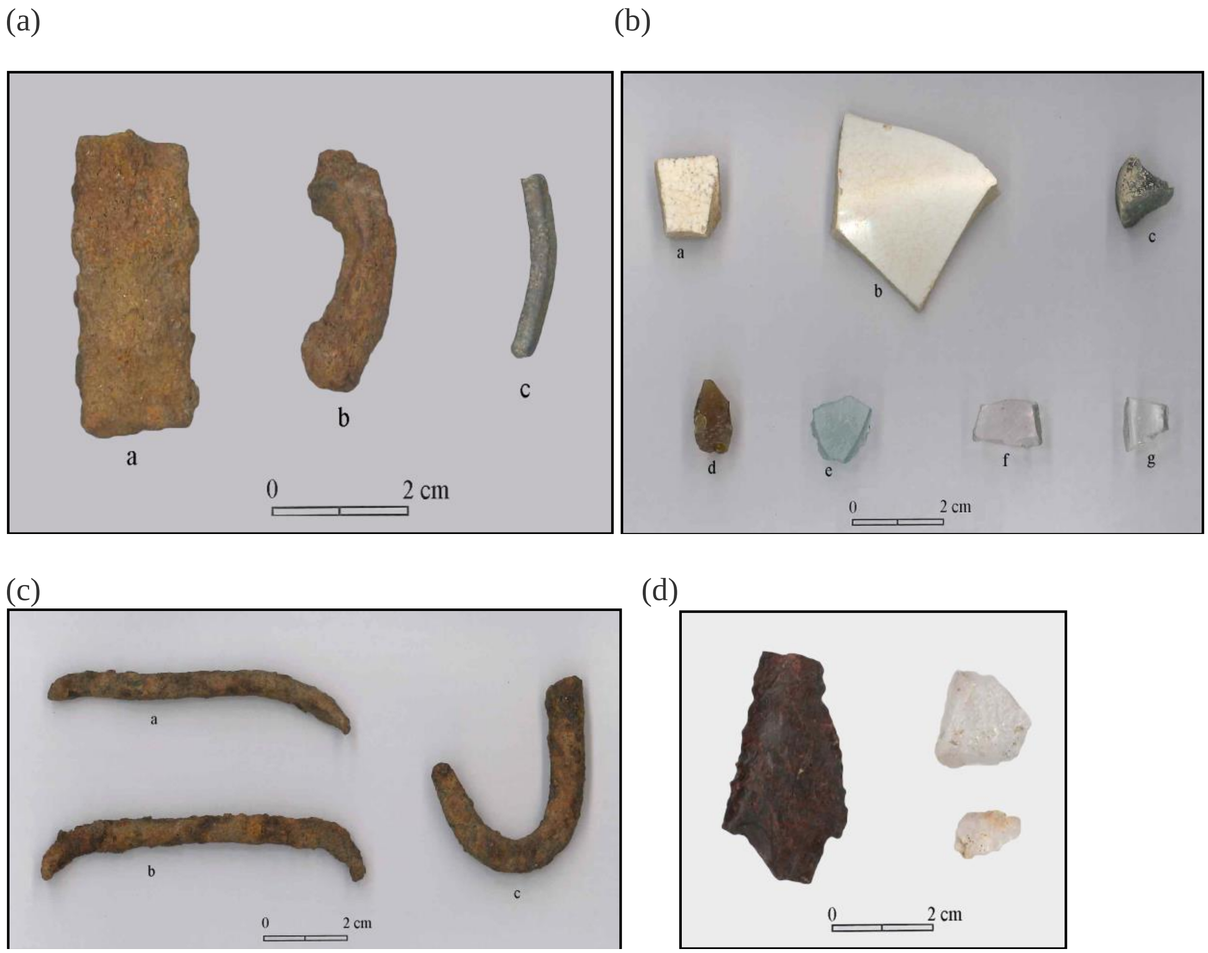

Figure 11. Photographs of (a) three metal artifacts recovered from Unit 1; (b) samples of stoneware fragments and glass bottle fragments recovered from Unit 3; (c) three curved metal artifacts recovered from Unit 4; and (d) a dark projectile point and two small quartz flakes recovered from Unit 5.