Finding the Boundaries of the Past: Where in Shippensburg is the Palisade of Fort Morris?

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FINDING THE BOUNDARIES OF THE PAST: WHERE IN SHIPPENSBURG IS THE PALISADE OF FORT MORRIS?

A Thesis
Submitted to the School of Graduate Studies and Research
in Partial Fulfillment of the
Requirements for the Degree
Master of Arts

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May 2014
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Between 1755 and the late 1760s Fort Morris stood as part of a line of frontier forts to protect the growing town of Shippensburg, Pennsylvania from Native American attacks during the French and Indian War. Through time the location of Fort Morris has been lost and only sparse and contradicting documentation of the fort exists today. In an effort to locate the palisade walls of Fort Morris, geophysical surveys were conducted on four properties along East Burd Street in Shippensburg. These geophysical surveys included the use of ground penetrating radar (GPR) and magnetic susceptibility within five survey areas within the properties of 329, 335, 322 and 324 East Burd Street.
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Sarah M. Mousetis
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CHAPTER I

PROJECT INTRODUCTION

Archaeology is a science of destruction. Philip Barker said it best when he stated that “Every archaeological site is itself a document. It can be read by a skilled excavator, but it is destroyed by the very process which enables us to read it” (Barker 1993:13). The field of archaeology has grown from almost blind excavations based solely on historical document research and educated guessing to a field that can incorporate various disciplines in order to locate and study sites beneath the surface. By utilizing geophysical techniques such as ground penetrating radar (GPR) and magnetic susceptibility, archaeologists can “see” beneath the surface and preview what may be encountered in order to prevent unnecessary excavations that would costly and time consuming. As these and other geophysical techniques continue to improve and adapt to archaeological needs, it may be likely that archaeologists can save more archaeological sites in the future.

Project Overview

This thesis research covers geophysical investigations at the proposed location of Fort Morris in Shippensburg, Pennsylvania on East Burd Street in April and May of 2012. The East Burd Street location was chosen as the location to investigate based on thorough historical and geographic research of the town of Shippensburg. The original location of Fort Morris has been lost in time due to inconsistent and incomplete documentation of the location and dimensions of the fort. Fort Morris has been reported to have been at three different locations according to historical data.
Previous excavations at 333, 327 and 335 East Burd Street conducted by Senior Archaeologist Stephen Warfel, Dr. Paul Marr of Shippensburg University and a team of volunteers in 2008 and 2009 revealed evidence that Fort Morris was once somewhere in the vicinity of the excavated portion of East Burd Street (Warfel 2008, 2010). These excavations were based on an intricate study of historical background material and systematic shovel testing of the area by Mr. Warfel and his crew. Despite thorough excavation of the area, the palisade walls of the fort and many fort-related structural remains have yet to be found (Warfel 2008, 2010).

This thesis project was created to help guide the May 2012 excavations in the area of East Burd Street. A combination of ground penetrating radar and magnetic susceptibility surveys were performed prior to excavation in an attempt to locate the palisade walls or other fort-related structures. Geophysical surveys were conducted in March through May 2012. Five survey grids were laid out in the residential backyards of 329, 335, 322 and 324 East Burd Street. Data collected at each location was then analyzed and interpreted by the author of this thesis.

As only two of the five survey grids were selected for the 2012 excavations, only anomalies of interest within those two grids were presented to Warfel prior to excavation. The survey grids in question were in the yards of 335 and 329 East Burd. Three other grids were chosen for investigation by the author; however they were not included in the 2012 excavation. As is discussed in Chapter II, in 2008 and 2009 excavations were limited to only three yards on the street. It is possible that the location of the palisade has not been found because the fort was in the area of the excavations but not in the 333 lot location.
Results of these excavations were incorporated into this research and into a report for the Pennsylvania Historical and Museum Commission (PHMC) and the Shippensburg Historical Society authored by Warfel (2012). Anomalies of interest in the remaining three grids are considered for potential excavations should landowner permissions change and funds become available for future research.

**Research Questions**

**Question # 1:** Can evidence of the palisade trench and other fort-related structures be found in the GPR and magnetic susceptibility data from the yards chosen for excavation?

Despite two large excavation seasons, the location of Fort Morris’ palisade walls has not been uncovered. However, in both the 2008 and 2009 excavations, various building foundations were discovered that can be dated to or around the time of Fort Morris. Three large features stand out in the previous excavations. A possible oven, large limestone cellar and a root cellar were uncovered within the two previous excavations (Warfel 2008, 2010). The biggest, labeled Feature 25 was a cellar lined with large limestone rocks and was most likely the cellar of a large building. Over 5,000 artifacts were recovered from this cellar and surrounding features as discussed in Chapter II. With the size and materials used to construct this feature, GPR would have located the cellar easily had it been employed at the onset of the project.

If limestone or foundations with similar building materials also supported the other large buildings of the fort such as the barracks, there is a strong possibility that more structures of this type exist beneath the surface of adjoining yards such as those at 329 and 335 East Burd. However, due to construction of the suburban area, it is likely
that many of these structural remnants have been destroyed or buried deep within varying amounts of construction fill. Performing a geophysical survey before the excavations occur would allow investigators to locate these limestone walls if they still exist. Prior geophysical investigation would also eliminate unnecessary excavation.

**Question # 2: Is there evidence of Fort Morris outside of the excavation area within 329, 333 and 335 East Burd Street?**

The exact location of the palisade is still unknown perhaps because too much attention has been focused on 333 East Burd alone and not on areas across the street as well. Although large amounts of fort-specific artifacts were unearthed in the previous excavations, this does not mean that the palisade was in the proposed 2012 excavation area. It is very possible that the excavations uncovered buildings or structures just outside the fort, not those within.

It is very likely that the previous excavations fell within or just outside the boundaries of Fort Morris due to the estimated size of the fort. Unfortunately Burd Street is a suburban area and much of the evidence may have been destroyed as previously stated. In order to discern whether or not the two properties across the street were, in any way, associated with Fort Morris, surveys using GPR and magnetic susceptibility would be invaluable. These two methods would allow the author to gather important information without breaking ground and violating the landowners’ wishes.

**Question # 3: With the clear presence of residential construction, will it be possible to find any historical features beneath the surface? What modern features may be masking or have destroyed fort-related features?**
As was mentioned previously, East Burd Street is an area of heavy residential construction. Any remains of the fort could have easily been destroyed once Shippensburg was beginning to develop as a large town. What remains beneath the surface could easily be masked by more recent features that show up much more clearly in the data as well. Other than the construction of the surrounding streets and homes, smaller intrusions will likely be found beneath the surface in the geophysical data. Common utilities, landscaping additions such as gardens and the planting of trees and walkways and paths all have negative effects on the detection of historical anomalies beneath the surface. Chapter III discusses the effects of modern intrusions such as pipelines on geophysical data as well as how they show up in the data.

Organization of Study

This thesis has been organized into six chapters. The next chapter, Chapter II, outlines the historical, environmental and archaeological background for the Fort Morris geophysical project. Chapter II includes the environmental context of Fort Morris including soil composition and how the landscape looks today. Within the historical background section of Chapter II, the reader learns why and how Fort Morris was built as well as the controversy that surrounds its location. Finally, the previous archaeological investigations in 2008 and 2009 are detailed including how the excavations took place and what was found.

Chapter III focuses on the geophysical techniques used within the project. Included is a brief introduction to the history and science of both magnetic susceptibility and ground-penetrating radar in the realm of archaeology. Potential pitfalls and positive aspects of each geophysical technique are explained.
Chapter IV details the methodology employed during the project. The description and location of each survey area is discussed as well as factors that influenced the location of each grid. Data collection methodology is covered based on the conditions in which the data collection would take place. Discussion of the data processing methodology completes this chapter.

Chapter V covers the results and interpretations of the geophysical surveys and results of the May 2012 excavations. The results of each geophysical survey are discussed including potential anomalies for ground truthing. Interpretations are made from the data based on background research into similar case studies from similar fort sites as well as general cases where GPR has been used. When applicable, data taken from the excavations headed by Warfel is compared to the respective geophysical survey results in areas where anomalies of interest were identified.

Chapter VI provides a summary of the results of project as whole. This chapter discusses the initial research questions and if the geophysical data and ground truthing addresses these questions. The success of the GPR and magnetic susceptibility techniques in this area are contemplated as well. Recommendations for further research are presented, especially for the survey areas that could not be excavated due to limited landowner permissions.
CHAPTER II
FORT MORRIS PROJECT BACKGROUND RESEARCH

Vital historical facts concerning Fort Morris have rapidly disappeared through time. For many years the people of Shippensburg, Pennsylvania have been unsuccessful in their attempt to finally locate Fort Morris and put the town's controversy to rest. However, recent clues have been uncovered that may finally locate where Fort Morris once stood.

The following thesis details both geophysical surveys and archaeological excavation in the area of East Burd Street. East Burd Street has been ruled as the most likely location of the French and Indian War era fort based on extensive background research conducted by Warfel and Marr of Shippensburg University (Marr 2004; Warfel 2008, 2010, 2012). What remains of Fort Morris’ story is discussed in this chapter as well as the environmental setting of the East Burd Street area and the previous excavations that took place in 2008 and 2009.

*The French and Indian War’s Affect on Shippensburg*

During the time of the French and Indian War, Shippensburg was the second oldest town west of the Susquehanna River (Kendall 1966). Shippensburg was founded by Edward Shippen III, a prominent business and political figure in Philadelphia and Lancaster, in 1730 (Kendal 1966). The area was first inhabited by 12 families of Scotch-Irish decent who made their home along Burd Run. The original town was part of Shippen’s 1,200 acre tract of land and was officially laid out in 1737 (Kendall 1966; Shippensburg Borough 2013).
Western Pennsylvania was an area of heated dispute with the French and English battling for control of the area (Waddell and Bomberger 1996). Where the Ohio, Allegheny and Monongahela rivers converge (modern day Pittsburgh) was one of the most contested areas in Pennsylvania due to its location on three of the major rivers in the state. War officially broke out in 1754 following tensions over land disputes. George Washington’s attack and ultimate defeat at Fort Necessity, prompted the French into action as well (Kaufmann and Kaufmann 2004; Waddell and Bomberger 1996). Washington’s defeat would not be the only defeat to prompt the construction of defenses in Pennsylvania however.

General Edward Braddock’s campaign on Fort Duquesne would prove central to the construction of Fort Morris (Warfel 2008). Braddock knew the importance of expelling the French from their stronghold at Fort Duquesne in order to control the three major rivers in western Pennsylvania. Braddock's pride led to him arguing with and angering both English military leaders and the Native Americans that offered to help him on his campaign (Borneman 2006). Having alienated the local Native American tribes, Braddock left Fort Cumberland with only a few Native American scouts to lead his troops on May 29, 1755 (Anderson 2005; Borneman 2006).

The slow journey and construction of a road from Fort Cumberland to Fort Duquesne prompted Braddock to divide his men in half. Leaving half of his men and his heaviest weaponry with his subordinate, Colonel Thomas Dunbar, he continued his march toward Fort Duquesne (Anderson 2005). On July 9 the French, knowing the British were near crossed the Monongahela River launched an attack against Braddock’s men. The British were soundly defeated and Braddock was killed. The retreat of the
British opened Braddock’s new road to the French and Native Americans and drew them ever closer to frontier towns such as Shippensburg (Waddell and Bomberger 1996).

The Construction of Fort Morris

Towns along the central and western portions of Pennsylvania, such as Shippensburg, grew ever fearful of attacks by the French and their Indian allies (Waddell and Bomberger 1996; Warfel 2008, 2010). The catastrophic British defeat spurred Governor Morris to build fortifications in Shippensburg as well as Carlisle. Charles Swaine, a man loyal to Edward Shippen, was charged with finding a location for the fort to be named Fort Morris after Governor Morris (Hunter 1960). By July 20, 1755 Swaine had found a good plot of land and had begun to develop the fort. Four days later he had cleared an area for a well with the help of 10 men and wrote to the Governor that he hoped more people would come help as well (Hunter 1960). However, sometime in October of 1755 Swaine ended his work on Fort Morris and left the construction to James Burd solely (Hunter 1960).

The imminent threat of Indian attacks became the central issue in Cumberland and York counties leading to a meeting of prominent leaders on October 30, 1755. The leaders of the surrounding area, including Governor Morris, resolved to create five forts through the two counties to defend major towns against attacks. By the time of the meeting, Fort Morris and the fort at Carlisle had already been started. Burd, who was present at the meeting, boldly stated that he “[expected] to be finished in 15 days…and had 100 men working at Fort Morris” (Hunter 1960:454). Also after the meeting both forts in Shippensburg and Carlisle were assigned four companies of militia upon completion.
Contrary to Burd's 15 day timeline, Fort Morris was still not complete by 1756 (Burkhart 1970). Major problems plagued construction of the fort. The depth of Swaine's well, started the year before, had reached a depth of 32 feet and had not shown any signs of water (Burkhart 1976). Without a well for the fort, it would be difficult to support as many soldiers and townspeople as the governor wanted within the fort. Burd was then called away to lead a Provincial troop at Fort Granville further delaying completion of the fort (Hunter 1960).

