GEOPHYSICAL INVESTIGATIONS AT THE DORSET PALAEOESKIMO SITE OF PHILLIP'S GARDEN, PORT AU CHOIX, NORTHWESTERN NEWFOUNDLAND

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by

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ABSTRACT

This thesis presents geophysical investigations at Phillip's Garden, a large Palaeoeskimo site located near Port au Choix, northwestern Newfoundland. Previous geophysical investigations at the site have focused on large scale magnetometry surveys, aimed at identifying possible buried dwellings at the site. This research expands on this by using two complimentary geophysical methods, magnetometry and ground penetrating radar, and focusing on small scale surveying aimed at identifying features within dwellings. The purposes of this research are testing the efficacy of magnetometry and ground penetrating radar in identifying features within dwellings, testing whether there is a difference between surveying excavated versus unexcavated dwellings, and assessing the best surveying increments for geophysically surveying dwellings at Phillip's Garden. The results of this research suggest that magnetometry and ground penetrating radar are useful in identifying features associated with dwellings at Phillip's Garden, particularly in unexcavated dwellings using a smaller increment between survey transects.

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CHAPTER 1

Introduction

1.1 Introduction to Research

This thesis presents the results of several geophysical surveys undertaken during two field seasons at the Dorset Palaeoeskimo site of Phillip's Garden, Port au Choix, northwestern Newfoundland (Figure 1.1).

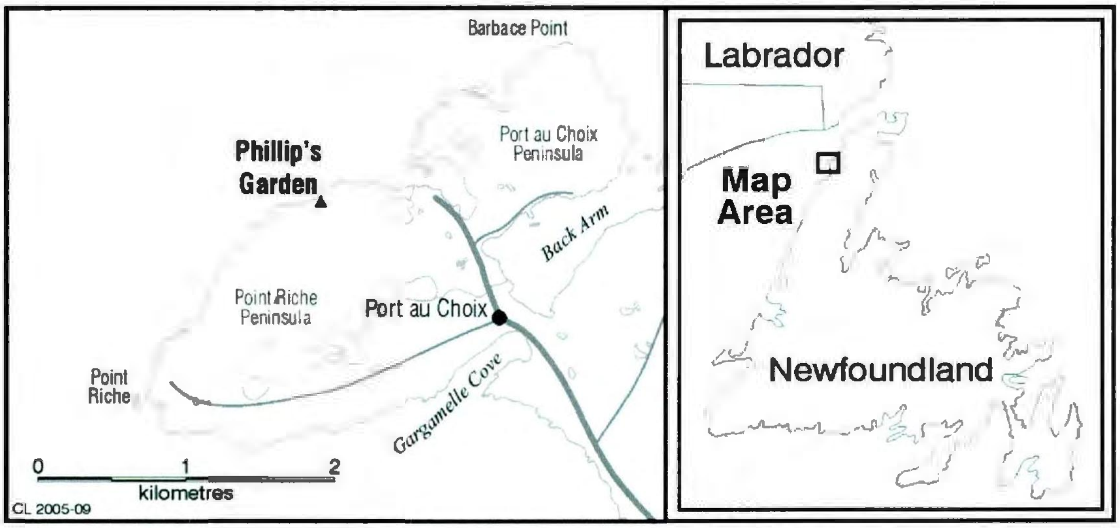

Figure 1.1: Port au Choix is located on the Point Riche Peninsula, on the Northern Peninsula of western Newfoundland (Image courtesy of PAC Project).

The surveys included using magnetometry and ground penetrating radar (GPR) to survey one excavated and one unexcavated dwelling at Phillip's Garden.

The site was previously excavated by Harp (1964) and by the Port au Choix Archaeology Project under the supervision of Renouf since 1985 (1985, 1986, 1987, 1991, 1992, 1993, 2002, 2003, 2009; Hodgetts 2001; Renouf et al. 2005; Cogswell et al. 2006; Wells at al. 2012; Renouf et al. 2013). Phillip's Garden is the largest and most intensively occupied Dorset site in Newfoundland, at approximately 2 hectares and with the remains of close to 150 identified dwellings (Renouf 2011a; Renouf et al. 2012; Renouf and Murray 1999). Most of these have been identified based on their visibility on the landscape and some through test-pitting, excavation, and geophysical surveying (such as magnetometry and real time kinematic surveying).

This research builds on previous geophysical explorations at the site carried out in 2001 by Eastaugh and Taylor (2011), who conducted a magnetometry survey at the site to identify buried structures which would otherwise be invisible on the surface. Eastaugh's and Taylor's (2011) survey comprised a 2,600 m^2 grid in the southwest corner of Phillip's Garden where they identified several anomalies which they interpreted as buried dwelling depressions based on comparisons with previous excavation data (Figure 1.2).

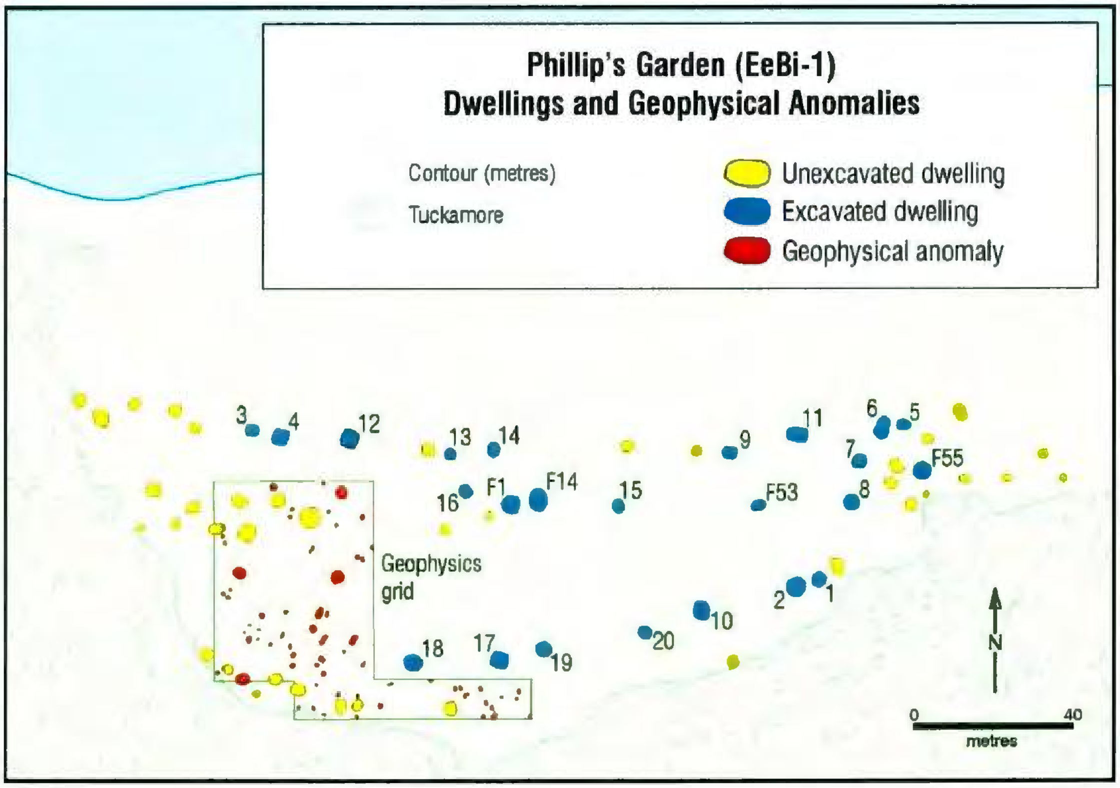

Figure 1.2: The Dorset Palaeoeskimo site of Phillip's Garden, plan view map displaying excavated dwellings (blue), identified unexcavated dwellings (yellow), and geophysical anomalies (red), the larger of which are associated with dwellings (Image courtesy of PAC Project).

1.2 Research Objectives

Eastaugh and Taylor (2011) demonstrated the successful application of magnetometry surveying at Phillip's Garden. Building on their research through this research I consider the feasibility and success of magnetometry surveying at a higher resolution at Phillip's Garden. Additionally, I also test the application of ground penetrating radar (GPR) data collection at the same scale as magnetometry at Phillip's Garden. In reaching this objective, several questions are considered: 1) can features within dwellings be identified through small scale magnetometry and GPR surveying at Phillip's Garden?, 2) is there a difference between geophysically surveying excavated versus unexcavated dwellings?, and 3) what effect does data collection surveying interval have on feature visibility in GPR data? These questions are discussed further below.

Can features within dwellings be identified through small scale magnetometry and GPR surveying at Phillip's Garden?

As mentioned above, Eastaugh and Taylor (2011) conducted a successful magnetometry survey at Phillip's Garden. Eastaugh (2002) also conducted a magnetometry and a resistivity survey at Point Riche, another large Dorset Palaeoeskimo site near Phillip's Garden. While his magnetometry survey was successful, his resistivity survey was not conclusive. As an extension of this, for my research I further test the applications of magnetometry surveying at Phillip's Garden. Additionally, I test whether another geophysical method, ground penetrating radar, would work at the site.