By 1757 only four of the original five forts built were still in use: Fort Lyttleton, Loudoun, Shippensburg (Fort Morris) and Carlisle (Hunter 1960). Eight companies of men belonging to Colonel Armstrong’s battalion garrisoned the four forts. However, after the Colonel’s stay at Fort Morris, he took a number of men of the garrison with him leaving the fort undermanned (Hunter 1960; Weiser 1896). Ultimately, Fort Morris was garrisoned until around 1759. Shippen made an effort to preserve the fort in 1761, even after its use expired (Burkhart 1976; Hunter 1960). One part of his efforts was to rouse the people of Shippensburg to take care of the fort. He urged them to build a six foot ditch around the fort and even went as far as obtaining two cannons for use at Fort Morris (Hunter 1960:462). Despite his efforts, the fort fell into disuse. The lack of Indian attacks and relative peace of the time meant that many frontier forts were not needed leading to their destruction by nature or human hand or reuse for other purposes (Warfel 2010). Fort Morris likely suffered a similar fate without its true location being properly recorded (Warfel 2008, 2010).

*Dimension Discrepancies*
Not only is the location of Fort Morris in dispute among Shippensburg historians, but the exact size of the fort is in question as well. No two historical sources cite the same dimensions of the fort. Descriptions of the size of the fort come from two main sources: a British Library plan entitled “Fort at Shippensburgh” describing the fort’s dimensions and General John Forbes’ *Headquarters Papers of Brigadier-General John Forbes Relating to the Expedition against Fort Duquesne in 1758* (further called Forbes Memorandum). The discrepancies found between the historic literatures have further complicated the search for Fort Morris. Warfel highlights the discrepancies about the fort’s size in his 2010 and 2012 project reports as referenced below.

Figure 1. The “Fort at Shippensburgh” plan that is housed within the British Library. Plan shows shape, dimensions and locations of several buildings within the fort.

The “Fort at Shippensburgh” plan (Figure 1) depicts the fort as a square structure with four bastions on each corner. Within the palisade of the fort are nine buildings, with only seven labeled on the key. The labeled structures are: two buildings labeled officers apartments, three barracks, a storehouse and a guardhouse. The plan shows the east wall, also called a curtain, as the location of the main gate to the fort. The gate is also
mentioned in the Forbes Memorandum (Warfel 2008, 2010). The plan depicts the length of each curtain as 88 feet and the distance from curtain to curtain as 154 feet (Warfel 2010, 2012). The measurements found on the plan vary greatly from those found on the Memorandum.

Forbes’ Memorandum describes in detail the dimensions of and notes the structures within the fort much like those found on the “Fort at Shippensburgh” plan. The Memorandum states that the fort “is a regular square with four Bastions, and one Gate in that Curtain which fronts due East toward the Town… [the fort has] Nine Huts and Houses…sufficient for Barracks, Magazine and Storehouse…A good Draw-Well, and an Oven” (Eschenmann 1987; Warfel 2012). The Forbes Memorandum also gives detailed measurements of each aspect of the fort as seen in Table 1. When compared to the measurements taken from the plan, the Memorandum measures the fort’s curtain and the distance from curtain to curtain smaller than those depicted in the plan (Warfel 2012). The Memorandum’s measurements have the length of the curtains as 25 feet shorter and the distance from curtain to curtain 41 feet shorter than those of the plan. As calculated by Warfel, the plan’s depiction of the fort is 36% larger than that of the Memorandum (Warfel 2012). Clearly, these measurements do nothing but confuse matters where archaeological excavation is concerned.
Table 1. Structural Aspects of Fort Morris with their Corresponding Measurements as Addressed in the Memorandum. Table Modified from Eschenmann 1987 and Warfel 2012.

*The Three Locations of Fort Morris*

The residents of Shippensburg have long argued over the location of Fort Morris. No historical documents accurately place the fort on the landscape of historic Shippensburg which fuels arguments between experts. In the past, three areas have been hypothesized as the location of Fort Morris: the Bull's Eye site on King Street, the East Burd Street location and the Ridge Avenue location (Figure 2 and 3).

![Map of Fort Morris Locations](image)

Figure 2. The three disputed locations of Fort Morris within the 1750s landscape. Image courtesy of Marr, 2004.
The Ridge Avenue site was proposed by Shippensburg historian Hayes Eschenmann in 1987. The Ridge Avenue site is located less than a mile south of the old town center on a raised area of town. Eschenmann, author of *The Elusive Fort Morris*, dedicates his book to the many proposed locations of the reported forts in Shippensburg. Eschenmann’s main focus is on his proposed location of the fort on the corner of Ridge Avenue and Walnut Street (Figure 3). Although the book provides a wealth of information (both historical and supposition) about the fort, its accuracy is disputed (Marr 2004).

Eschenmann did not believe that Fort Morris stood at either Bull’s Eye or East Burd Street because the existing arguments of the time did not hold any historical merit (Eschenmann 1987). Eschenmann argues in his book that the Burd Street site was the location of an old private fort prior to 1755 and could not have been Fort Morris. At the center of his argument for the Ridge Avenue location was the placement of swivel guns on the walls of Fort Morris. A single line in Forbes’ Memorandum states “There are three Swivel Guns on the salient Angles of the SE, SW and NW Bastions, but none on the NE:
These guns are so fix’d, that they can’t be pointed to any object, but in one horizontal line” and this is the aspect of the Memorandum that Eschenmann calls “critical” (Eschenmann 1987). Based on Eschenmann’s reasoning, the only logical reason why there was no gun in the NE bastion was because the NE bastion faces the town and the town would not be a source of attack.

He further states that the fort had to be on a hill on the southwest of town in order to properly orient the fort with the town (Eschenmann 1987). Ridge Avenue is in fact on the highest area in eastern Shippensburg, giving this possible location some credence. Another positive aspect of the area that Eschenmann discusses was that there was a deep well in the area that could have serviced the fort had there been one there. However, deep wells were found throughout Shippensburg (Eschenmann 1987). Finally, throughout his book, Eschenmann (1987) states that there is “no tradition” associated with the Ridge Avenue location while both the Bull’s Eye and Burd Street locations are surrounded by unreliable oral tradition and few facts. In his words “the documented fact that there was no cannon on the NE bastion far outweighs unverified tradition” (Eschenmann 1987:112).

According to Dr. Paul Marr in his 2004 article entitled, “Finding Fort Morris”, Eschenmann places too much stock in some of the details presented in the few printed resources of the time (Marr 2004). Marr disagrees with Eschenmann’s central argument (Marr 2004). It is unlikely that the NE bastion did not have a swivel gun for that reason. It was more likely that due to the circumstances of hastily building a fort and how difficult it was to obtain guns at that time. The builders of Fort Morris simply may not have been able obtain another gun for the fort (Hunter 1960; Marr 2004). Marr also states
that the missing swivel gun could have been due to the placement of the fort’s well. It was common in early frontier fort construction to not have a swivel gun where there was a well. Due to the lack of surviving documents about the fort, the real reason why there were only three guns on the palisade may never be known. Marr also states that to put a fort in this area would not have protected the town at all, but rather would have put the town in front of the fort in the line of fire (Marr 2004).

To further rule out the Ridge Avenue site, an early geophysical and limited excavation survey was conducted from 1989 through 1991. The geophysical survey was carried out by Tethys Consultants using a Geonics EM-38 electromagnetic induction meter (Bechtel 1991; Glunt 2009). Thethys Consultants’ report (1991) stated that no traces of the fort were found as a result of the geophysical or exploratory excavations which convinced Warfel, Marr, the author and other local historians that this location was not where the fort once stood (Warfel 2008).

Another possible location is Bull’s Eye on King Street (Figure 2 and 3). This location is on the west side of town on a large rocky hill overlooking King Street, a prominent street in both the modern and historic town. Charles Stotz (1985) describes what engineers would have considered a promising location for the construction of any fortification. Included in their survey requirements for a fort location was whether there were “level areas for campsites” and “commanding hills that had to be avoided” (Stotz 1985:62). Further, both Stotz and Marr state that a fort was refuge for those escaping imminent Indian and military attacks. Bull’s Eye is almost a mile from the town center, bordered by Middle Spring Creek marsh land and on top of a steep, rocky hill; the fleeing civilians would have had difficulty reaching this refuge (Marr 2004; Stotz 1985).
The Civic Club of Shippensburg, driven by a need to preserve what they believed was the location of Fort Morris, raised the necessary $1,000 to buy and restore the Bull's Eye property and to erect a tablet to mark the "location" of Fort Morris (Stewart, Date Unknown). Until recently, the Bull’s Eye location was marked by the same tablet placed at the site by Pennsylvania Historical and Museum Commission (PHMC) and the Civic Club of Shippensburg in 1921 (Figure 4). Because so many local sources stated, however inaccurately, that the location of Fort Morris was on Bull's Eye few people questioned the placement of the tablet until after it was placed (Elva Goodhart, personal communication 2012). As arguments grew within the town and local historians began to lose faith in the Bull’s Eye location, Mrs. Goodhart states that the tablet was going to be moved because of the excavations on Burd Street and the findings there.

On November 3, 1961 a Pennsylvania Historical Marker was placed at the Bull's Eye location stating that the location was Edward Shippen's stone house. The historical mark states, “In 1755 supplies for Braddock's army were stored here in Edward Shippen's strong stone house "at the back Run." James Burd, the son-in-law of Shippen, opened a road to carry these supplies to the west. After Braddock's defeat remaining supplies were given to sufferers from Indian attacks” (Pennsylvania Historical and Museum Commission 1961).
The final location, the Burd Street site, is the most promising of the three locations and was chosen for excavation during Warfel's three different projects in 2008, 2009 and 2012. On the 1872 Beers Atlas map of Shippensburg, two fort locations are indicated. The first is simply called “Site of Old Fort” and is at the location of Bull’s Eye. The second is called “Old Eng. Fort” at the Burd Street location (Figure 5). For the Burd Street location to be specifically marked as an “English Fort”, it is very likely that the English did in fact have a fort noteworthy enough to be placed on the map in that location.
The Burd Street site is just outside of the historic town center and is best positioned to defend the town against attack (Figure 2 and 3). Charles Swaine, the man sent to survey the area for a fort, wrote to Shippen that he had began to lay out the fort on Shippen’s land using Shippen’s wood to build the fort from Shippen's “saplin” (or sapling) land (Hunter 1960; Marr 2004). The “saplin” land was located north of the old town and along Burd Run which would have also provided vital water for both the town and the construction of the fort (Figure 2). Shippen’s “saplin” land is referenced by Shippen himself in a letter to James Burd, his son-in-law, inquiring about the fort. He instructs Burd to “get pine Logs & black Oaks from Saplin Land, If Mr. Swain & you differ in judgment about the fort let me know it privately” (Hunter 1960:454).

Marr (2004) also presents a solid argument for the Burd Street location. At the Burd Street location a marker was erected noting the location of a well (Figure 5). While the marker states that the well was part of Fort Franklin, a fort often confused with Fort
Morris by the local population, it was thought that a well did stand on the property (Figure 7) (Shippensburg Chronicle, Date Unknown). Multiple references to the well have been made by observers such as Swaine and Colonel William Eyre, a British military engineer, who stopped in Shippensburg in 1762 (Burkhart 1976; Hunter 1960; Warfel 2008, 2010).

<table>
<thead>
<tr>
<th>Location</th>
<th>How Far From Town (Miles)</th>
<th>Depth to Water (Feet)</th>
<th>Distance to Saplin Land (Feet)</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge Ave.</td>
<td>0.3</td>
<td>110</td>
<td>3,300</td>
<td>740</td>
</tr>
<tr>
<td>Burd St.</td>
<td>0.1</td>
<td>70</td>
<td>1,700</td>
<td>700</td>
</tr>
<tr>
<td>Bull’s Eye</td>
<td>~ 1</td>
<td>30</td>
<td>5,600</td>
<td>680</td>
</tr>
</tbody>
</table>

Table 2. Summary of Ridge Avenue, Burd Street and Bull’s Eye’s Measured Characteristics. Table Created from Marr 2004.

Marr, as a geographer, notes that the Burd Street location is 60 feet higher than the nearby Burd Run and that if a well was constructed here, water could be found at about 70 feet below the surface. This is the same depth that of the well Eyre observed (Hunter 1960; Marr 2004). If a well had been dug at the Bull’s Eye site, water would have been reached at around 30 feet, making digging a well to 70 feet pointless as water would have already been reached. It was noted by Hunter (1960) that progress on the well had reached 32’ and no water had been reached. Groundwater would have been found at 110 feet at the Ridge Avenue site and a deeper well would have been needed. For these reasons, neither the Bull’s Eye nor the Ridge Avenue would have likely been plausible (Marr 2004).

Summary of Fort Franklin

To further complicate the location of Fort Morris, local historians and local oral tradition adds a second fort within Shippensburg. Unlike the specific mention of Fort Morris in the Forbes Memorandum, Fort Franklin has no mention. In History of
Fort Franklin was a log structure located in the northeastern part of Shippensburg around 1740 and was disassembled in 1790. Warner, Beers & Company, authors of the *History* (1886:51), state that Fort Morris and Fort Franklin existed around the same time; however Fort Morris was on the rocky hill known as Bull’s Eye and was built of stone. In this account, Fort Morris was completed in December 1755 (Warner, Beers & Company 1886).

Other accounts of Fort Morris are just as confusing. Eschenmann states that Dr. George P. Donehoo, once Secretary of the Pennsylvania Historical Commission (PHC), commented on Fort Franklin many times. In one statement, Donehoo says that he wondered if Shippensburg did in fact have two forts but highly doubted that both were frontier forts that would have been listed by the PHC (Eschenmann 1987). He states that the name Fort Franklin was likely given to Fort Morris but because there was already a Fort Franklin in nearby Northampton County, the name was changed to Fort Morris. No Fort Franklin was on his list of frontier forts and it is likely that they are in fact the same fort (Eschenmann 1987:71).

One of the most well-known contributors to the location confusion is Clarence M. Busch, author of *Frontier Forts: The Report of the Commission to Locate Frontier Forts of Pennsylvania 1896*. In his book, Busch references both Fort Morris and Fort Franklin and admits that there is confusion over whether there were one or two forts (Busch 1916). Even Busch (1916) cannot seem to place either fort on the landscape with any certainty. In one chapter of his book he places Fort Morris at Bull’s Eye and then he switches the two locations and says that Fort Franklin was at Bull’s Eye (Busch 1916).
Along with the report, Busch provides a map of the Shippensburg area with markings of his supposed locations of Fort Morris and Franklin (Figure 6). He states that Fort Franklin was located on Burd Street and at the time of the survey, the old well was still visible (Figure 6) (Busch 1916). Today, a marker stands at the East Burd Street site marking the location of a well associated with Fort Franklin further perpetuating the town’s belief that Fort Franklin once stood on East Burd Street (Figure 7).
Environmental Context

Shippensburg is located in south central Pennsylvania on the border between Cumberland and Franklin Counties (Figure 8). The town is bisected by the two counties creating Shippensburg Township and Shippensburg Borough. The town of Shippensburg is within the Great Valley Section of the Ridge and Valley Province of Pennsylvania (Figure 9). The Great Valley Section is made up of a lowland area with an abundance of rolling hills. The project area lies in the southern portion of the Great Valley Section which is lower in elevation than its counterpart and consists of limestone and dolomite formations (Pennsylvania Department of Conservation and Natural Resources [PA DCNR] 2009).
Figure 9. Map of physiographic provinces of Pennsylvania with Shippensburg marked by the red symbol (PA DCNR 2009).

The entire Great Valley Section ranges in elevation from 140 – 1,100 feet amsl. The study area is part of the Conodoguinet Creek Watershed which cuts through Cumberland and Franklin Counties and covers 524 square miles. The largest tributary of the watershed is Middle Spring Creek, found closest to the project area. This particular tributary is within the larger Conodoguinet Creek Watershed (Pennsylvania Department of Environmental Protection [PA DEP] 2004, 2013).

The soil type present in the Burd Street project area, Duffield silt loam (DuB), dominates the entire project area. Three other soil types lie near the project area; however, they are not found where surveys took place. These three soil types are Haggerstown silt loam (HaC), Urban land and Udorthents (Ub) and Duffield silt loam, 8 to 15 percent slopes (DuC) (Figure 10). According to the Penn State University (PSU) Soil Mapping System, Duffield silt loam areas are well drained with slopes of three to
eight percent. Soils within the project area are considered to be prime farmland. This is because of a higher amount of carbonate in the soil due to the abundance of limestone in the area (PSU Soil Map 2013, PA DEP 2004). In areas of DuB soils, the lithic bedrock is in the range of 60-80 inches beneath the surface with the depth of the water table more than 80 inches beneath the surface (United States Department of Agriculture Natural Resources Conservation Service [USDA NRCS] 2013).

Previous Archaeological Excavations

The 2008 excavation was the first attempt to locate Fort Morris at the East Burd Street location (Warfel 2008). The excavations took place between June 2 and July 2, 2008. The initial investigation included three 14 foot long trenches at 333 East Burd Street. In the west portion of the side yard 22 shovel tests pits (STPs) were laid out and excavated (Warfel 2008). Each trench and shovel test hole location was recorded using a total station as shown in Figure 11. Both the excavation trenches and STPs were
excavated recording stratigraphic information including soil color and texture. All artifacts uncovered in the excavations were labeled and bagged according to the stratigraphic level in which they were found (Warfel 2008).

![Excavation plan of 333 East Burd Street in 2008. Trenches and shovel tests locations are depicted and labeled. Image courtesy of Warfel 2008.](image)

Three stratigraphic layers were identified within the excavation. Within the first level, 13 ceramic sherds were recovered. The ceramic sherds included “one plain creamware sherd, three pearlware sherds (plain and hand-printed), and nine transitional 19th century white earthenware sherds” (Warfel 2008: 10). Only the single creamware sherd was diagnostic of the fort period, designated 1755-1764.

Level 2 contained a higher percentage of historic artifacts than modern materials such as plastics and modern toys. Fort period artifacts within level 2 included Delftware, undecorated white and Scratch Blue salt-glazed stonewares. Warfel (2008:11) calls these types “good markers for the French and Indian War period.” Outside of ceramics sherds,
a kaolin pipe stem was found with a diameter of 5/64” dating to around 1710-1750 and a brass button dated to 1760-1780 similar to other types found at French and Indian War forts (Warfel 2008).

Two lower levels were uncovered in trench 2 and 3. A clay fill layer was found that corresponds with the digging of a basement for the current house as well as the insertion of a metal water pipeline through the yard. Similar ceramic sherds and modern debris were found in this level as the two upper levels (Warfel 2008). The modern land surface labeled level 3 lies beneath the clay fill. This layer is distinctive because the ceramics from this level all date from the time of Fort Morris to about the 1850s and include ceramic types such as Jackfield, red earthenware and creamware. Other fort-related artifacts included a tombac button and pipe bowl fragments (Warfel 2008). The last level was sterile subsoil and was not excavated. Of the features discovered in the trenches, none dated to the time of Fort Morris.

The 22 STPs excavated revealed interesting artifacts as well. Ceramic types found within the first layers the STPs mirrored those found in the trenches. The buried land surface of the test holes yielded ceramic types from the fort period into the 19th century. Based on mean ceramic date calculations performed by Warfel, the side yard’s historic land surface is 1771.5 which post-date the period of Fort Morris (Warfel 2008). Lead musket balls and a musket flint were also found. The type of flint found, called Clactonian, is often found on sites dated between 1700 and 1775 (Warfel 2008:23). Some of the important features in the shovel tests include fire-reddened clay in shovel test 2, a large quantity of limestone rubble in shovel test 5 and 9 and a feature with the shape of a right angle in shovel test 10 (Warfel 2008). Such finds indicate that there were people in
this location, though it is difficult to prove the features were made during the occupation of Fort Morris.

![Figure 12. Examples of 18\(^{th}\) and 19\(^{th}\) century artifacts from the 2008 excavations. (a) and (b) are Tombac buttons, (c) is a pipe stem and (d) is a musket flint. Image courtesy of Warfel 2008.](image)

To continue the search for Fort Morris, Warfel conducted another excavation project between May 4 and July 17, 2009 (Warfel 2010). Once again 333 East Burd Street was the center of focus for the investigation as well as 335 and 327. A large search grid was laid out within the west side yard of the 333 lot on top of the previous year’s STPs to further investigate what was found prior. The grid was divided into 48 test units. Two extension trenches were added to the grid to the north and south as well as one in the back yard. The northern extension was comprised of test units 49-55 while the south extension was labeled 58-61. The backyard trench was excavated as a single unit (Figure 13).
Figure 13. 2009 Map of test units and backyard trenches at 333 East Burd Street overlaid on Google Earth map. Locations are approximate. Test trench and unit image courtesy of Warfel 2010.

Thorough excavation of the 333 East Burd Street test units and back yard trench began with level 3, the historic buried land surface. All artifacts found in the first two levels were deemed unimportant to the investigation due these being fill layers with mainly 19th century to modern day artifacts (Warfel 2010). The historic land surface yielded 18th and 19th century ceramic types identical to those in 2008, clothing items such as tombac buttons, dietary remains, house wares, a prehistoric projectile point and pipe bowl and stem fragments. Dates for the land surface were calculated once again by mean ceramic dating as well as pipe stem dating. A mean ceramic date from the ceramic assemblage resulted in a date of 1782.9 while the pipe stem date, based on 28 pipe stems, was 1762.5 (Warfel 2009).

Within the historic land surface, three features stood out as indications that a fort could have stood at the Burd Street location. The first is Feature 25 which has been
labeled a cellar (Warfel 2010). Feature 25 consists of a large limestone wall with a width of almost two feet. As can be seen in Figure 14 and 15, the cellar walls intersect with the present day house foundation and show that the structure was demolished. Limestone is laid on the floor within the walls of the cellar. The feature fill was made of 18th and 19th century ceramics, clothing items, house wares and building materials. The average ceramic date calculated from 487 ceramic sherds came to 1767 while the average date for the 19 pipe stems came to 1768 (Warfel 2010). Although both date estimates fall outside the fort period date of 1755-1764, the dates are close enough to the fort period to state that the area was still in heavy use whether a fort may still have been standing or not.

Figure 14. The cellar labeled Feature 25. Image courtesy of Warfel 2010.
The next fort period feature is a probable oven. The feature is of questionable origin as it does not fit the general description of ovens used on fort sites. In his description of the feature, Warfel states that this feature could be that of an earth oven instead of a masonry oven made of brick. He goes on to say that earth ovens are rock-lined however “one would expect the pit’s walls and floor to be scorched from frequent use” (Warfel 2010:21). The pit that was excavated was not burned but an area nearby the pit shows clear evidence of fire burned soil. Dietary bone comprised most of the feature's artifact assemblage and with many rat holes nearby, it is clear that this feature served some sort of food-related purpose. Whether it was an oven or not is still questionable (Warfel 2010).
The third feature on the historic land surface was that of a root cellar. Artifacts collected from this feature included much the same as the previous features with the addition of a bone utensil, a trigger guard fragment and a lead musket ball. Dating of the feature was possible by the identification of a particular type of ceramic called Scratch Blue white salt-glazed stoneware that was produced in the late 1730s through the end of the American Revolution in 1783 (Maryland Archaeological Conservation Lab 2002). It is the most recent type of ceramic found in the feature, indicating that the feature was not in use after the time of Fort Morris (Warfel 2010).

Figure 16. Feature 26, interpreted as a root cellar. Image courtesy of Warfel, 2010.
Outside of the main 333 East Burd excavation of the side yard, three other trenches were explored in the back yard of 333 and 327 and the front yard of 335 East Burd. The location for these three trenches was based on the placement of the British plan of the fort over the modern surface of the area that showing portions of the palisade residing in the areas of excavation (Figure 17) (Warfel 2010). At 327, no buried land surface was found resembling that at 333 and no artifacts were found dating specifically to the period in question. Only a terracotta pipe was uncovered (Warfel 2010). The back yard trench at 333 had almost identical results as those found at 327 with the addition of limestone and concrete pieces. Only one sherd of Scratch Blue white salt-glazed stoneware was found and thus no date could be reached for the age of the trench. Only the trench at 335 exhibited traits similar to those in the 333 side yard. The trench did contain a portion of the old land surface and uncovered an assemblage of artifacts that compares to that in the side yard of 333 (Warfel 2010).
CHAPTER III

THE SCIENCE BEHIND GEOPHYSICAL INVESTIGATIONS

The use of geophysical instruments in archaeological surveys was adapted from different sciences outside of archaeology. The first recorded geophysical survey in North America occurred in Williamsburg, Virginia in 1938 by Mark Malamphy (Bevan 2000). Malamphy was a geophysicist from Canada who undertook a survey of a churchyard. He used a method called equipotential surveying to investigate a church property. Equipotential surveys have been likened to today’s resistivity surveys but are ultimately different in many ways (Bevan 2000). The results of the survey included the location of an area of strong resistivity which, at the time, the investigators believed to be a stone vault used by the church. However, upon further excavation, the anomaly was deemed natural and not a vault at all (Bevan 2000; Conyers 2004). Since this early geophysical investigation, the use of similar methods has been growing in the United States.

Ground penetrating radar (GPR) surveys began in the United States in the middle to late 1970s with crude instrumentation by today’s standards (Conyers 2004). The first real attempts at utilizing GPR in archaeology included machinery that recorded all data points on paper. Data was later interpreted by experts post-survey or even in the field. Surveys completed entirely on paper were very useful to early archaeological projects, however their accuracy was often poor and without more sophisticated technology, the anomalies found were often indistinguishable from natural anomalies if able to be interpreted at all (Conyers 2004).

As computers became more available, GPR manufacturers adapted their equipment to utilize computers in the 1980s. Data could be seen on computer screens
while still in the field which helped immensely with processing and interpretation (Conyers 2004). As GPR devices improved, they were able to store more data. Processing software also improved (Conyers 2004, 2006).