Eastaugh and Taylor's (2011) magnetometry survey at Phillip's Garden covered a large area (a composite composed of five 20 m by 20 m grids and three 20 m by 10 m grids) with a 1 m interval between survey transects. This was designed to be an efficient and fast method of identifying subsurface anomalies which may correspond with dwelling depressions. Since Eastaugh and Taylor (2011) proved that through a large scale magnetometry survey subsurface dwelling depressions can be identified at Phillip's Garden, the purpose of my research is to test whether features *within* dwellings can be identified through small scale magnetometry and GPR surveying at Phillip's Garden. To achieve this, my research focuses on 20 m by 20 m grids with a 10 and 25 cm spacing between survey transects.

One previously excavated dwelling and one unexcavated feature were surveyed. One dwelling, previously excavated by both Harp (1964) and Renouf (2005) was also excavated (Wells et al. 2012) to ground truth the geophysical survey results.

Is there a difference between surveying excavated versus unexcavated dwellings?

In order to establish the success of small scale magnetometry and GPR surveying at Phillip's Garden both excavated and unexcavated features were tested. The purpose ofthis is to ascertain whether these surveying methods would be more successful when applied to previously excavated features or unexcavated features – or if it makes no difference.

What effect does surveying interval have on feature visibility in GPR data?

Eastaugh and Taylor's (2011) magnetometry survey had a spacing of 1 m between survey transects, which was efficient in identifying subsurface anomalies corresponding with dwelling depressions. This set up, however, could not be used to identify smaller features within the dwellings since by taking a survey line every meter; any feature smaller than 1 meter would be completely missed. To remedy this, I reduced the spacing between survey transects, which not only increased the resolution of the results but also the time it took to conducted the survey.

Thesis Organization

This thesis is organized into six chapters. Chapter 2 provides a geographical, geological, and cultural background for the current research focusing on the Port au Choix area, the Dorset Palaeoeskimos and their occupation of Phillip's Garden. Chapter 3 presents the research methodology. Chapters 4 and 5 present the research results as well as their interpretation. This is followed by a discussion in Chapter 6 where the research objectives are addressed in terms of the results and conclusions are presented.

CHAPTER 2

Dorset Palaeoeskimo Occupation at Phillip's Garden

2.1 Introduction

This chapter presents the cultural context of the undertaken research. A brief characterization of the Dorset Palaeoeskimos in Newfoundland and Labrador is provided. This is followed by an overview of the Dorset Palaeoeskimo occupation at Phillip's Garden, Port au Choix. This description focuses primarily on the Dorset Palaeoeskimo dwellings at Phillip's Garden.

2.2 The Dorset Palaeoeskimos in Newfoundland and Labrador

Dorset Palaeoeskimos were semi-nomadic Arctic-adapted hunters whose occupation spanned the Canadian Arctic (Maxwell 1985; McGhee 2001), Greenland (Andreasen 2000; Grønnow and Sørrensen 2006), the Quebec Lower North Shore (Fitzhugh 1972; Pintal 1998), Labrador (Cox 1978; Fitzhugh 1972; Tuck 1975), Newfoundland (Harp 1964; Renouf 2011a), and St. Pierre et Miquelon (Leblanc 2008). Dorset subsistence was primary based on hunting seals; however, depending on geographic location other animals were also exploited (such as caribou, fish, birds, and walrus) (Maxwell 1985).

The Dorset Palaeoeskimo culture was first identified by Jenness in 1925 at Cape Dorset, in the south east corner of Baffin Island. Jenness (1925) identified a new culture in the collection retrieved from Cape Dorset, characterized by small well-defined chipped stone tools (chert, quartz, quartzite) and gouged (as opposed to drilled) holes on tools.

Jenness (1925) named this the Cape Dorset culture, which became defined by holes made by scratching and gouging (Maxwell 1985).

Based on changing material culture characteristics, specifically harpoon heads (Maxwell 1985), the Dorset cultural span is divided into three periods: Early Dorset, lasting between 2500 and 2000 BP (uncalibrated years before present); Middle Dorset, lasting between 2000 and 1200 BP; and Late Dorset, lasting between 1000 and 500 BP (Fitzhugh 2001; Linnamae 1975). Although Early, Middle, and Late Dorset sites have been identified in Labrador, only Middle Dorset sites occur in Newfoundland (Renouf and Murray 1999; Renouf 2003). The Dorset Palaeoeskimos occupied seasonal and semi-permanent coastal sites in Newfoundland from 2000 to 1200 cal BP (Renouf et al. 1999).

Dorset dwellings in Newfoundland tend to be larger than in Labrador, ranging between 15 and 121.5 m^2 (Renouf 2011b:143; Wells et al. 2012:7). They are oval or rectangular and mostly subterranean. The dwellings are constructed out of stacked beach stones or gravel or soil berms and perimeter post holes. The interior is either paved or cleared and has an axial feature made out of cobble and slab pavement (Renouf 2003). Axial features are characteristic of Palaeoeskimo dwellings. They were areas used for cooking and they are characterized by well-defined areas outlined by upright stone slabs, cobble pavement, and a line of pits (Renouf et al. 2005).The dwellings have side and/or rear platforms and some have entrance passages (Renouf 2003). The largest Dorset dwellings in Newfoundland are at Phillip's Garden, where their footprint ranges between 28.3 and 121.5 m^2 (Renouf 2011b; Wells et al. 2012).

2.3 Phillip's Garden

The most extensive and richest Dorset Palaeoeskimo settlement in Newfoundland is located at Phillip's Garden, Port au Choix, on the Northern Peninsula (Eastaugh and Taylor 2011; Renouf 2003, 2006, 2011a; Renouf and Bell 2008; Renouf and Murray 1999) (Figure 2.1).

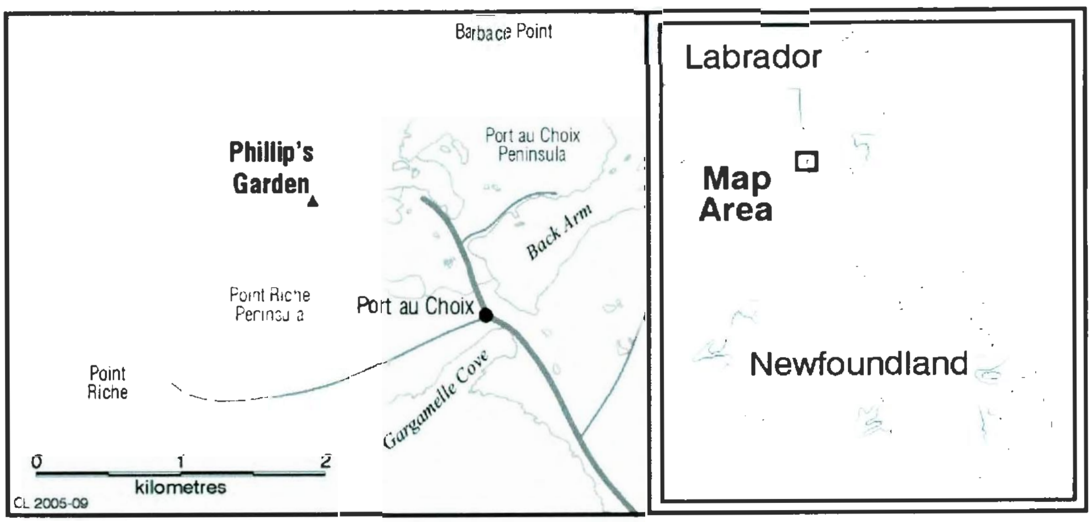

Figure 2.1: Map of Phillip's Garden which is located on the north edge of the Point Riche Peninsula, approximately 2 km from the community of Port au Choix on the Northern Peninsula, western Newfoundland (Map courtesy of PAC Project).

The site is located approximately two kilometers from the community of Port au Choix on the north-west coast of Newfoundland. It is on the north shore of the Point Riche Peninsula which extends approximately one and half kilometers into the Gulf of St. Lawrence.

The area is characterized by physiography typical of the West Newfoundland Coastal Lowland: elevation is generally 50-70 meters above sea-level or below with subdued local relief; low, parallel forested ridges are separated by lakes and bogs, and the coast areas are dominated by coastal barrens devoid of trees (Damman 1983). This lowland physiography is created by the gently westerly inclined underlying Ordovician-age (490-440 million years ago) carbonate rocks (dolomite and limestone) deposited in shallow, tropical sea shelves (Knight 1991).

The landscape is characterized by the dissolving of the carbonate bedrock by physical and chemical weathering creating unusual surface and subsurface features such as rough and uneven terrain, caves, and disappearing streams. This type of landscape is commonly known as karst topography (USGS 2013). Physical and chemical weathering exploited zones of weakness in the bedrock creating tidal platforms and sea cliffs around the modern coast and inland as well as limestone caves. The coastal terraces provided both cliff-top sites (wide seascape views) and cliff-bottom sites (providing shelter) used by prehistoric inhabitants. The limestone caves were used by the Dorset Paleoeskimo as burial sites (Bell and Renouf 2011).