*Ground Penetrating Radar (GPR)*

Ground penetrating radar is classified as an active geophysical technique. An active geophysical technique is one in which an instrument produces its own energy to investigate what is beneath the surface (Georgia Department of Transportation 2012). The opposite, a passive method, is one in which data is collected in the form of variation in natural energy fields. GPR utilizes the combination of electric and magnetic fields to create radar pulses that are sent into the ground. These radar pulses travel beneath the surface until the pulses are reflected by buried objects or natural and manmade interfaces back to the GPR antenna (Conyers 2004, 2006).

The reflective surfaces often are composed of distinctly different materials than the surrounding soil causing the waves to return to the antenna at differing speeds (Neubauer 2001). Anomalies that are large, hollow, or linear are targets that are best suited for GPR surveying (Conyers 2006:131). In addition, anomalies buried between two or more highly contrasting electrical or magnetic soils are also ideal because the returning waves will be much stronger (Cameron 1998:419). The way in which the radar pulses move is similar to that of radar found in airplanes or how dolphins and other creatures use sonar to locate objects around them (Conyers 2004; Kvamme 2003). Because of the manner in which GPR pulses travel through the ground, Lawrence Conyers and Catherine Cameron (1998:418) state that GPR is most often used when a
target anomaly is “between a few tens of centimeters and five meters [beneath the surface].”

For a GPR survey to be successful, one must understand how GPR pulses move through the ground and what factors affect them. When a GPR device is pushed along the surface of a survey area, electromagnetic waves move through the ground away from the device. This movement is called propagation (Conyers 2004). Propagation from the device into the ground is in the form of a cone that widens as it travels further into the ground. The waves eventually reflect off of an object or interface back to the device and recorded as raw data often called a radargram (Conyers 2004, 2006; Conyers and Cameron 1998).

A large number of data points are collected along these transects at a predetermined sample rate to create what is called a trace (Conyers 2004). Figure 18 shows an example of the raw data stored in the GPR device as the antenna is moved along a transect in a survey. The time that it takes for the pulse to be generated, bounce off an anomaly and return to the antenna is recorded in nanoseconds (ns) which can be used to calculate the depth of the anomaly (Conyers 2004; Conyers and Cameron 1998).

Figure 18. Data image (radargram) of a transect in the Stóra Seyla Churchyard survey obtained in 2011 by the University of Massachusetts Boston. This radargram was collected with a 500 MHz antenna. Image courtesy of the Skagafjordur Archaeological Settlement Survey
There are two general types of anomalies that can be found within a radargram: planar reflections and point source reflections (Conyers 2006). Planar reflections are simply reflections of a horizontal buried layer that is either natural or man-made. Examples of planar reflections include buried stratigraphic layers or man-made planes such as buried floor structures (Conyers 2004). Point source reflections are the result of objects beneath the surface and are generally smaller in size and singular in nature. Point source anomalies create the hyperbolic shapes seen below in Figure 19.

Figure 19. A radargram collected from a survey depicting hyperbolas caused by pulses passing over a culvert, a pipe and two tunnels. The pipe and culvert are smaller in diameter than the two tunnels, thus forming smaller hyperbola apexes. Image courtesy of the United States Environmental Protection Agency (EPA) 2011.

As the propagating waves from the antenna move through the ground, they reflect off objects that fall directly beneath the antenna as well as in front of and behind the antenna (Gaffney and Gater 2004). The slope or “arms” of the hyperbolas seen in Figure 19 are caused by the distance the object is from the antenna at the time of the pulse. When the pulses first detect an object, it is often at the edge of the pulse’s range and the distance the pulse travels to the object and back is very long due to the oblique nature of the propagating waves (Conyers 2004). The longer the pulse takes to return to the antenna the deeper the object is recorded to be even though the object is further away
from the antenna instead of deeper in the ground (Conyers 2006; Kenyon 1977). As the antenna moves toward the object, the travel time of the waves is shorter and creates narrowing of the arms of the hyperbola. The process then reverses once the object is passed over and creates the other arm (Conyers 2004, 2006). The slope and angle of the arms of the hyperbolas also give an indication of how wide the anomaly is. The wider the arms, the wider the object is beneath the surface (Kenyon 1977).

**GPR Complications**

Because the structure of GPR pulses is so fragile, there are many factors that can affect data and ultimately make it uninterpretable (Gaffney and Gater 2004). If the wave loses one of its parts due to attenuation (the dissipation of the pulse) or absorption by the surrounding soil, the wave will not propagate and the signal will be lost or disappear much quicker (Conyers 2004). Issues caused by attenuation and absorption of the signal can be caused by many factors within a survey.

One example is the frequency of the antenna used in a project. GPR instruments can have a wide range of antenna frequencies that can be used depending on the project. Antennas can have frequencies between 10 and 1,200 MHz (Conyers 2006; GSSI 2012). Antennas that are larger in size transmit lower frequency waves that penetrate deeper beneath the surface. These wavelengths are longer and do not reflect well off of smaller targets.

The opposite is true of smaller antennas. The higher the frequency the more likely the waves will be dissipated by the soil (Conyers 2004; GSSI 2012). An antenna that is labeled at 500 MHz actually does not produce only at that wavelength. The labeled MHz is generally the central wavelength that the antenna utilizes. In fact, the antenna produces
a range of frequencies and, in the case of a 500 MHz antenna, wavelengths emitted can range from 0 – 1000 MHz in an uneven wave shape (Gaffney and Gater 2003). No pulse from any antenna is produced perfectly at the advertised wavelength and thus noise can and almost always appears in collected data. Post-processing of the data often can eliminate the noise but may not be able to erase all of it. Experts suggest taking this into consideration when choosing an antenna and while processing data (Conyers 2004; Gaffney and Gater 2003).

A second cause of an altered radar wave is the composition of the soil itself. The dielectric properties of the soil being investigated play a large part in how radar waves will be transmitted through the ground. The term dielectric refers the amount of electricity that a type of material can store and then transmit back through the soil (Conyers 2006; Kvanme 2003). The relative dielectric permittivity (RDP) is expressed as a numerical value assigned to a type of soil composition. For example, the RDP of air is 1 while the value of clay is has a range of 5-40 (Table 3).

In short, if the material’s RDP range is high, a radar wave will move more slowly. Slower wave velocity often results in stronger images within resulting data. The best anomaly images are produced when the RDP with which a wave travels through changes quickly rather than slowly over transmission (Conyers 2004, 2006).

The electrical conductivity of the soil plays a major role in the transmission of radar waves (Conyers and Cameron 1998). Electrical conductivity is the measure of how well a material like soil will allow electricity to flow through it. Ultimately because of the natural electrical conductivity of soil, radar waves will attenuate the further they travel. As Lawrence Conyers and Catherine Cameron (1998:420) state, “the best conditions for energy propagation are dry sediments and soil, especially those without and abundance of clay…While these conditions are optimal, any low conductivity media will transmit radar energy, no matter what its moisture content.” The more water, clay and other additives such as salt in the soil, the higher the given electrical conductivity (Conyers 2004).

The electrically and magnetically conductive materials within clay cause attenuation and give poor results. Water’s dipolar nature and the magnetic characteristics of elements such as iron and salt often cause the separation of the magnetic portion of the radar wave from the electrical part due to the attractions of the ions (Conyers 2004; Weaver 2006). As stated before, if either portion of the radar wave becomes separated from the other, a wave will die and cannot be recorded. Even the smallest amount of clay can cause problems to a survey because of its high electrical conductivity (Conyers 2004;
Doolittle 2013). However, the presence of clay and other highly conductive materials does not fully restrict the use of GPR in an area. If a soil composition is made up of less than 10% clay, a survey can still be undertaken with good results. Soils with more than 35% clay composition generally are not favorable unless the clay is made up of materials that are not highly conductive (Conyers 2004; Doolittle 2013; Weaver 2006).

Background noise can play a significant role in the collection of GPR data as well. The electromagnetic waves emitted by the GPR antenna are similar to those utilized by other electrical components that can be found near or within the survey area (Conyers 2004, 2006). Any device that has the same range of wavelength frequency as the antenna in use will ultimately leave a footprint in the data (Conyers 2006). Areas that pose the most threat of background noise are survey areas found in cities where overhead wires and radio antennas are present (Conyers 2004; Toushmalani 2010). While background noise can result in data that is unusable, most of the background noise can be filtered out in post-acquisition filtering.

Two final examples of complications in GPR surveys are airwaves and near surface obstructions. In Lawrence B. Conyers’ 2004 book, he states that these types of complications can be due to the antenna being used. Similar to the antenna frequency section discussed earlier, air waves and near surface obstructions are created by the wide range of frequencies generated by the antenna. Conyers defines airwaves as “high amplitude readings within the data that move through the air.” (Conyers 2004:77) The airwaves produced are often the product of power lines, buildings and other large objects that are found in the survey area. Unshielded antennas used by many GPR devices cause
pulses to be sent through the air at a constant velocity that differs from changing
velocities encountered in the ground.

Figure 20. Radargram depicting visible sloping airwaves (a) and multiple point-source anomalies seen as stacked, alternating readings. One example is marked as (b). Conyers notes that the airwaves were caused by nearby truck traffic and the point sources by pieces of metal. Image courtesy of Conyers, 2004.

Because the airwaves move at a constant velocity, it is easy to find these types of intrusions in GPR data. Airwaves appear as straight, diagonal lines that increase in depth across a radargram as in Figure 20 (Annan 2001; Conyers 2004). While these obstructions can be removed from the data, it is very difficult and often the process can eliminate viable anomalies in GPR data. Annan (2001:148) states that sometimes GPR data with an abundance of airwave signatures cannot be used and that it is “a fact of life and must be accepted as one of the limitations of GPR.” By using a shielded antenna, one can help to avoid airwave problems; however the issues may still arise.

Near surface obstructions are also common complications in the processing of GPR data (Conyers 2004). Many of the near surface obstructions encountered in a GPR survey are made of metal. Metal or “ring down” objects are very common. Metal is a
“perfect reflector” that creates distinct hyperbola signatures in data (Conyers 2004). All waves produced by the antenna that reach metal objects are bounced back to the surface where they are once again sent into the ground. This continuous process creates the stacked hyperbolas seen in Figure 20. Despite the obvious stacking of radar waves, some energy will bypass the metal object and travel deeper into the ground creating usable data (Conyers 2004, 2006; Gaffney and Gater 2004).

*Magnetic Susceptibility*

![Image of MS2 Magnetic Susceptibility Meter](image.png)

Figure 21. Image of MS2 Magnetic Susceptibility Meter similar to the device used in this project. Image courtesy of Terraplus Geophysical Equipment Supplier, 2013.

By definition, magnetic susceptibility is “the ratio of the magnetization induced in a sample to the inducing field on the order of earth’s magnetic field” (Dalan 2004). Soil can be impacted magnetically by remnant (permanent) magnetization or may be induced by an outside source. Remnant magnetization can be measured at any time while magnetic susceptibility can only be measured when an inducing magnetic field is involved. If there is no magnetized field applied to a test area, the magnetic susceptibility cannot be measured. In order to detect the central induced fields within a survey area, the soil magnetic composition must change or become “enhanced” (Dalan 2008).
Enhanced soils, as Rinita Dalan (2008) states, can be naturally occurring through the decomposition of an inorganic or organic nature or through human processes such as the use of fire or movement of soil as fill. Natural processes of reduction, oxidization and fermentation often create areas of lesser or greater magnetization within the topsoil and thus create magnetic susceptibility that can be measured (Dalan 2006). Fire, which can be natural or created by human activity, is one of the most common examples of the processes of reduction and oxidization. The process of burning results in areas of high magnetic susceptibility within the soil because of the transformation of weak magnetic particles to highly magnetic oxides (Bartington Instruments Ltd. 2013). When in the presence of fire, materials found within the soils of an area burn at temperatures of around 600-700 °C inciting a change of hematite (a very weakly magnetic iron oxide) to magnetite, the most magnetic mineral on Earth (Bartington Instruments Ltd. 2013; Gaffney and Gater 2004). Often, but not always, it is these fire-related, highly magnetic signatures that can pinpoint the location of possible features such as hearths and kilns within a tested data.

The identification of high areas of magnetic susceptibility can also be attributed to human alteration of the surface through the creation and use of habitation areas. Not only can the use of fire alter the magnetic signature of an area, but the mere movement of soils can change the signature as well (Dalan 2006, 2008; Gaffney and Gater 2004). Humans change the landscape of an area by tilling soil for farming, removing soil to clear large areas for a settlement, digging and by adding magnetic building materials or stones while creating new housing for residents (Schmidt 2007). These changes inevitably affect the magnetic field of an area and can be located during a magnetic susceptibility survey. The
more magnetic material created by fire, human alteration or naturally in the soil, the higher the magnetic susceptibility reading will be (Kvamme 2003; Schmidt 2007).

There are two places where magnetic susceptibility can be applied in archaeology: during a survey and in the laboratory. The former is the method applied in this study and will be discussed in more detail. In the field, a magnetic susceptibility survey can be conducted at the surface or beneath the topsoil within an excavation trench or borehole (Dalan 2006, 2008). Excavation trench and borehole applications have developed within the last decade and have not been conducted as often as the more conventional topsoil investigations (Dalan 2006).

Figure 22. Image at left depicts the use of the Bartington MS2 device with the MS2D coil in a topsoil survey while image at right depicts the instrument without the MS2D coil in soil wall surveys. Images courtesy of Bartington Instruments Ltd, 2013.

The Bartington MS2 device was used in this project. Signals from these devices can penetrate to 10 cm given optimal field conditions; although the typical single coil instrument can only reach about 1-3 cm (Gaffney and Gater 2004; Dalan 2006). The shallow depth with which this instrument can penetrate the surface is often viewed as a disadvantage in this technique; however readings of the topsoil alone can be valuable to an investigator depending on the scope of a project. Magnetic susceptibility surveys are
also commonly paired with magnetometer surveys, bolstering the notion that despite its poor penetration depth, the instrument is still very useful in archaeological investigations.

In the field, the MS2 device’s operation is relatively straightforward and user-friendly. Readings are taken after zeroing the instrument and then taking a reading of the soil in the test area (Dalan 2006; Gaffney and Gater 2004). A reading is taken by placing the end of the device directly on the soil surface. This process is repeated until the test area is covered, generally with intervals of 5-20 meters between transects and data points (Dalan 2004, 2006). While the instrument is easy to use, it does not come without its limitations and drawbacks.

As previously mentioned, the surface penetration of this instrument is very shallow. Magnetic susceptibility instruments are also very susceptible to drift in recordable readings. This leads to frequent re-zeroing during data collection (Gaffney and Gater 2004). Magnetic susceptibility surveys may also be sensitive to metal fencing, overhead power lines and pipelines and thus data can be skewed if these objects are nearby a collection area. Even the moisture content of the soil can affect readings in a survey (Dalan 2006). However, the MS2 does not generally face these problems due to its single coil design (Dalan 2006). Ideal field conditions for the MS2 are areas where the surface is flat with minimal vegetation. If the survey area is undulating or the surface is covered in vegetation, the device may not properly couple with the surface and can produce an inaccurate reading (Dalan 2006; Schmidt 2007).
CHAPTER IV

GEOPHYSICAL METHODOLOGY

The geophysical surveys conducted on Burd Street were designed to cover as much of the area allowed by the landowner permissions that could possibly contain parts of the fort’s palisade walls or inner structures based on the overlay of the "Plan at Shippensburgh" used in the 2008 and 2009 excavations (Figure 17). Based on the information presented within Warfel's 2008 and 2010 reports, communication with Professor Paul Marr and Marr's 2004 article, the proposed location of Fort Morris on Burd Street was chosen for investigation.

A total of five grid areas were surveyed during this study based on landowner permissions and environmental conditions in each yard. Three of the grid areas (Survey Grid 2, 3 and 4) in Figure 23 were surveyed by both magnetic susceptibility and ground-penetrating radar while two of the grids (Survey Grids 1 and 5) in Figure 23 were surveyed using ground-penetrating radar only. Two of the grid areas lie on either side of 333 East Burd Street at 329 and 335 East Burd Street where previous excavations were conducted in 2008 and 2009. The other three testing grids are located across the street at 322 and 324 East Burd Street.
No previous excavations or surveys have been conducted across the street from 333 East Burd Street due to the fact that these areas fall outside the proposed orientation of the floor plan on the modern landscape (Figure 17). However, it is highly probable that the floor plan is not correctly superimposed on the landscape and that the fort may have been further from the proposed location because of the inaccuracy of the historical documents and floor plan. Because of this probability, it is important to explore as much of the Burd Street area as possible to test the validity of the theorized location of Fort Morris.

*Magnetic Susceptibility and GPS Data Collection Methodology*

The first stage of the project was composed of two parts: recording the location of each survey grid using GPS and three magnetic susceptibility surveys. Trimble R-8 rover and data station were used in order to plot the coordinates of the four corner points of each survey grid. These points were marked with plastic stakes as to not interfere with the magnetic susceptibility and ground-penetrating radar surveys. Sidewalks that were still
present on the current landscape were not marked with GPS points as they appear clearly in the data. The GPS points were then entered into Google Earth to create a map of the survey grids on the current landscape.

The second step was to complete a magnetic susceptibility survey of each of the five grid locations. However, due to the timing of the excavations, time limit of landowner permissions and the last minute decision to survey a grid at 329 East Burd Street, only three of the surveyed grids have corresponding magnetic susceptibility data. These survey grids were labeled Mag Grid 2, 3 and 4 (Figure 22). A Barrington MS2 Magnetic Susceptibility System was used in the area to ascertain a broad understanding of topsoil magnetic properties and areas of human disruption in the area of interest on Burd Street. Each of the three grids surveyed with the magnetic susceptibility device had different dimensions dependent on how much space was available. The grids included 9m x 8m grid was laid out in the yard of 335 East Burd Street (Mag Grid 2), a 15m x 5m grid at 324 East Burd (Mag Grid 3), and a 20m x 9m grid in the front portion of the backyard of 322 East Burd Street (Mag Grid 4).

In order to collect the data within the three grids, the MS2 was allowed to acclimate to the environment. For such an instrument it is suggested that the device warm up. Some manuals suggest at least 10 minutes before use while others state "for a few minutes" (Bartington Operation Manual 2013:23; Dearing 1999:11). Once warmed up, each data point is collected by first collecting a sort of “zeroing” the instrument by holding it at lease a meter about the ground surface and then taking a reading of the soil by placing the probe on the ground surface (Dalan 2006). Data points, recorded as numbers, were recorded as points along the x and y axis of the grid. Each point was
recorded by hand because the MS2 device does not internally store data during a survey. Data points were collected using the MS2 in SI (International System of Units) mode at intervals of 1 m along and between each transect. Such spacing was chosen to have enough spacing between the transects not only record small point differences in the soil, but to also gain a wider understanding of the survey area.

**GPR Data Collection Methodology**

The second geophysical instrument that was used in this project was a ground-penetrating radar (GPR) survey. The survey grids used in the magnetic susceptibility survey were again used in the GPR survey along with two new survey grid locations. Five total grids were surveyed using GPR: GPR Grid 1 (329 East Burd), GPR Grid 2 (335 East Burd), GPR Grid 3 (324 East Burd) and GPR Grid 4 and 5 (322 East Burd). A MALA Ramac X3M ground-penetrating radar device was used to gather data. Ground-penetrating radar devices generally have a wide range of antenna frequencies that may be used based on the needs of the project. Each different frequency can detect features of a certain size range and to different depths beneath the ground surface. In the case of MALA systems, antennas vary in MHz with the four most available sizes being 100, 250, 500 and 800 MHz (MALA Geoscience 2012).

The choice of antenna frequency used in a project is a very important decision and many factors play a part in that decision. The three factors that influenced the choice of antenna frequency in this particular project were the approximate depth of possible features in question, the size of possible features and how clearly these possible features would be displayed in the resulting data. According to Lawrence B. Conyers (2004), a guideline to follow about antenna frequency states that the higher the antenna frequency,
the shallower the radar waves will travel with better clarity of the data. The inverse is also true for lower frequency antennas: the lower the frequency, the deeper the radar waves will penetrate with lower resolution. Conyers (2004) also states that features at about 1 meter below ground surface are best detected with antennas between 400 and 900 MHz with good resolution of data. Features at a depth of about 1-3 meters are also the most easily found with antenna that range 500-200 MHz.

According to MALA Geoscience (2012), “the 500 MHz is the most popular antenna size and can reach medium to shallow depths with good resolution.” At Indiana University of Pennsylvania (IUP), the Anthropology Department has two antennas that can reach the depth necessary for this research: 250 and 500 MHz. Either of these antennas would be reliable for this investigation. In this particular case, the historic ground surface has been noted at about three feet (about 1 meter) below the current land surface in the Burd Street area (Warfel 2008, 2010). Because a 500 MHz antenna should be able reach depths of around 1-3 meters with good clarity, it was chosen for this particular survey (Conyers 2004, 2006).

The 500 MHz antenna was situated on the MALA’s rough terrain cart along with the X3M controller and VXII Monitor to create the total unit for survey as seen in Figure 24. A second individual was needed to hasten the process by standing at the end of each transect in order to accurately traverse each transect. Each survey began in the southwest corner of the grid and was traversed in both the X (East to West) and Y (South to North) directions with 0.25 meter transect spacing.
This particular survey method was chosen for a number of reasons. The first was the grid size. Because the survey areas and possible linear anomalies were so small, it was important to cover as much of that area as possible with the GPR. Second, authors such as James Pomfret (2006) have stated that the use of smaller transect spacing intervals and data collection in both the x and y directions have produced clearer images of smaller linear features within completed data at the Ceylon Plantation test site. Although Pomfret’s 2006 test used 0.5 meter transect spacing instead of 0.25 meter transect spacing, it can be inferred that the use of 0.25 meter spacing would provide an even clearer picture of what anomalies found at the site.

Data collection was relatively easy due to the nature of the environment. As these areas are residential backyards, the grass was mown and the vegetation did not affect the majority of the grids that were surveyed. The most common impediments were trees and bushes. When one of these obstacles was encountered, the MALA was wheeled up to the obstacle and the transect was stopped and the distance along the transect was recorded. The MALA was then positioned on the opposite side of the obstacle and its position was
once again recorded. A new transect was started and the remainder of the transect was finished. Concrete walkways were found in two of the five survey areas although they did not pose any significant problems for data collection. Transects were not stopped when the antenna passed over cement pathways.

*Data Processing Methodology*

Each geophysical method required different processing software and methodology to achieve the necessary images for analysis. It is important that the users of geophysical processing software know that processing raw data can result in deletion of important anomalies as well as inadvertently creating anomalies that never existed (Conyers 2004). It is important to only choose steps within processing software that will aid in the analysis being conducted and not any extraneous steps that may mislead the researcher.

The GPS data collected from each survey grid was downloaded from the Trimble R8 controller and raw shape files were generated before a map of the area was created. The shape files were inputted into Google Earth to record the location of each grid corner point. These points were applied to an aerial map of the Burd Street area. Resulting images from the magnetic susceptibility and GPR surveys were then georeferenced on top of the grid locations for an overall image of the area (Figure 21).

Data processing for the magnetic susceptibility surveys was a relatively simple process. As mentioned earlier, the Bartington MS2 does not internally store data collected in the field. The handwritten data taken in the field was entered into a Microsoft Excel spreadsheet in an x, y, z columned format. The x and y portions of this format corresponded to the location of each data point in the survey. Each x and y point was one meter apart along one meter spaced transects throughout each grid. The z portion of the
data represented the data value read by the MS2. Once the data was entered into the Surfer program, a contour map of the area was created. Color scales were added to the contour map in order to see differences in readings across the surveyed area. The final product depicts where highs and lows in the data can be found and overall trends throughout the area.

While the goal of magnetic susceptibility is to show broader trends throughout a survey area on the surface, the goal of GPR data processing is to ascertain the depth and size of an anomaly of interest beneath the surface. Processing GPR data is a great deal more difficult than the processing of magnetic susceptibility data. Outside of changing the various scales on a magnetic susceptibility map, the user does not require much more manipulation of the data in question. What manipulation occurs within the data processing of GPR data varies from project to project and also by what the individual user wants to see within his or her data. Such different circumstances can easily complicate data processing and analysis if the correct steps are not chosen.

Raw data from the field was seen on the MALA screen; however this data was only minimally useful until further processed. The MALA device stored the raw data from the project within its internal memory drive which was removed using a USB device. The data was then transferred to a computer to be manipulated. GPR data processing for the Fort Morris project took place within the GPR Slice 7.0 where it was converted to a useable format (Goodman 2012). Conversion required the creation of new information files for the project, editing the information and then ultimately converting the data into a format that could be analyzed.
As mentioned above, the user must convert the raw data into a format that could be read and processed by the computer program. The conversion stage is also where gain and wobble was added and subtracted. Next, the Burd Street data was sliced and resampled. The slice and resample and XYZ step is where time slice datasets are created from radargrams (Goodman 2012). The time slices mentioned are the colored plan views of what is beneath the surface. These images are what are most commonly seen in geophysical reports and articles. After slicing and resampling, the data was gridded. Gridding creates the time slice maps needed in order to interpret the data. This is also where low pass filters were applied in order to remove gridding noises. The options of a 3x3 or 5x5 low pass filter are available here. These filters remove frequency “noise” that is found within GPR data (Goodman 2012). For the Burd Street project, a 5x5 low pass was applied based on Goodman’s suggestion that such a filter is very useful for highly noisy surveys such as those at Burd Street (2012). The time slice maps were then saved as jpeg files for analysis.

Last, the completed data was given to Mr. Warfel prior to his 2012 excavation in order to guide his excavations. Features located in the excavations were photographed and recorded by either the author or Warfel in the field. Upon completion of the excavations, data from the 2012 project report was used to compare the author’s data to that which was found in the excavations.
CHAPTER V
GEOPHYSICAL SURVEY RESULTS AND INTERPRETATIONS

The results and interpretations discussed in this chapter are the product of GPR and magnetic susceptibility surveys conducted within five grids (GPR Grids 1-5 and Mag Grids 1-3) at four properties on East Burd Street in Shippensburg, Pennsylvania (Figure 24). The methodology used to conduct the geophysical surveys in each area is discussed in Chapter IV. Each survey grid was laid out in order to investigate as large an area within each property’s back yard as could accommodate the large GPR device.