Phillip's Garden measures over 2 hectares and is located in a meadow surrounded on three sides by stunted spruce forest, locally called tuckamore (Figure 2.2). Three beach ridges are visible at the site, ranging from 6 to 11 m above sea level. These were created due to isostatic rebound.

Figure 2.2: Aerial photo looking east of Phillip's Garden which is located in a 2.17 ha meadow surrounded on three sides by tuckamore. Note the footpath dividing the beach and the meadow for scale (Photo courtesy of PAC Project).

After the last ice age, roughly 12,000 years ago, as the ice melted it released some of the weight and pressure it put on the earth, which started to rebound resulting in what is known as isostatic rebound. This occurred very slowly, taking several thousands of years and including the ancient occupation at Phillip's Garden. The isostatic rebound, along with ocean volume changes (from the melted ice) can be seen at Phillip's Garden as raised beach ridges on which the Dorset Palaeoeskimos built dwellings (Bell and Renouf 2011).

Shallow depressions, 3-4 m in diameter, associated with dwellings' central depression are visible on the upper two terraces (Figure 2.3) and within the forest. These can also be identified based on pockets of irises growing inside the depressions (Figure 2.4). Close to 150 possible dwellings have been identified at the site based on depressions (Renouf et al. 2013).

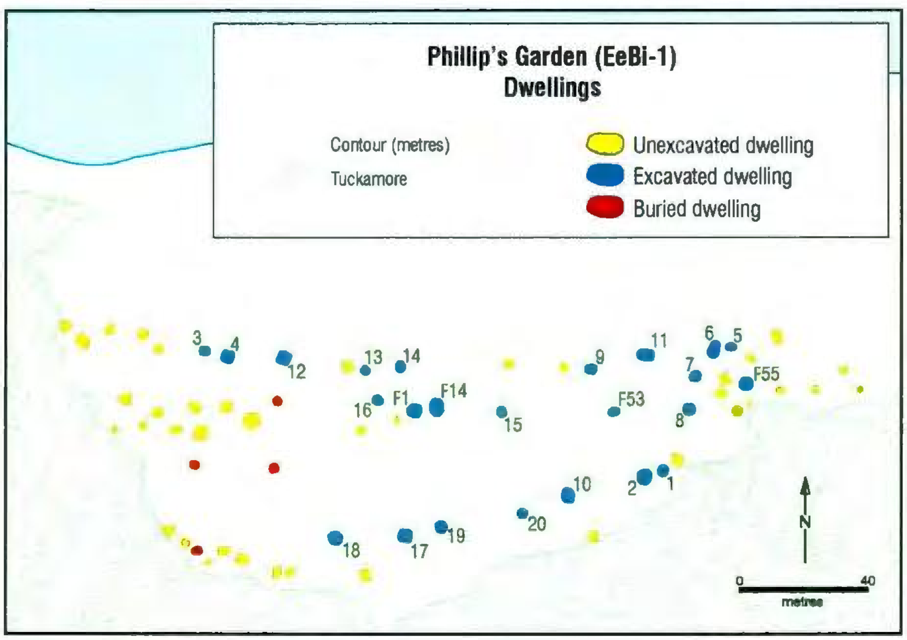

Figure.2.3: Map of Phillip's Garden: Two beach ridges, ranging between 6 and 11 m, are visible at the site. Sixty-eight dwellings had been identified at the site; however, in 2012 close to 160 possible dwellings were identified (Image courtesy of PAC Project).

Harp seals were the economic basis for the occupation of Phillip's Garden, which due to its geographic location was a very productive place for the seal hunt (Hodgetts et al. 2003). Harp seals have a bi-annual migration: mid-December and March-April (Renouf 2011b; Bell and Renouf 2011; Renouf and Bell 2008). During this time, seals would appear in great numbers a short distance from the shore, on the ice lead (Renouf 2011b). The Dorset Palaeoeskimos, who were marine specialists, occupied Phillip's Garden seasonally for hunting and processing harp seals (Renouf 2011b). Based on lithic tool assemblage Renouf (2011b) suggests that hide-working was as important as the hunt at Phillip's Garden. This would have included soaking the seal skins, depilating the hides, and tanning the skins which would have later been worked into boots (Renouf and Bell 2008).

Figure 2.4: Iris clumps associated with dwelling central depressions. Looking north, note the stunted spruce for scale (Image courtesy of PAC Project).

Phillip's Garden occupation spans over 800 years from 1990 to 1180 cal BP (Renouf 2011b). Based on 37 radiocarbon dates from 15 dwellings, Renouf and Bell (2009) divide the site into three arbitrary temporal phases: early (1990-1550 cal BP), middle (1550-1350 cal BP), and late (1350-1180 cal BP) (Figure 2.5). The phases are based on occupation derived from overlapping radiocarbon dates (Renouf and Bell 2009). This suggests an initial low to medium occupation, followed by an increase to maximum occupation, and a return to medium occupation prior to abandonment (Renouf and Bell 2009).

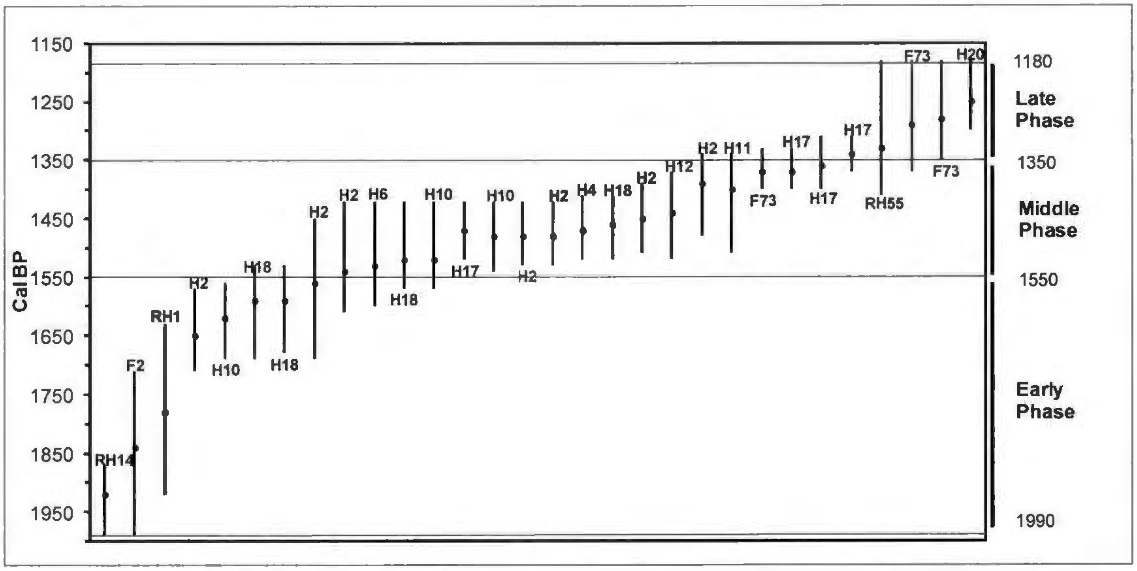

Figure 2.5: Renouf and Bell (2009) divide the occupation of Phillip's Garden into three temporal phases: early, middle, and late based on 37 radiocardbon dates (Image courtesy of PAC Project).

Phillip's Garden was initially investigated by Wintemberg (1939), who test-pitted the site and characterized it as a rich Cape Dorset archaeological deposit. Following Wintemberg, Phillip's Garden was extensively studied by Harp (1964, 1976), who excavated seven dwellings and tested 13 more. Beginning in 1984, the Port au Choix Archaeology Project under the direction of Renouf (1985, 1986, 1987, 1991, 1992, 1993, 2002, 2003, 2009; Hodgetts 2001; Renouf et al. 2005; Cogswell et al. 2006; Wells at al. 2012) excavated four dwellings and re-excavated four of Harp's previous excavated dwellings (Figure 2.6). Beginning in 2008, Renouf (2009) began excavating areas outside and between dwellings.