Each survey grid was studied separately as each represented a different area with different conditions that could allow or hinder the location of fort period anomalies. The resulting images are magnetic susceptibility maps and 2-D GPR time slices or plan views of each grid and their accompanying radargrams, or profile views. The time slices indicate amplitudes of anomalies beneath the surface over the entire survey area while the radargrams represent a specific transect, or pass, within the grid. The depth of each slice and radargram are indicated by either a scale or written indication to the side or above each image. Note that the depths recorded on both the radargrams and slices are approximate and may not be located exactly where they appear in each image.

Two of the five geophysical survey areas were excavated during the 2012 excavation project lead by Warfel. These grids were 335 (GPR Grid 2 and Mag Grid 1) and 329 East Burd Street (GPR Grid 1). The other two locations were 322 East Burd Street (GPR Grids 4 and 5 and Mag Grid 3) and 324 East Burd Street (GPR Grid 3 and Mag Grid 2) (Figure 25) were not excavated during the 2012 excavations. The 2012 excavation trenches were carefully chosen by Warfel in order to intersect areas in which
he believed portions of the palisade once stood based on the Forbes Memorandum dimensions (Figure 26) (Warfel 2012). A similar approach was taken when the author chose which yards to survey. If the location of Warfel’s plan overlay of Fort Morris is correct, both 329 and 335 East Burd Street would have portions of fort structures within them (Figure 25 and 26). If the overlay's position is incorrect, it is possible that 322 or 324 could have portions of the fort as well.

Figure 25. GPR and Magnetic Susceptibility grids in relation to the Memorandum’s dimensions of Fort Morris.
329 East Burd Street: GPR Grid 1

The geophysical investigation of Grid 1 was comprised of only a GPR survey due to time restraints between equipment availability and the excavation timeline. The grid measured 8mx7m and included a cement pathway that runs north to south in almost the center of the grid (Figure 27). A large dirt pile prevented much of the backyard from possible survey. No other features appear on the surface within the survey area. Recent alterations to the 329 property have occurred since the 2009 excavations. A back deck was added to the main house and its construction may have destroyed any fort period remnants that had survived the construction of the main house.
Three large anomalies were identified within the GPR data. The three anomalies are labeled 1, 2 and 3 as seen in Figure 28. Anomaly 1 is the previously mentioned cement pathway on the modern surface. The sidewalk is 1.25 meters in width and appears as a high reflectivity area due to the density and composition of the cement. The time slice of 101-114 cm still depicts the anomaly although it appears as an area of low reflectivity (Figure 28). At this depth the radar pulses bounce off the underside of the pathway and lose their strength by the time they reach the antenna, resulting in a low reflectivity signature. The location of the sidewalk is clear in the radargrams as a strong, rectangular signature at 4.5-5.5 m along a west-east transect (Figure 29). Sloping readings immediately before and after the strong portion of the anomaly are the result of the antenna passing up and over the pathway.
Figure 28. Two of the 12 GPR time slices created from the data collected at 329 East Burd Street. The top two show unlabeled views of the slices taken at 25-38 cm and 101-114 cm beneath the surface while the bottom show the same slices with anomalies labeled.

Anomaly 2, an anomaly of mid-level reflectivity, appears as a circular area with two extending features (Figure 28). The anomaly’s signature is the most prominent at a depth of 25-38 cm. All slices deeper than 38 cm show large high reflectivity areas within the vicinity of the circular structure, with the strongest and largest signature at 76-88 cm beneath the surface. The circular anomaly is clear within the 2.5 m west-east transect radargram as well. It begins at around 5.5 m and continues past the end of the transect (Figure 29). A foundation-like structure can be seen from 5.5-7 m followed by a highly reflective area to the end of the transect.
Anomaly 2 was revealed in the 2012 excavation within a trench labeled Trench 5. The trench was dug to subsoil at a depth of about 2.5 feet (0.762 m). When the anomaly was unearthed, it was discovered that the extending portions were two terracotta pipes extending from a rounded, limestone foundation (Figure 31). The foundation walls measured 16 inches in width (40.64 cm) and the entire structure measured at least eight feet wide (2.438 m) (Warfel 2012). Even when a portion of the trench was excavated further, the final depth of the structure was not determined as shown in Figure 31.
The structure is oriented in the same direction as Feature 25, the historical “cellar,” found in the 2009 excavations (Warfel 2012). The darker soil within the feature, which was identified as burned materials such as coal and ash, was the cause of the higher reflective readings within the GPR data within the foundation signatures (Warfel 2012). Had there been time to conduct a magnetic susceptibility survey before excavation, these materials would certainly have appeared as an area of high magnetic susceptibility due to the burned materials (Dalan 2006).

Figure 31. Southeast facing view of the privy structure at 329 East Burd Street. The privy corresponds with the location of Anomaly 2 in the GPR data. At bottom left are the two terracotta pipelines visible in both the radargram and time slices. Image courtesy of Warfel 2012.

Warfel determined that the structure is a privy. The structure fits descriptions of similar privy structures of the 19th and 20th centuries. In Robert A. Genheimer’s (2003) article titled “Digging the Necessary: Privy Archaeology in the Central Ohio Valley,” Genheimer notes that privy shafts are often very deep, even up to nine meters and most
commonly dry-laid with limestone. Limestone was the most viable material as it often resulted in a sturdier privy shaft that could be used for a longer period of time on residential lots. It was also a cheap and abundant material in many areas.

Had the privy at 329 East Burd Street been associated with the fort, it would not have built of stone due to the time it would take to construct such a privy as well as the temporary nature of the fort itself (Genheimer 2003; Hunter 1960). Privies were also not found within forts such as Fort Morris due to their unsanitary nature and the rampant diseases they often carried (Waddell and Bomberger 1996; Warfel 2012). Warfel dates the privy after the time of Fort Morris, likely between 1765 and 1860. The present house likely used the structure for waste drainage until the end of the 19th century (Warfel 2012).

The third anomaly within the grid can be seen most prominently in the fifth time slice at a depth of 101-114 cm. Anomaly 3 was not located within the singular trench dug at 329 East Burd. The anomaly appears to be square-like in shape with at least one discernable right angle. The discernable portion of the anomaly is at least 2.25 m wide and lies directly beside the cement walkway. When the anomaly is studied in the radargrams, the anomaly appears to be bigger than in the time slices. Figure 28 shows that the anomaly likely starts at 1.5 m and extends underneath the pathway to at least 4.5 m along the transect. A one meter section (1.5-2.5 m), a highly reflective area with many hyperbolas and another one meter section (3.5-4.5 m) can be seen similar to that of anomaly 2. There is rounded bottom to the anomaly unlike the other nearby anomalies previously discussed.
Based upon the shape, size and GPR signature of the feature it is likely that anomaly 3 is a structure with a foundation or a trench of some kind. Much like the signature of the privy in the radargrams, the start and end of the anomaly in Figure 29 contain “voids” consisting of small areas of high reflectivity with roughly the same depth and signature. In the privy anomaly, this was the result of the dry-laid limestone and a similar area is seen in anomaly 3 as well. The corner of the square anomaly located at (3x, 2y) on the 101-114 cm time slice (Figure 27) appears between 2.25 and 3.25 as two highly reflective areas, presumably marking the two “walls” meeting to form the corner.

Figure 32. Radargram from Donna Smith’s investigation at Fort Shirley seen at top. Anomaly 4.4 corner of right angle marked. Radargram from 329 East Burd Street seen at bottom with corner of right angle marked.
When the corner’s radargram signature is compared to other GPR surveys that contain building corners, the similarities are numerous. At Fort Shirley, an unidentifiable corner of a building was found within GPR data collected by Donna Smith (2013), a recent Indiana University of Pennsylvania graduate. In Figure 32 the anomaly is labeled as Anomaly 4.4 and consists of two stacked hyperbola anomalies about 1 m apart. Within the two stacked hyperbola anomalies is a distinct hyperbola (Smith op cit). Multiple similar anomalies are found in the data at 329 East Burd Street. One such anomaly is marked in Figure 30. Like Smith’s anomaly, the portion of Anomaly 3 outlined has stacked hyperbolas with a distinct hyperbola at the center (Smith 2013). Directly beside the indicated portion, another similar anomaly can be seen that may represent a possible western wall of Anomaly 3.

Three hypotheses are considered by the author as to what this angle could be. The first is that Anomaly 3 may be the unnamed square building closest to the storehouse on the “Fort at Shippensburgh” plan layout (Figure 1 reprinted as Figure 33). Although the location of Anomaly 3 is not an exact match for the southeast corner of the building in Warfel’s overlay, it is possible that the overlay may be off by only a few feet or meters (Figure 34). The overlay is only an educated guess based on a foundation found and the questionable dimensions recorded in Forbes’ Memorandum. However, if the plan is oriented as seen in Figure 34, and moved a few meters to the north, the anomaly and the unnamed building align almost perfectly.
Figure 33. “Fort at Shippensburgh” plan, reprinted. Unnamed square building indicated.

Figure 34. Hypothesis 1: Location of Anomaly 3 in relation to Warfel’s overlay of the Memorandum’s dimensions of Fort Morris over 329 East Burd Street. Noted is the unnamed square building and the storehouse.

The second hypothesis is that the dimensions in Forbes’ Memorandum are correct; however the overlay is not aligned on the correct building. Warfel’s overlay is based on the southwestern corner of the gate barracks. Another plausible identity of Warfel’s Feature 25 is that it is the southwest corner of the guardhouse. If this were the case, the fort overlay would need to be shifted northeast to align Feature 25 to the
guardhouse (Figure 35). By shifting the overlay in this manner, the portion of the southwest bastion corner attached to the west curtain would be in almost the exact location of Anomaly 3. The angle of Anomaly 3 and the bastion and curtain angle are almost identical (Figure 36).

![Figure 35. Hypothesis 2: Location of Warfel’s overlay of the Memorandum’s dimensions of Fort Morris (left) compared to the location presented in the author’s second theory (right).](image)

The third hypothesis about the identity of Anomaly 3 is that it has nothing to do with the fort at all. Much like Anomaly 2, the privy, it is possible that this anomaly is the result of a later structure associated with the house that stands today. The shape may be
purely coincidental. Without further investigation at this exact location, the identity of this anomaly will remain unknown.

335 East Burd Street: Mag Grid 1 and GPR Grid 2

Figure 37. Magnetic susceptibility map of 335 East Burd Street.

Mag Grid 1 yielded general information about the yard prior to the more in depth GPR survey. The bright green U-shaped area near the center of Figure 37 and 38 represents the Y-shaped cement pathway that bisects the grid. Cement gives low magnetic susceptibility readings due to its composition. Higher magnetic readings can be seen in the southwest and northeast corners as well as along the southern boundary of the grid between 0 and 6 m on the x-axis. These high readings along the southern boundary correspond with higher reflective areas within the GPR data as well marked as Anomaly 7 in Figure 39.
The higher magnetic values are good indications that some sort of disturbance took place in the area. The southern boundary of the grid is close to the present house and construction and foot traffic is likely the cause of such disturbance. The higher readings in the northeast corner may be caused by a tree on the other side of the property boundary (Figure 38). However, it is also likely that the higher reading is caused by foot traffic from the back deck of another home that borders the northern boundary of the grid. A third and most likely possibility is that these readings correspond to subsurface Anomaly 5 that will be discussed in the following GPR section.

GPR Grid 2 yielded four interesting anomalies. Similar to the GPR Grid 1, a large pathway is visible in the data (Figure 39). The pathway was not considered an anomaly in this grid because the affects of similar cement pathways have already been discussed and
the anomaly is clear on the modern surface. The pathway, however, is visible in every
time slice and radargram leaving a distinct y-shaped signature.

The first anomaly, labeled number 4, is a linear anomaly that runs in a northeast
to southwest direction. It is most visible from 25-88 cm beneath the surface. The anomaly
appears as a series of mid-level reflective areas that curve slightly toward the southwest
corner of the survey area. The anomaly is most visible in the fourth time slice at a depth
of 75-88 cm. Coordinates for the ends of the anomaly are (0x, 0y) to (3x, 9y) on the time
slices. Within the x=2m radargram, the anomaly appears as a highly reflective concise
hyperbola at about 7m along the transect (Figure 40).

![Figure 39. 25-37 cm time slice images of 335 East Burd Street. Anomaly # 4-6 marked at left.](image)

Anomaly 5, another linear anomaly, is similar in size and shape to Anomaly 4.

Anomaly 5 is the most visible in the 25-37 cm time slice (Figure 39) although parts of it
can be seen as deep as 113 cm. Similar to Anomaly 4, Anomaly 5 runs northeast to
southwest and appears as a curved line. The anomaly’s length runs at least as long as the
entire survey area. The two ends are located at (6x, 0y) and (8x, 9y). Anomaly 5 is
comprised of mid-level reflective readings. Radargrams depict the anomaly as an area of
high reflectivity from 5.5 m to 7 m along the transect with a clear hyperbola at the center (Figure 40).

Figure 40. 335 radargrams at x=2.5m (top), x=7m (center) and x=5m (bottom). Anomalies 4-7 indicated. Y-shaped cement pathway visible in top and bottom at 3 m along transect.

The third anomaly, labeled Anomaly 6, is a circular anomaly located at the end of the horizontal portion of the cement pathway and is indicated on the modern land surface by a clear depression (Figure 39). Anomaly 6 is visible in all 10 time slices as either mid-level reflective areas or as a void in the surrounding readings. With a width of 1.5 m and its circular shape, it resembles the privy found in GPR Grid 1. The resulting time slices
for the grid do not reveal the entire anomaly; however the south to north width of the anomaly is visible in both the time slices and radargrams. The westernmost point of the anomaly is at (7x, 3y), the northernmost at (8x, 4y) and the southernmost at (8x, 2.5y) (Figure 39).

The fourth anomaly, Anomaly 7, is a 3 m x 4 m rectangular-shaped area of mid to high reflective anomalies. The anomaly area is visible throughout all 10 time slices and only becomes more visible with depth, with Anomaly 7 best seen at 100-113 cm beneath the surface. At about (5x, 1.5y) within the large anomaly is a diagonal area of low reflective readings appearing to stem from Anomaly 6 (Figure 41). In time slices of below 100 cm, the high reflective areas can be seen surrounding the area of low reflective readings, especially along the southernmost border of the survey area. Within the radargrams the large anomaly is composed of a series of hyperbolas and valleys. At 1.5 m along the 5 m transect is a valley immediately followed by a hyperbola at about 2 m.

Figure 41. 100-113cm time slice at 335 East Burd Street. Linear feature within Anomaly 7 marked in red. Anomaly 6 labeled in yellow.
Another almost identical valley follows the hyperbola at 2.25 m (Figure 39). The anomaly resembles that of Anomaly 4 and 5.

Figure 42. 25-37 cm time slice at 335 East Burd Street with Warfel's 2012 trench map overlaid on top. Trench 7 seen just outside of grid as well as Trench 10 within the grid. Trench 8, seen to the west was not included due to its lack of anomalies. Location approximate.

Both anomalies 4 and 5 have been interpreted as pipelines connecting the modern houses to either the modern sewer system or to an older system of privies and outbuildings. The location of the pipes was uncovered in the 2012 excavations within trenches 7 and 10 (Figure 42 and 43) (Warfel 2012). The 0.61 m x 9.22 m trench 7 was located just outside of the survey grid, sharing the northern border of the survey area (Figure 42). The trench was 1.22 m wider than the survey area. Excavation of trench 7 uncovered a cast iron pipe about 4 m from the west end of the trench and a clay pipe on the easternmost end of the trench. Both findings correspond almost exactly with the location of anomalies 4 and 5 in Figure 39 (Warfel 2012).

Trench 10, located at the crook of the y-shaped pathway (Figure 42) was 0.61m wide and 5.385m long. The trench intercepted where Anomaly 4 should have been in the time slices. A dark linear stain running southwest to northeast in the area of Anomaly 4
was revealed by excavation revealing the location of the cast iron pipe. This is the same pipe that was uncovered in Trench 7 (Figure 43). As seen in Figure 43, a cement wash line anchor and a circular stain were found as well (Warfel 2012). Unfortunately, neither the palisade nor any fort-related structures were found in either trench.

Figure 43. Partially excavated Trench 7 facing grid west (left) and Trench 10 facing grid north (right). The cast iron pipe is visible in the eastern most excavated portion of trench 7. The linear stain in Trench 10 directly south of the cement anchor indicates the location of the same cast iron pipe as in Trench 10. Images courtesy of Warfel, 2012.

Anomalies 6 and 7 were not included within the 2012 excavations in either trench 7 or 10. Therefore no ground truthing was done within the area in question. Anomaly 6 is likely the location of an old privy similar to the one found at 329. Personal communication in 2012 with Warfel allowed the author to come to the conclusion about the interpretation of Anomaly 6. Warfel noted that the depression in the ground was where the privy once stood and that was why the horizontal portion of the sidewalk abruptly ends at that location (Warfel, personal communication 2012).
Based upon the size and shape of the linear area within Anomaly 7 and its proximity and alignment to Anomaly 6, the linear feature is likely some sort of pipeline from the old privy to the current house or another former outbuilding. The high reflective areas around the linear portion are likely the result of the construction of the pipeline where the ground was disturbed. However, without further investigation in the area, the anomaly's identity remains unknown. No other excavations were conducted outside of 329 and 335 East Burd Street in 2012. Figure 44 below depicts a summer of the location of each excavation in 2012 and how they correspond to the two GPR surveys conducted in the area. Also depicted are the 2008 and 2009 excavations.

Figure 44. Image of 2008 – 2012 excavations on Burd Street. No written information exists concerning the 2010 excavation which was not excavated by Warfel and his crew. Image courtesy of Warfel 2012.
Within the magnetic susceptibility data in Mag Grid 2, there did not seem to be any real areas of interest upon first glance (Figure 45). When the data is compared to the GPR survey in the area, an interesting anomaly appears. In both the GPR and magnetic susceptibility data there is a sort of "void" visible as a lack of any significant readings that forms an angle (Figure 46). When this area is compared with the magnetic susceptibility data, a similar shape can be loosely interpreted. The most visible aspect of this right angle appears from the corner of the grid at point (0x, 0y) in a northeast direction to about (5x, 15y) (Figure 46).
Two high readings are apparent at (2x, 6y) and (5x, 4y). The anomaly at (2x, 6y) roughly corresponds to an area of high reflective readings in the GPR data (Figure 46) at the same location. It is likely that this and the anomaly beside it have something to do with the linear anomaly it is part of. These could be areas where some object once stood or may be nothing more than rocks or a different type of soil in the area.

Locating any possible clear linear anomalies in the time slice data collected in GPR Grid 3 was somewhat difficult. However, as was shown in the magnetic susceptibility data, two linear features form a visible angle in the GPR data. The upper portion has been labeled Anomaly 8 and the lower portion Anomaly 9 (Figure 47). In the 0 – 12 cm time slice, Anomalies 8 and 9 are composed of a mix of high and low reflective readings. The majority of the lower reflective readings are found within the two linear anomalies. As the time slices go deeper, Anomalies 8 and 9 change in composition.
At 25 – 38 cm beneath the surface, Anomaly 8 composed of mostly groupings of high reflective readings forming a linear feature. At 101- 113 cm (about one meter beneath the surface) Anomaly 9 appears as a “void” of low reflective readings where the higher readings once were (Figure 47). The 101 – 113 cm time slice was chosen for analysis because this is the approximate depth of the historic land surface at 333 East Burd Street during the 2009 excavations (Warfel 2010).

Anomaly 9 seems to be the opposite of what is seen in Anomaly 8. At 0-12 cm beneath the surface Anomaly 9 is similar to Anomaly 8 but with higher readings along the southern border of the survey grid. At 25-38 cm, the high reflective readings along
the southern border become clear. Overlap of the Anomalies 8 and 9 is visible at (3.75x, 9y) as a large highly reflective area (Figure 48). Whether this high reflective area belongs solely to Anomaly 8 or 9 is unknown. At the depth of 101 – 113 cm Anomaly 9 is visible as almost completely high reflective readings, the largest along the western border of the survey grid between (0x, 6y) and (1x, 2y) (Figure 48). A clear void is seen in the data where the two anomalies cross at (3x, 9y) where the high readings in the 25 – 38 cm were.

Figure 48. Overlap and high reading areas within Anomalies 8 and 9 in GPR Grid 3.

In the radargrams, especially in the x=3.5m transect in the south to north direction, the linear feature is very similar to the angle in the 329 data (Figure 49). Distinct point source anomalies begin and end the anomalies with “voids” of low reflective anomalies and a center of high reflective hyperbolas.
Figure 49. Radargram of the x = 3.5m transect in south to north direction in GPR Grid 3 (top) and y = 2.25m in GPR Grid 1 (bottom). Anomalies 7 and 8 outlined in black (top) and Anomaly 3 (bottom).

The angular anomaly roughly corresponds to the location of a pathway to the east of the survey grid. The path borders a parking lot for the house at 324. Anomaly 8, the upper portion, aligns on a northwest to southeast angle approximately with the shed to the north of the grid and the path to the east. Because of its alignment with both these aspects, the anomaly has been interpreted as a possible path from the shed to the main path (Figure 50).
Anomaly 9, the lower portion, does not have as clear of a purpose as it does not line up well with the established sidewalk. Only a property boundary to the west lies at the same angle as Anomaly 9 on the modern surface. In a Sanborn Fire Insurance Map from 1921, a stable is depicted in the backyard of the lot at 322 East Burd Street. The approximate location of this stable aligns roughly with the location of GPR Grid 3 and Anomaly 9 (Figure 50 and 51). The stable does not exist today on the modern surface.
Figure 51. Portion of 1921 Sanborn Fire Insurance map of East Burd Street. Pictured is the location of the old stable with GPR Grid 3 and the projected path of Anomaly 9.

It is possible that Anomaly 9 may have been a path from the stable to the house at 324 or 326 East Burd. Perhaps the stable was shared by those living at 322 and 324 in or around 1921 and a path was needed between the houses. If Anomaly 9 was in fact a path from GPR Grid 3 to the stable, it would account for why the anomaly is seen deeper beneath the surface. The historic land surface may have been covered by modern construction fill as is seen at 333 East Burd Street (Warfel 2008, 2010, 2012). The survey at 324 East Burd Street was not included in the 2012 excavation and therefore findings within the survey area have not been verified and the identity of the anomaly may remain unknown.
322 East Burd Street Grid 1

Figure 52. Magnetic Susceptibility map for 322 East Burd Street. Vertical anomaly at 5m along x-axis corresponds to a possible old pathway.

Collection and interpretation of the magnetic susceptibility survey in Mag Grid 3 was simpler than the previous two. The survey revealed a single linear anomaly at the five meter mark on the x-axis. Communications with the property owner revealed that at one point there was a walkway from the house to the north of the survey area to the back of the yard. Neither owner could remember exactly where the path was however. Because of the location and composition of the anomaly, it is likely that the linear anomaly is the same as Anomaly 10 in the GPR data (Figure 54). The initial placement and then later removal of a cement pathway would disrupt the topsoil in the area. The resulting damage would lead to the higher readings collected by the magnetic susceptibility device because of the new mixture of soils where the path once was (Figure 52).
Figure 53. Comparison of Magnetic Susceptibility Grid 3 and GPR Grid 5 depicting the old pathway in the same location.

The survey at 322 East Burd Street Grid 1 (GPR Grid 3) included a large evergreen tree at (0x, 12y) that caused subsurface disturbance in the immediate area because of the numerous roots of the large tree. A playground to the east of the grid and a large willow tree to the south may also be the cause of some of the subsurface noise due to their vicinity to the survey area.

The GPR survey in this grid yielded two large, linear anomalies labeled 10 and 11 (Figure 54). Anomaly 10 is a two-pronged anomaly that is not completely straight. The anomaly is almost exclusively visible at 51-63 cm in the time slices. Both aspects of the anomaly start at the northern border of the survey and fork at 19 m on the y-axis. The anomaly is about two meters wide at its widest, tapering to about one meter at the southern end (Figure 54). When viewed in the radargrams, the anomaly has a dual nature (Figure 55). The western aspect of the anomaly appears as a strong reflective area with a clear hyperbola near the center. The eastern aspect does not have as strong of a signature
although it does contain a gently sloping hyperbola as well. The shape of the main hyperbola in the eastern portion of the anomaly is due to the angle at which the antenna passed over the anomaly.

![Figure 54](image)

**Figure 54.** 51-63 cm time slice at 322 East Burd Street Grid 1. Anomalies 9 and 10 marked at right.

Anomaly 11, the straight anomaly, can be seen throughout all the time slices but most prominently in the 25-38 cm time slice. The anomaly is about 2 m wide at 5-7 m on the x-axis and is 20 m long. At deeper depths in the time slices, the anomaly only appears as a column of low reflective readings. The 15.25 m radargram Figure 55 shows the complexity of the anomaly. The radargram confirms that the anomaly is two meters wide with a triangular hyperbola at the center, not rounded like in Anomaly 10. Areas of high reflectivity surround the center of the anomaly.
Anomalies 10 and 11 are anomalies that are difficult to interpret. At least one portion of Anomaly 10, the western portion, is a pipe running from the house to the north through the back yard to the south. The signature of the pipe is very similar to those found in the 335 survey (Figure 54). The hyperbola found in the center of the anomaly is surrounded by high reflective readings with a void above it; common in pipeline signatures as a trench would have had to been dug to accommodate the pipe. Why there are two pipes beside each other is another question. It may be that the two pipes serve two different purposes for the main house. The western pipe extends directly from the house into the backyard, likely as an outlet for sewage or water to or away from the house. The pipe seems to flow almost directly into Anomaly 14 of GPR Grid 5. The western portion of Anomaly 10 may have fed water into Anomaly 14 as well. Anomaly 14 represents the former location of a pool that will be discussed in the next section. The eastern pipe seems to connect the house to the garage to the east, likely as a source of water for activities dealing with the garage (Figure 56).
Figure 56. Image of 322 Grid 1 and 2 and 324. Area in blue depicts the projected western pipe trench of Anomaly 10. The purple line follows Anomaly 11, the old pathway.