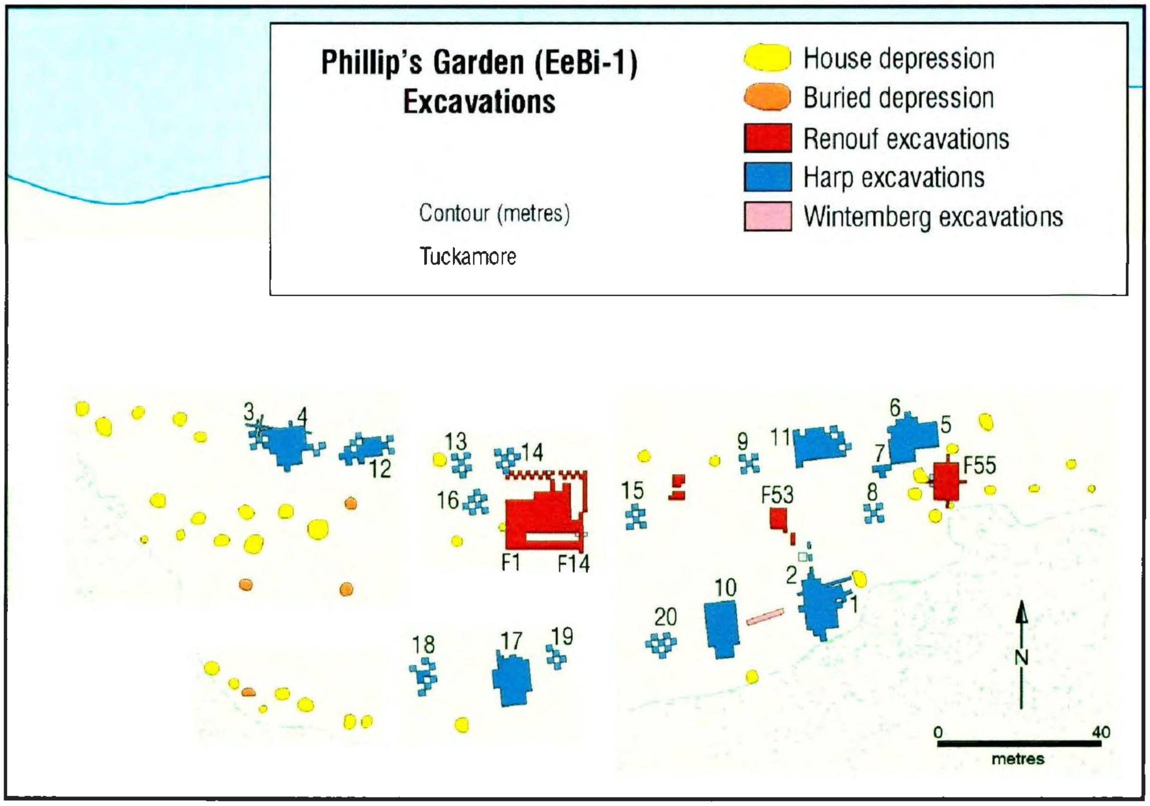

Figure 2.6: Excavation map of Phillip's Garden: Wintemberg initially test-pitted Phillip's Garden. Following him, Harp excavated and tested 20 dwellings. Renouf excavated four dwellings and re-excavated four of Harp's previous excavations (Image courtesy of the PAC Project).

Until the Port au Choix Archaeology project excavations, it was widely believed that Dorset dwellings in Newfoundland were small round skin tents or rectangular houses measuring at 15-20 m^2 (Linnamae 1975). However, Renouf discovered that some of the house structures at Phillip's Garden were significantly larger than previously thought, in the range of 90-121.5 m^2 (Renouf 2003, 2006, 2009; Wells et al. 2012).

2.4 Dorset Architecture and Space Use at Phillip's Garden

Most of the excavated dwellings at Phillip's Garden date to the middle phase occupation period (1550-1350 cal BP). All of the known middle phase houses were excavated by

Harp (1964). Renouf re-excavated House 2 (Renouf et al. 2005), House 18 (Cogswell et al. 2006), House 17 (Renouf 2007, 2009), and House 10 (Renouf et al. 2005; Wells et al. 2012). House 2, 17, and 18 will be discussed below. House 10 will be discussed in Chapter 4.

2.4.1 House 2

Harp (1976) characterized the dwellings at Phillip's Garden based on his excavation of House 2 (Figure 2.7), which he identified as a large winter dwelling (Renouf 2003, 2011b; Renouf et al. 2005). House 2 is located on the highest visible terrace at Phillip's Garden (Figure 2.6). According to Harp (1976), House 2 was a sub-rectangular dwelling with a square interior depression and a semi-circular rear sitting platform raised 25-31 cm above the dwelling floor (Renouf et al. 2005). The depression was constructed by clearing out limestone slabs from a central area and stacking them around it to form what Harp described as well-defined low walls, measuring 31-36 cm above floor level (Figure 2.7). A line of rocks and four stone-lined pits (31 cm deep) bisected the central depression (Figure 2.7). House 2 interior measured 38.8 m^2, the exterior measured 64 m^2, and the central depression measured 20.88 m^2 (Renouf and Murray 1999). Harp (1976) suggested that the dwelling would have been covered in animal skins supported by wooden poles.

Based on Harp's (1976) interpretation of House 2, all dwellings at Phillip's Garden were thought to be oval or rectangular structures enclosed by limestone slabs, measuring approximately 38 m^2.

Figure 2.7: Image of Harp's House 2 excavation: the dwelling consists of a central depression with 30-40 cm high walls and it is bisected by a line of pits and rocks (Image courtesy of PAC Project).

Re-excavations by the Port au Choix Archaeology Project showed that the features originally identified as walls by Harp (1976) were platforms and that the dwellings were significantly larger than previously thought, ranging from 75-105 m^2 (Renouf 2003, 2006, 2011b, Renouf and Murray 1999, Renouf and Bell 2005).

Figure 2.8: Renouf excavated an east-west and a north-south trench through House 2 (Image courtesy of PAC Project).

In 2004 Renouf re-excavated House 2. This consisted of an east-west trench (measuring 1.5 m by 15 m) extending beyond Harp's limestone walls and a north-south trench (measuring 2 m by 9 m) through the central area of the dwelling (Renouf et al. 2005:5) (Figure 2.8).

Renouf et al. (2005) found the walls originally identified by Harp (1976) extended 1.34 m east (interpreted as a wall or bench) and 4.19 m west (interpreted as a platform) from the central depression (Figure 2.9 and Figure 2.10). These were constructed out of 3-4 layers of stacked limestone slabs (Renouf et al. 2005:6). They also identified a platform at the rear of the dwelling; however, the north-south trench did not extend past it, so its full extent could not be measured.

Figure 2.9: House 2: image of the eastern slab of rocks, measuring 1.34 m east, which was interpreted by Renouf et al. (2005) as either a bench or wall. Note the north arrow and scale (Image courtesy of the PAC Project).

Figure 2.10: House 2 looking southwest: image of the western perimeter, measuring 4.19 m west from the central depression which was interpreted by Renouf et al. (2005) as a platform. Note the person for scale (Image courtesy of PAC Project).

An axial feature oriented north-south was identified in the center of the dwelling. It measured 123 by 75 cm and it constructed out of 4-5 layers of cobble and rocks (Renouf et al. 2005:8). One pit was located at each end, which were interpreted as a post holes. The northern post hole measured 558 cm in diameter and 55 cm in depth. The southern post hole measured 58 cm in diameter and 81 cm in depth (Renouf et al. 2005:10). Another pit was identified south of it in line with the other two. It measured 45 cm in diameter and 65 cm in depth (Renouf et al. 2005:10).

The newly calculated width of House 2 suggests that the dwelling's roof would have needed central support. By dismantling the dwelling, Renouf et al. (2005) found that what Harp identified at a line of pits in the axial feature were centrally placed post-holes (Renouf et al. 2005; Renouf 2011b).

The dismantling of the dwelling revealed a period of earlier use: during the initial phase there were three pits associated with the axial feature, two of which were used as post holes while the third was used as a refuse pit. This was followed by a period of decay where the post holes and refuse pit were filled with midden. New smaller post holes were built after some time and at some point, the northern post hole was discontinued (Renouf et al. 2005).

Based on Renouf et al.'s (2005) excavations, the exterior perimeter of House 2 was re-calculated at 94 m^2 and the interior perimeter was re-calculated at 78.4 m^2 or 87.7 m^2 depending on whether the eastern stack of stones was a wall or a bench.

In order to test whether House 2 was characteristic of middle phase houses (i.e. large), the PAC Project excavated an additional middle-phase dwelling: House 18, which was previously excavated by Harp in a checkered board pattern and re-excavated by the PAC Project in 2005.

2.4.2 House 18

The PAC project excavated a total of 76 m^2 associated with the dwelling and an additional 60 m^2 associated with the immediate vicinity. During the excavation, the crew identified many features associated with the dwelling (Cogswell et al. 2006:1).

House 18 had two platforms associated with its central depression: an eastern platform and a western platform. The eastern platform was 2.94 m wide and it was characterized by a well-defined raised flat area (Cogswell et al. 2006:18). The western platform was 2.96 m wide (Cogswell et al. 2006:21).

An axial feature was identified. It was characterized by a concentration of large slabs of rock in the central area of the dwelling and it measured 1.3 by 1.9 m (Cogswell et al 2006:9). It was associated with two post holes (a southern and a northern one) abutting it on each end (Figure 2.11). The southern post hole was characterized by a ring of stones measuring 60 by 50 cm. The hole was circular and measured 30 cm in diameter at the top and 15 cm at the bottom. It was 50 cm deep and it was lined with cobbles with a flat rock at the bottom (Cogswell et al. 2006:9). The northern post hole was a circular pit lined with cobbles. It had a diameter of 28 cm (Cogswell et al. 2006:10). The post holes/axial feature configuration matches the one found in House 2 (Cogswell et al. 2006).

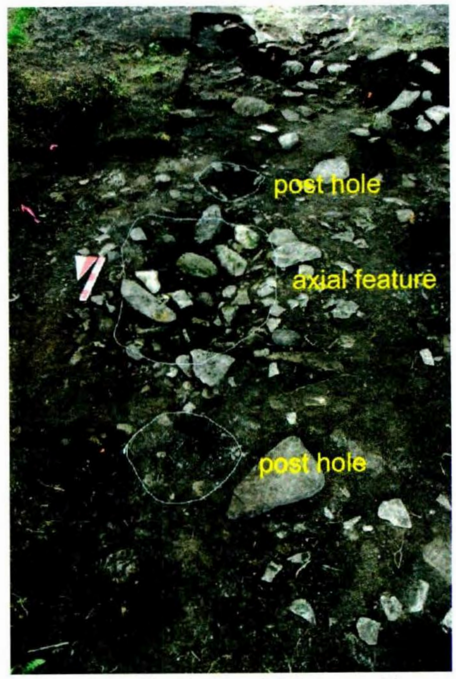

Figure 2.11: House 18 axial feature with associated pits (Image courtesy of PAC Project).

At the back of the dwelling two other pits were identified: a storage pit and

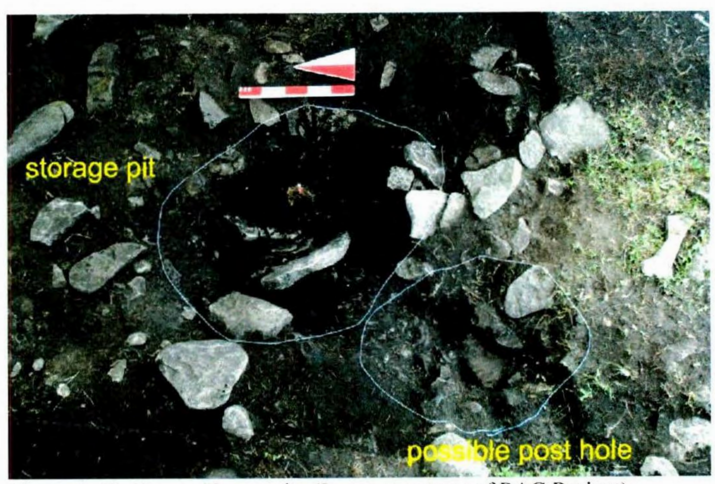

Figure 2.12: House 18 rear pits (Image courtesy of PAC Project)

possible post hole (Figure 2.12). The storage pit was large and square, measuring 56 by 60 cm at the top, 49 by 22 cm at the bottom, and 60 cm in depth. It was also stone lined. The possible post hole was close to the storage pit and was circular, measuring 65 cm in diameter and 45 cm in depth. It was also lined with stones (Cogswell et al. 2006:13).

Forty-two small perimeter pits were identified around the dwelling depression. These were small, measuring 10-15 cm in diameter and 10-15 cm in depth and most were rock lined. They were interpreted as small post holes (Cogswell et al. 2006:21).

The entrance to the dwelling was interpreted as north of the axial feature. Two midden-filled pits were associated with it (Cogswell et al. 2006).

2.4.3 House 17

In order to further characterize middle phase dwellings the PAC Project re-excavated House 17 (Renouf 2007) and the area surrounding it (Renouf 2009). House 17 was previously excavated by Harp. The goal of the PAC Project excavations was to see whether the axial feature was similar to House 2 and House 18 and to see whether it was a large dwelling (Renouf 2007).

Harp described House 17 as trilobate shaped with two side and one rear platform. He also described the central area shaped like a lentil. In 2006, the PAC Project excavated 135 m^2 of the western half of the dwelling (including the central area and an area to the west, south, and north of the dwelling) (Renouf 2007:3).

Two platforms (rear and western) were identified during the PAC Project excavations. The rear platform measured 1.97 m north-south and an estimated 7.9 m east-west. It was constructed out of a single layer of rocks. The western lateral platform measured 4.59 m north-south and 2.93 m east-west. It was constructed out of a 5 cm layer made up of sand, loose soil, small rocks, and topped with a single layer of rocks. Harp's excavations show a third eastern platform; however, this was not excavated by the PAC Project (Renouf 2007:12).

The axial feature measured 92 cm east-west and 1.9 m north-south (Figure 2.13). It was characterized by five slabs in an approximate line, two of which were stained with fat and discolored by heat (Renouf 2007:7). Renouf (2007) concluded they were part of a soapstone pot stand. Four pits were associated with the axial feature, two of which were interpreted as post holes (Figure 2.14).

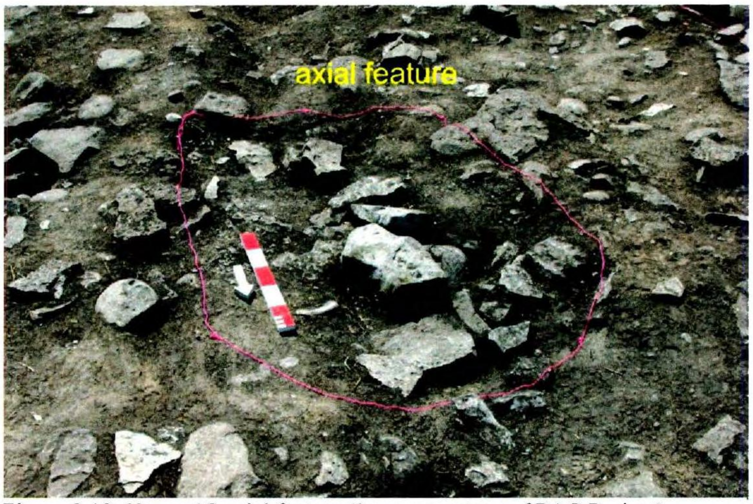

Figure 2.13: House 17 axial feature (Image courtesy of PAC Project).

The northern post hole measured 33 by 45 cm and it was 25 cm deep. The southern post hole measured 26 by 37 cm and it was 30 cm deep (Renouf 2007:7). Two gullies outlined the axial feature. They were 10-15 cm wide and a few cm deep (Renouf 2007:7). Renouf (2009) suggests that the gullies were formed by whale ribs lying onto the ground to demarcate the central axis.

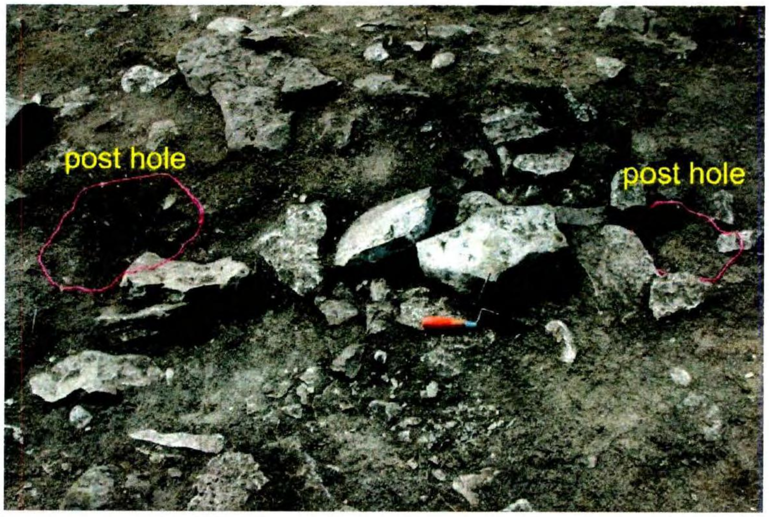

Figure 2.14: House 17 the two post hole abutting the axial feature. The trowel in pointing north (Image courtesy of PAC Project).

Two rear pits (Feature 162 and Feature 163) were identified in front of the rear platform. Feature 162 measured 50 cm in diameter and 60 cm in depth. It was similar in size and construction as the storage pit in House 18. Feature 163 was a shallow circular pit, measuring 87-90 cm in diameter and 35 cm in depth (Renouf 2007:12).

Perimeter post holes were also identified around and within the dwelling perimeter. Four types of pits were identified. Deep and oblong post holes measuring 9-17 by 12-31 cm and 9-32 cm deep were found on the outer margin of the dwelling and one was found in the rear platform; upright whale ribs fitted in these holes (Figure 2.15). Large oval and round post holes measuring 12-73 cm in diameter and 5-26 cm deep were mostly found in the perimeter of the structure. Small oval and round measuring 7-28 cm in diameter and 5-26 cm deep were all identified within the perimeter of the dwelling.

Very small indentations were also identified and they were interpreted as stake holes (Renouf 2007:6).