Anomaly 11 is likely the old sidewalk that the landowners mentioned was in the back yard. When both GPR Grid 4 and 5 at 322 East Burd Street are overlaid on the surface, the location of Anomaly 11 corresponds almost directly with a cement pathway still visible on the surface outside of the survey area. In Figure 56, the approximate line from the modern pathway through Anomaly 11 is outlined and shows that the anomaly aligns with the modern pathway as well as a linear anomaly found in GPR Grid 5. No evidence of the palisade or incorporated structures was found in the data.

322 East Burd Street Grid 2

The survey of GPR Grid 5 was the last area to be surveyed. Due to the time between the survey and further excavations in other areas as well as instrument availability, no magnetic susceptibility survey was conducted at this site. The location of 322 Grid 2 was chosen in order to fully investigate as much of the yard as possible. The survey of a larger grid was not possible due to a line of small trees along the southern
edge of the grid as well as a garden to the west and a property fence to the east. A large willow tree to the north of the grid between GPR Grid 4 and 5 impeded survey between the two grids. Discussion with the landowner (2012) informed the author that at one time there was an old concrete pool at the south end of the property as well as a path that led to it. Also, a large tree was uprooted during a past storm near the back of the yard (Figure 57). The tree’s location can be seen in Figure 57.

Survey of GPR Grid 5 revealed three large anomalies for study. Anomaly 12 is a very large circular anomaly almost 7.5m wide and almost 9.5m long (Figure 58). The anomaly is composed of both high and low reflective readings in the time slices with a cluster of high readings at the center. The anomaly is visible in all the time slices to some degree. The resulting radargrams depict the anomaly as a mass of hyperbolas and general subsurface disruption for almost half of the length of each transect it appears in. This
anomaly is almost certainly the collapsed tree the landowners spoke of. Upon further discussion, the owners verified that the area in question was approximately the location of the tree.

Figure 58. 322 East Burd time slices at 0-12 cm and 25-38 cm. Anomalies 10-12 outlined.

The second, Anomaly 13, is the same linear feature found in GPR Grid 4. An indentation in the modern surface revealed that something was once sitting on top of the surface in this location. Anomaly 13 is about two meters wide between 8.5 and 10.5 m along the x-axis and extends the entire length of the survey grid (Figure 58). In GPR Grid 5, the old pathway also has a probable branch to the west leading somewhere else in the yard. Minor traces of this branch can be seen on the modern surface where stepping stones may have been. Stepping stones may have been what created the circular high reflective areas between 0 and 9 m on the x-axis of the time slices. An area of interest
within the old pathway occurs at (8.5x, 8.75y) in the time slices and at 8.5 m along the 8.5 m transect in the radagrams.

![Radargram Images]

Figure 59. 8.5 m and 12 m radargrams at 322 East Burd Grid 1. Transects run south to north. Anomalies 13 and 14 noted. Possible location of the old path marked as well.

The last anomaly of interest, Anomaly 14, is an almost perfect square of 3x3m. Anomaly 14 is located in the eastern portion of the survey grid and appears as a dense highly reflective area. Anomaly 14 is so dense that its shape can be seen on the surface as well as in each time slice. Within the radargrams this feature creates distinct bands of reflective energy due to the densely packed earth beneath the surface. It is likely whatever was in this area was very heavy and rather big to make an impact like that shown.

Anomaly 14 is the location of the old pool. One of the landowners stated that the pool was not that large and that she remembered playing in it when she was a child. She recalled it being cement or concrete, not the typical construction or size of a pool today (Personal Communication 2012). The old path leads directly from the house to the site of
the former pool (Figure 60). Because there is no pool on the modern surface, the pathway was likely removed as it would serve no purpose and lead to no features on the surface.

There was no indication that the fort stood at this location. No excavation could be conducted in GPR Grid 4 and 5, so the above statements are all speculation and cannot be definitively proven.

Figure 60. Locations of Anomalies 12-14. Anomaly 13, the old path, appears to lead to the old pool.

In Summary

GPR and magnetic susceptibility surveys within the five grids revealed many modern features beneath the surface. Features such as pools, pipelines and pathways littered the survey areas likely destroying any remains of the fort if the Memorandum overlay is correctly placed on the surface. Two anomalies however, Anomaly 3 in the 329 survey and the angular anomaly composed of Anomalies 8 and 9 at 324, merit more investigation as they may represent former structures.
CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

Summary of Research

The goal of this thesis research was to locate portions of the palisade or inner structures of Fort Morris in Shippensburg, Pennsylvania. Fort Morris, a French and Indian War fortification, was the product of heightened concern of Indian attacks in the Shippensburg area. Two previous excavation projects took place at the proposed location of Fort Morris based on extensive research of sparse and differing historic sources. Documented descriptions of the size and orientation of the fort were questionable at best and had to be viewed with caution going into any excavation projects.

Only two surviving sources were found indicating the possible size of the fort: Forbes’ Memorandum and the “Plan at Shippensburgh”, a schematic of the fort. The plan, while helpful, did not depict the fort on the landscape and therefore could not fully aid in the location of Fort Morris. The two sources differ in the size of the fort with the Memorandum’s dimensions being smaller than the plan’s. The Burd Street location was chosen for excavation based on its proximity to the old town, its depth to the water table and to the most likely source of wood for the fort’s construction. Based on the above factors, Warfel and his crew conducted two excavation projects in 2008 and 2009 in an attempt to locate Fort Morris.

The 2008 and 2009 excavations were focused on the 333 East Burd Street property, believed to be the central location of the fort although smaller excavations at 327 and 335 were conducted as well in order to locate the palisade. As a result of the excavations, thousands of artifacts pertaining to Fort Morris as well as the remains of at
least three structures likely to have been within the fort were found. However, the palisade was never located (Warfel 2008, 2010). Three years later in 2012 a new excavation was undertaken to attempt once more to find the Fort Morris’ palisade.

As no geophysical surveys had been conducted at the proposed location of Fort Morris, it was the goal of the author to employ geophysical surveys at properties surrounding prior investigations to help guide excavations during the 2012 project. Magnetic susceptibility and GPR were the chosen instruments to conduct the geophysical surveys. Surveys at 329, 335, 322 and 324 East Burd Street were conducted in April through May in accordance to landowner permissions. No excavations were undertaken by the author as Warfel’s 2012 excavations were conducted with the two survey areas where permission to dig was given. Warfel’s report was used in conjunction with the author’s data as the ground truthing portion of the thesis project.

The geophysical surveys uncovered interesting anomalies, many of which were modern in nature. These included pipelines, former pathways and an old pool. An post-fort period privy was excavated at 329 East Burd Street as well as the location of another possible privy at 335 East Burd that was not excavated. One unexcavated anomaly was of particular interest to the author. Anomaly 3, located at 329 East Burd, is a probable foundation or trench that forms a right angle along a modern cement pathway. It is recommended that the area be investigated through limited excavations in order to determine the nature of the GPR anomaly. Limited excavations at 324 East Burd Street would also be beneficial to rule out the right angle anomaly as a structure of some kind. It is likely the anomaly is only the remnants of old pathways, however excavations would give the full answer to its identity.
Research Questions Revisited

At the end of any project it is important to revisit the initial research questions posed in order to see if the project was successful in answering these questions. The author posed three research questions prior to the geophysical surveys. These questions are revisited below.

Question # 1: Can evidence of the palisade trench and other fort-related structures be found in the GPR and magnetic susceptibility data from the yards chosen for excavation?

The magnetic susceptibility and GPR surveys conducted at 329 and 335 uncovered a number of anomalies. The magnetic susceptibility survey at 335 did not yield any anomalies of interest other than the location of a cement pathway still visible on the modern surface. The GPR survey at 335 located four anomalies for further investigation: Anomalies 4, 5, 6 and 7. In the 2012 excavations, two excavation trenches 7 and 10 were dug and revealed two pipelines, Anomalies 4 and 5. The third anomaly, Anomaly 6, was interpreted as an old privy due to its location and the visible depression on the modern surface. Anomaly 6 was not excavated. Anomaly 7, the large rectangular area of high reflective readings was not excavated either. Based upon comparison to the pipeline anomalies in 335 and to the pipes extending from the privy at 329, it was interpreted that much of the disturbance within Anomaly 7 was due construction of similar pipelines coming from Anomaly 6. No portions of the fort were found at 335, indicating that this location was either an empty area within the fort or outside of the fort altogether.
The GPR survey at 329 East Burd Street uncovered two anomalies of interest. Excluding the location of a cement pathway on the surface, a circular anomaly (Anomaly 2) and a linear anomaly forming a right angle (Anomaly 3) were located within the time slices and radargrams. An old dry-laid limestone privy was located in the eastern portion of the survey area corresponding to the location of the circular anomaly in the data. Further excavation of this anomaly during the 2012 project dated the privy to the post-fort period. Anomaly 3, the angular anomaly, remains unexcavated and thus its identity is unknown. The size and shape of the anomaly roughly resembles a portion of an unnamed inner building or even a portion of the palisade itself. However, until this area is excavated the identity of the anomaly is mere speculation.

Based upon the historical privy structures found and the unknown identity of Anomaly 3, it is likely that the backyards at 329, 333 and 335 East Burd Street may fall within Fort Morris and the palisade may not have been far away. Whether or not a portion of the palisade can be found in this area due to the house construction and lack of open space is the question. There are some open areas within 329, 327 and even 337 that could be investigated if landowner permission was granted. At this time, the answer to this research question is maybe. It is possible that an old structure may be found at 329 however more excavation is necessary.

**Question # 2: Is there evidence of Fort Morris outside of the planned excavation area?**

Geophysical investigations at both 322 and 324 East Burd Street resulted in data full of modern features and anomalies. Four anomalies were located between the two grids at the 322 East Burd Street location. Based on communication with the landowners
and review of the data, Anomalies 10, 11, 12, 13 and 14 were located and identified. The above anomalies include an old pathway, old cement or concrete pool, a pipeline and the location of a fallen tree. No excavations could be done at 322 but it appears from the data that none would be needed as there were no other interesting anomalies located.

Data collected at 324 East Burd Street yielded two anomalies that were combined to form one larger anomaly. The anomaly was in the form of a right angle. Upon further interpretation, it is likely that the anomaly depicts where two former pathways connect to create the angular anomaly. The northern portion likely connected a shed to a pathway to the east of the survey. The southern portion’s identity is unknown as its angle does not align with the eastern path and seems to lead nowhere in particular. Further investigation by excavation would help to identify the source of the anomaly although it is unlikely this or any other anomalies at 322 or 324 have any relation to Fort Morris.

**Question # 3:** *With the clear presence of residential construction, will it be possible to find any historical features beneath the surface? What modern features may be masking or have destroyed fort-related features?*

Despite the disrupted nature of the yards on East Burd Street, GPR and magnetic susceptibility surveys may have located at least one fort-related anomaly at 329 East Burd Street. The construction of a deck and a privy at this location does not appear to have affected the anomaly. This is fortunate because if there had been any other remnants of the fort beneath the surface, they are all but gone now.

Pipe trenches are what may have caused the most damage in the survey areas. Creation of the pipe trenches left large disruptions beneath the surface and because of the number of houses in the Burd Street area, many such pipes were found. The signatures of
the pipes themselves are often very strong and could mask subtle fort features in their vicinity.

Recommendations for Future Research

The data collected on East Burd Street in the unexcavated areas has led the author to consider further research in the future if funding becomes available. The first avenue of research would be to conduct a small-scale excavation in the location of the right angle in the 329 survey grid. A test unit of at least 1m x 1m should be investigated intersecting the corner of the anomaly to uncover the nature of the “corner.” A 1m x 1m test unit should be wide enough to accommodate the width of the corner given the dimensions of the anomaly in the time slices and radargrams. The corner may be the location of two construction trenches or walls meeting and therefore it is important to investigate this location. If it is determined that the anomaly is in fact a corner, the test unit can be expanded to follow the anomaly to its widest extent.

A second recommendation would be to excavate at the location of the right angle at 324 East Burd Street. As of now the landowner has not given permission to excavate this area, but it may be likely that, if gently persuaded with compelling evidence, the landowner may change his or her mind and allow excavations to take place. If permission is given, short trenches could be dug perpendicular to each arm of the “path.”

A third recommendation would be to survey each grid using another geophysical method such as magnetometry or resistivity. Magnetometry was not used on Burd Street due to the large number of electrical lines and metal structures surrounding each yard. However, in the hands of an experienced operator a magnetometer survey may be able to be utilized at each location and may yield new anomalies or verify the shape and location.
of known anomalies. The author was not familiar with resistivity surveys and did not opt to use this particular method.

Finally, an in-depth investigation of the artifacts found during the 2008, 2009 and 2012 excavations could shed more light onto the history of Fort Morris. A study centered on the artifacts may tell what activities were going on at various areas of the site and determine whether or not the features found were truly fort-related or just various other past structures on the site.
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APPENDIX: MALA GPR Time Slice Images of East Burd Street

329 East Burd Street: GPR Grid 1
335 East Burd Street: GPR Grid 2
324 East Burd Street: GPR Grid 3
322 East Burd Street: GPR Grid 4
322 East Burd Street: GPR Grid 5