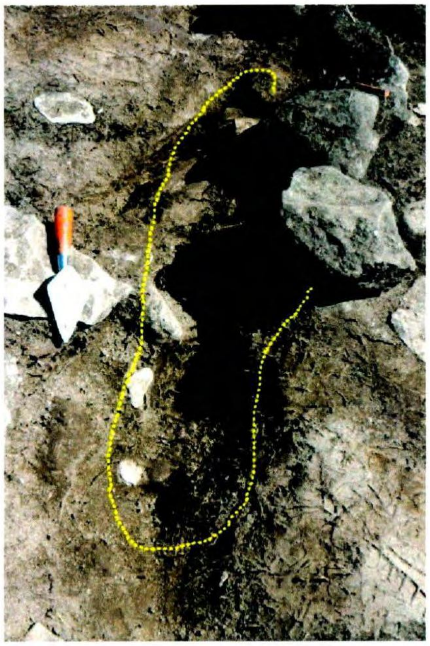

Figure 2.15: House 17 line of perimeter post holes. The trowel is pointing north (Image courtesy of PAC Project)

The entrance to the dwelling was interpreted as a break in the front sandy berm of the dwelling. It was 44 cm wide, 1.56 m long, and 13 cm deep. It was orientated in line with the central axis and opened to the north (Renouf 2007:14).

During the 2009 field season the PAC Project further excavated the area outside House 17. Several features were identified, including an outdoor axial hearth associated with a pot support. Several more post holes were also identified: a concentration of divots interpreted as a rack (Renouf 2009), a line of divots and stake holes outlining a structure 80 cm wide and 140 cm long, six post hole pairs outlining a structure at least 6 m wide which Renouf (2009) suggest may be part of a fence, and five large and shallow post holes four of which form a curve around a pit where a midden formed (Renouf 2009).

2.4.4 Summary of Middle Phase Dwellings at Phillip's Garden

Based on recent excavations, Renouf (2011b) suggests middle phase dwellings at Phillip's Garden are mostly semi-subterranean, large, oval or rectangular structures with one rear and one or two side platforms constructed out of stacked limestone. They also have a central depression bisected by an axial feature. The axial features are defined by cobble or slab pavement and a line of post holes. There are also two pits at the rear of the dwelling: one storage pit and a second pit or post holes. Their walls are defined by stacked rocks or perimeter post holes (outside and defining the dwellings). The entrances, often oriented towards the ocean (north), are characterized by breaks in the wall areas (Renouf 2011b). Renouf (2009b) also suggests that whale bones would have been used to frame the roof of the dwelling, which would have likely been covered with seal skins. Some dwellings were reconstructed and renovated (Renouf et al. 2005; Renouf 2011b). Several possible structures outside the dwellings but associated with them were also identified (Renouf 2009; Renouf et al. 2011).

2.5 Summary

This chapter provides a brief characterization of the physiography and cultural history of the Dorset occupation at Phillip's Garden, Newfoundland. Phillip's Garden is the largest and most intensively occupied Dorset site in Newfoundland, with large dwellings measuring between 90-121.5 m^2. For the purpose of this research, this chapter focused primarily on middle phase Dorset architecture and space use at Phillip's Garden. This is further described in subsequent chapters.

CHAPTER 3

Geophysical Investigations and Field Methods

3.1 Introduction

This chapter provides a review of geophysical methods in archaeology as well as the geophysical principles of the ground penetrating radar and magnetometry – the two methods used in this research. This is followed by a description of the instrumentation, field surveys, and the data processing. This research spans two consecutive field seasons: the aims of the 2011 field seasons were 1) testing the difference between excavated and unexcavated dwellings and 2) ground-truthing some of the surveyed dwellings. The aim of the 2012 field season was testing the best surveying interval to use with GPR at Phillip's Garden.

3.2 Geophysics in Archaeology

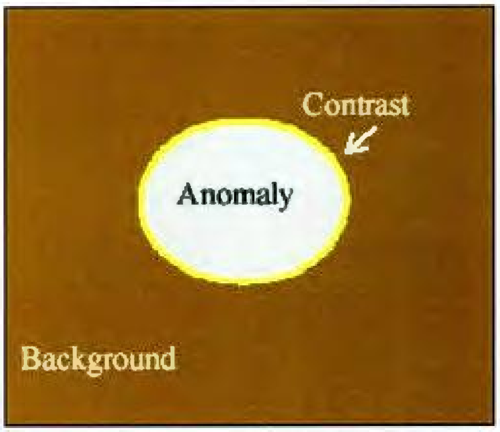

Figure 3.1: Geophysical methods detect the contrast between the background and an anomaly. In order to effectively detect features the background and the anomaly must have a strong enough contrast.

Geophysical methods operate by detecting boundaries between materials with different physical properties. These methods fall in the category of remote sensing meaning that they can collect information about a feature without touching it. Therefore, the contrast between the feature (or anomaly) and the background (surrounding matrix) must to be strong enough to be measured from a distance (Figure 3.1) (Kvamme and Ahler 2007; Pettinelli et al. 2011). Geophysical methods can be divided into two types: active and passive. Active methods (such as ground penetrating radar) induce a phenomenon to measure properties and detect anomalies. Passive methods (such as magnetometry) measure naturally occurring phenomena (Gaffney and Gater 2003).

Choosing an appropriate geophysical method for archaeological surveying often depends on the physical properties of the site soil and what archaeological feature you are looking for (also known as the target), the depth of the target, whether the target is above or below the water table, the accessibility of the site, and the presence of interference related to human activities (Pettinelli et al. 2011).

Geophysical techniques are particularly useful in archaeological prospecting as their results can be used for excavation plans (Arciniega-Ceballos et al. 2009; Bini et al. 2010; Bonomo et al. 2010; Kvamme and Ahler 2007; Rodriguez et al. 2009); however, their benefits can go much further than that and can include testing anthropological hypotheses about the human past related to site layout, feature size, and orientation (Conyers 2009; Hargrave 2011).

For example, Bonomo et al. (2010) used ground-penetrating radar to detect new structures at the Palo Blanco - a Formative Period agricultural-pastoral settlement occupied between 200 CE (common era) and 700 CE in Argentina. The main aim of their geophysical survey was to detect new dwellings at the site. Hargrave (2011) conducted a magnetic survey at the Mississippian site of Ramey Field, Cahokia in Illinois, occupied around 900 CE. The geophysical investigations were conducted in order to collect more information about the site's occupation and settlement plan. Hodgetts et al. (2011) conducted a magnetometry survey around Maguse Lake, Nunavut, Canada. Their aim was to test the method in the Arctic. They surveyed several archaeological sites and one non-archeological site as a control. Hodgetts et al. (2011) were successful in identifying several archaeological features.

Another example comes from the Dorset Palaeoeskimo site of Point Riche, Port au Choix, northwestern Newfoundland where GPR survey was conducted by Dominic Lacroix (PhD student in the Department of Archaeology, Memorial University of Newfoundland) with the assistance of Dominique Lavers (Canada Research Chair Research Assistant, Department of Archaeology, Memorial University of Newfoundland) (Anstey 2011). The conducted their survey over the Feature 64 area (a possible house depression in the southern part of the site). Based on their results, they identified a possible 5.5 m by 5 m berm surrounding the central depressions, a large amount of gravel north of the depression, and a break in the western side of it (possibly an entrance) (Anstey 2011). The excavations conducted on Feature 64 demonstrated that a small berm did surround the central depression and a possible entranceway was identified southwest of the depression.

Eastaugh (2002) surveyed Point Riche using a magnetometry and resistivity in order to determine how many dwelling depressions exist at the site as well as their distribution. Eletrical resistivity measures the earth's ability to conduct electricity and its resistance to the flow of electricity in the subsurface (Gaffney and Gater 2003). The resistivity survey was unsuccessful due to varying levels of soil moisture across the site.

The magnetometry survey identified a possible historical building as well as at least ten possible Dorset Palaeoeskimo dwellings (Eastaugh 2002).

More recently, Wolff and Urban (2012) conducted a magnetometry and GPR survey at the Dorset Palaeoeskimo site of Stock Cove, Trinity Bay, southeastern Newfoundland. Anomalies correlating with architectural features were identified in both and magnetometry and GPR results.

On the other coast of Canada, Tudor (2010) conducted a study at the Coast Salish site of Trail Bay in Sechelt, British Columbia. She used resistivity, GPR, and magnetometry in order to identify possible archaeological subsurface features. She identified several anomalies which may correspond with a hearth, several pits, as well as several berms (Tudor 2010). Archaeological investigations have yet to inform further analysis.

Using one type of geophysical method in archaeology can be useful; however, using several methods can provide a more holistic picture of the site (Arciniega-Ceballos et al. 2009; Chianese et al. 2010; Kvamme and Ahler 2007; Lasaponara 2010; Leopold et al. 2010; Lockhart 2010; Maki and Fields 2010; Rodriguez et al. 2009; Sapiai et al. 2010). There are several geophysical methods that test different properties; therefore, cultural features not revealed by one method may be revealed by another. Additionally, some features may render different results based on the method used.

For example, Arciniega-Ceballos et al. (2009) conducted a geophysical survey at the Prehispanic site of San Miguel Tocuila, Basin of Mexico, located close to an Aztec ceremonial center. The main aim of the study was to identify and map subsurface structures at the site. They used three different methods: magnetometry, seismic refraction tomography, and ground penetrating radar. They initially used magnetometry to survey their whole grid area. Based on those results, they targeted areas with high anomalies which they further investigated using seismic refraction tomography and ground penetrating radar. Using these three methods, which test different properties at different depths, they were able to locate and characterize the geometry of buried buildings.

Another example comes from the Basilicata region, in southern Italy where Chianese et al. (2010) used electric resistivity, ground penetrating radar, and magnetometry to survey the Rossano of Vaglio archaeological site – a fourth century BC sanctuary dedicated to the goddess Mephitis. The main aim of the study was to investigate the presence and characteristics of buried structure associated with the sanctuary. Chianese et al. (2010) carried out the magnetometry survey in order to detect the location of the buried structure, the ground penetrating radar survey to detect outer the walls, and the electric resistivity survey in order to infer the depth of the structure. They were successful in identifying several collapsed walls associated with the sanctuary.

Ground truthing geophysical results is an important part of archaeology as it validates the findings (Kvamme and Ahler 2007). Most of the time it can difficult to differentiate between archaeological and natural features when studying geophysical anomalies. Excavating the anomalies is the most comprehensive way to determine the nature of the anomaly. Correlations between geophysical anomalies and excavated archaeological features are necessary as many anomalies can be natural or caused by modern day interferences such as trash or cars. A strong knowledge of the site would also be useful in identifying archaeological anomalies, but ground truthing will still provide the surest correlation.

3.3 Magnetometry Survey Principles

Magnetometry is a passive geophysical method. Magnetometry surveying is based on the measurement of the earth's magnetic field which is modified by the magnetic properties of local materials. The magnetic field strength unit of measurement is the Tesla (T) (Witten 2006). The Tesla is a very large unit of measurement making it harder to keep track of small magnetic disturbances; therefore, magnetic field strength tends to be measured in nanoteslas (nT), which is equal to a Tesla divided by one thousand million (Oswin 2009).

The earth's magnetic field travels from the south pole to the north pole perpendicular to the equator and behaves like a bar magnet is at its center. The earth's magnetic field measures approximately 70,000 nT at the poles and 30,000 nT at the equator (Kvamme 2006, Witten 2006). Archaeological features produce small variations in the magnetic field, ranging from 0.05 to 5 nT (Gaffney and Gater 2003; Kvamme 2006; Oswin 2009). In magnetic surveying, the earth's magnetic field is taken into consideration plus any magnetic field caused by subsurface features (Witten 2006).

Magnetic surveying uses two principles: thermoremanence and magnetic susceptibility (Gaffney and Gater 2003). In order to differentiate a feature from its surrounding soil, the feature must produce an anomaly detectable by the magnetometer.

This anomaly can be caused by thermoremnant magnetism, magnetic susceptibility, or both (Gaffney and Gater 2003).

Thermoremanence refers to weakly magnetized materials or bodies that have acquired their magnetization from being heated and cooled in a specific magnetic field. At high temperatures, a material's magnetic properties are erased. As the material cools, it becomes re-magnetized. The earth's magnetic field changes over time. A material will have a different magnetic signature than the surrounding soil if it was heated before the earth's magnetic field changed and if it cooled after the change (Gaffney and Gater 2003, Oswin 2009). In archaeology, this can be seen in fireplaces, furnaces, burnt clays, fire layers, ash filling, and pieces of coal (Hasek 1999).

Magnetic susceptibility is the magnetic signature of a material or body when placed in a magnetic field. In archaeology, this can be seen in pits in the subsoil filled with topsoil and/or refuse. Topsoil and refuse have a different iron content than subsoil; therefore, they would have different magnetic signatures (Gaffney and Gater 2003; Oswin 2009).

The sources of magnetic anomalies can be divided into natural and cultural processes. Natural processes encompass differences in magnetic susceptibility, or the amount and state of iron content in materials. Cultural processes refer to human activities such as creating fire, using fired materials, human constructions (which remove or accumulate topsoil), importing materials, human waste (waste rich in bacteria increases the magnetism of topsoils), and of course iron artefacts (Kvamme 2006).

Magnetometry is not efficient in all archaeological contexts; it only renders good results in soils with good iron content (Oswin 2009). The chances of a feature being detected through magnetic surveying is dependent on the amount of contrast between the target and the background (Figure 3.1), feature size relative to sampling intervals, the depth of the feature, the amount of magnetic interference close to the site, the pattern of the feature (whether it has a geometrically well defined shape), instrument sensitivity, and data acquisition quality (Kvamme 2006).

Magnetometers usually have several components: a computer and one or two sensors (Figure 3.2) (Aspinall et al. 2008). They operate by taking point by point readings or taking readings during a continuous survey where the operator moves in a grid pattern. There are two main types of magnetometers available: those that measure energy (such as proton magnetometers) and those that measure the magnetic field (such as fluxgate magnetometers). I will focus on proton magnetometers as that is the instrumentation we used in the field.


Figure 3.2: A proton magnetometer with two sensors. A continuous survey mode is employed (Image courtesy of PAC Project).

Proton magnetometers were the first geophysical instruments used in archaeology (Hasek 1999; Oswin 2009). They operate by measuring the energy of atoms when placed in a magnetic field. Proton magnetometers have one or two sensors filled with hydrogen atoms in methanol (also known as methyl alcohol). As magnetic fields change, the energy of atoms also changes. Proton magnetomers measure this change relative to the Earth's magnetic field (Oswin 2009). The downside to proton magnetometers is that they are an older and therefore slower type of instrument compared to newer types (Kvamme 2006). They are also heavier than other magnetometers (such as fluxgate magnetometers) and therefore more difficult to operate.

3.4 Ground Penetrating Radar Survey Principles

Ground penetrating radar is an active geophysical surveying method (Gaffney and Gater: 2003; Conyers 2004; Oswin 2009). It is based on the transmission of high frequency radar pulses from a surface antenna into the ground. Radar travel times are measured in nanoseconds, or billionths of seconds. The pulses sent by the GPR are waves of electromagnetic (EM) energy composed of oscillating electrical and magnetic fields which travel at the speed of light ($c = 3.10^8 \times sec^{-1}$ or c = 299.793 km/sec or about 30 cm/ns) through air. The travel time through sand is 15 cm/ns, while the travel time through water saturated soil or clay is 5 cm/ns (Conyers 2004, 2006; Oswin 2009). The GPR measures the elapsed time between when the pulses are transmitted, reflected from subsurface features, and received back by the antenna. Depth of penetration can be calculated by using the estimated velocity at which energy travels (Conyers 2004; Oswin 2009).

The transmitted and received waves are called traces and are stacked together along the transect line to create a profile of the subsurface. The waves slow down as they penetrate the ground and encounter subsurface features or physical changes between soil levels, some energy will reflect

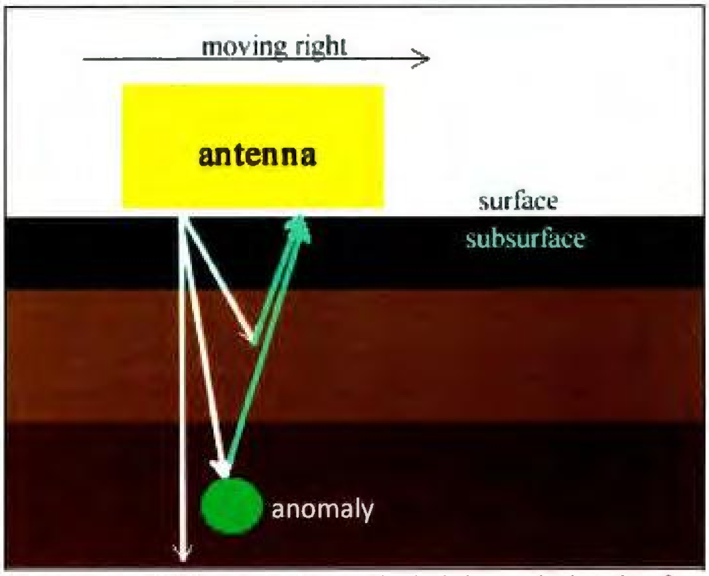

Figure 3.3: As GPR waves encounter physical changes in the subsurface (such as changes in electrical properties, water content, density, or soil changes), some waves will reflect off these changes while other waves travel deeper until they dissipate.

off them, while other energy will continue downwards and reflect deeper features or levels (Figure 3.3). Eventually, those radar waves will dissipate into the ground. In order to be detected features must be morphologically different from the surrounding soil (Conyers 2004; Oswin 2009) (Figure 3.1).

Electromagnetic waves travel in a conical pattern, similar to sonar (Figure 3.4). They also disperse to the side

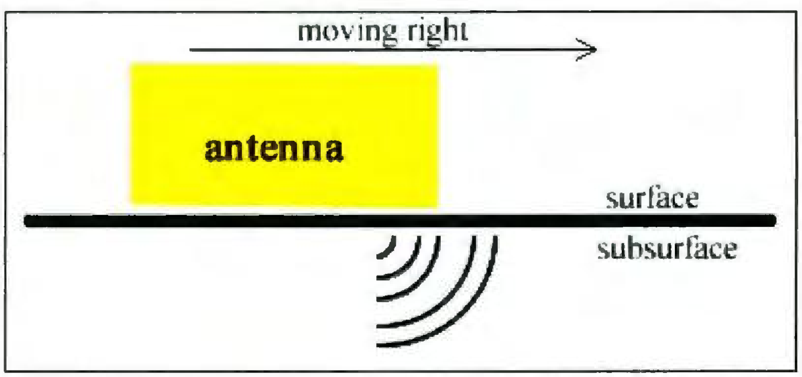

Figure 3.4: GPR waves propagate in a conical pattern into the ground.

allowing the GPR to locate features not just directly below the antenna but also in front and behind it (Figure 3.5). Due to this energy dissipation, targets appear as hyperbolas in the subsurface profile (Figure 3.5 and 3.6) (Conyers 2004). Hyperbolas can be caused by archaeological features as well as stones, tree roots, and burrowing tunnels (Conyers 2006).

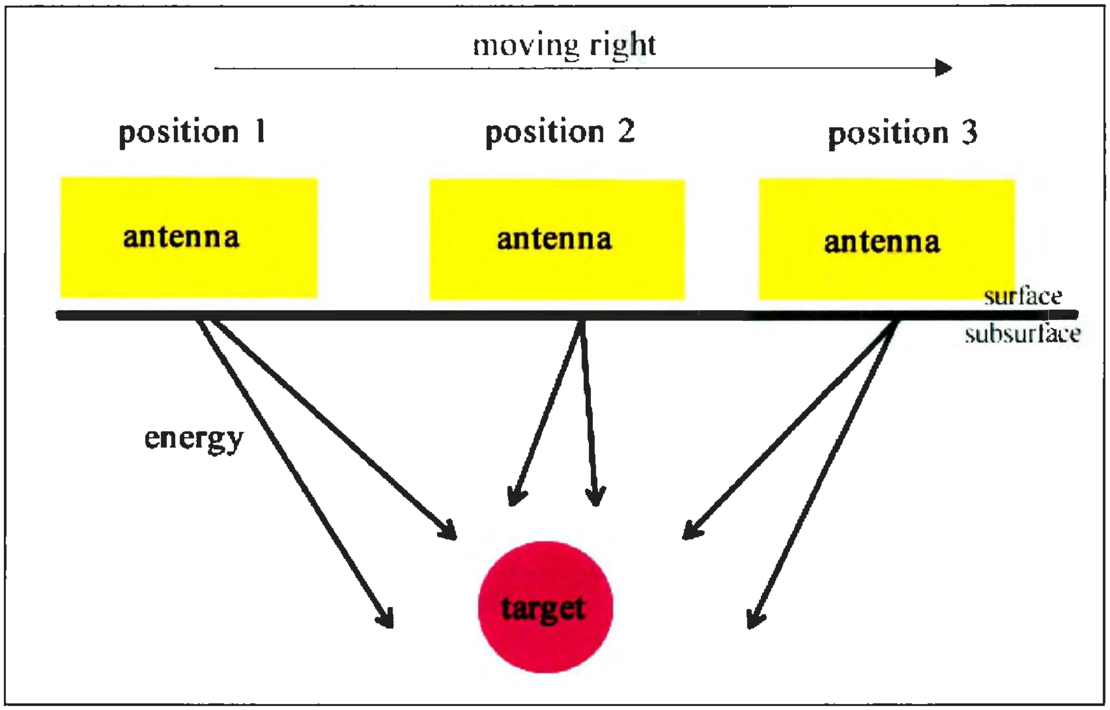

Figure 3.5: As it is dragged across the ground, the GPR antenna will detect a subsurface target in front of it (position 1), below it (position 2) and behind it (position 3).

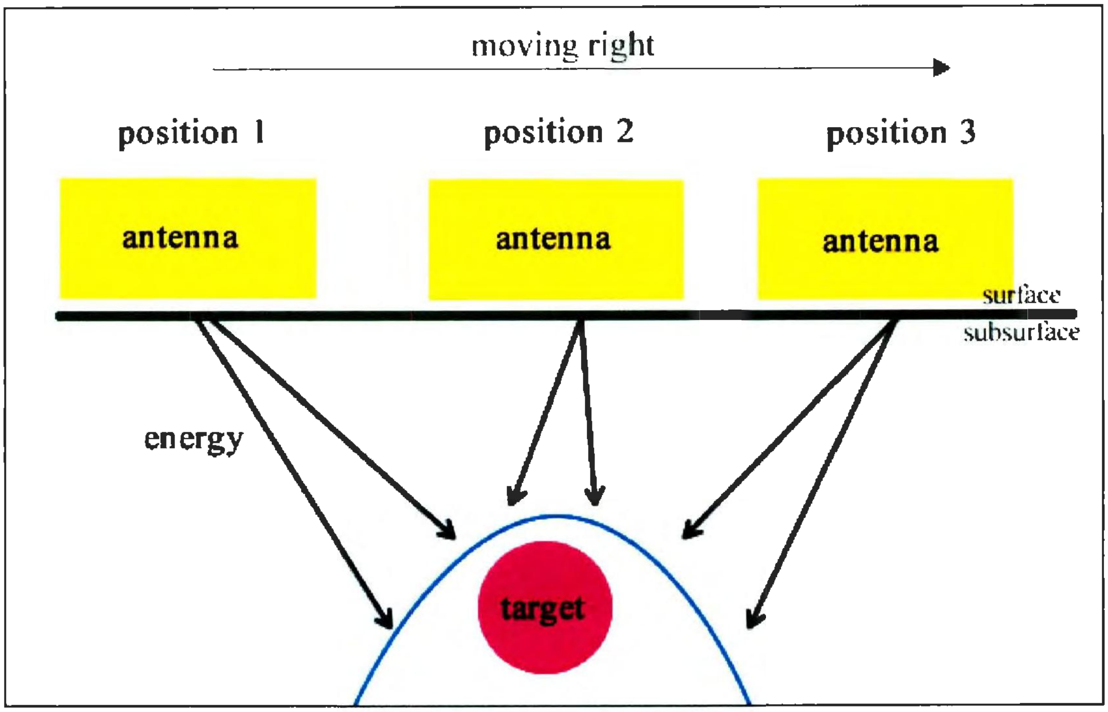

Figure 3.6: As the antenna detects features while they are in front of it, below it, and behind it the subsurface target is often displayed as a hyperbola in the subsurface profile.

The traces in a transect are plotted horizontally to render a 2D subsurface profile. These profiles are often distorted due to topography – this can be corrected through computer processing such as creating a topographic map of the survey area and comparing it to GPR data to rule out anomalies cause by topographic features (Conyers 2004; Oswin 2009).

GPR antennae vary based on the frequency they transmit. Frequency refers to the speed of energy oscillation, or the number of radio energy wave crests passing through a point in a specific period of time. It is measured in Megahertz (MHz). The higher the frequency (e.g. 250, 450, 1000 MHz antennae), the shallower the radar pulses penetrate and the higher the resolution. Low frequency antennae (such as 100 MHz) have a lower resolution but can penetrate much deeper (Conyers 2004; Oswin 2004). Different antenna are appropriate for different sites depending on the depth at which archaeological materials are located.

All GPR systems operate in a similar fashion. A GPR system has a transmitting and receiving antenna which is pulled over the ground. Distance markers are added to the data file by an automatic odometer (often attached to a wheel) or via a hand trigger. Sometimes, the antennae are mounted on a sledge or on a wheeled cart (Figure 3.7). A computer is also attached to the antenna – it can either be part of the system or it can be a stand-alone PC (Gaffney and Gater 2003).

Figure 3.7: GPR with a 500 MHz antenna on a wheeled cart – the antenna is mounted on the bottom of the cart while the computer is mounted by the handle (Image courtesy of PAC Project).

One of two methods of data acquisition is generally adopted: a continuous survey, where the antenna is dragged or pushed across the ground at walking speed or a step survey, where data is captured at a set distance along a transverse (Gaffney and Gater 2003). In a continuous survey as the antenna moves along the ground, reflections are recorded every 2 -10 centimeters along the transects (Conyers 2004).

The data can be viewed as a subsurface profile, which shows a slice of the ground along a specific transect where depth and distance are plotted. It can also be viewed as a time slice, which shows an area (the surveyed grid) in plan-view at a single depth under the surfacc. This is called a time slice as it is a map of all points with the same radar return time – not be confused with archaeological time frameworks (Oswin 2009).

It should be noted that not all terrain is suitable for a GPR survey. For example, tall and dense vegetation impairing traditional surveying would make any GPR exploration nearly impossible as it can prevent the energy from getting into the ground (Gaffney and Gater 2003; Conyers 2004). Furthermore, the success of a GPR survey is dependent on several factors such as ground moisture, the depth at which archaeological material is located, and topography. Soil conditions are particularly important in GPR surveys as ground moisture slows down data travel times, creating reflections and obscuring cultural features (Conyers 2004, 2006). Additionally, topography and vegetation can prevent the antenna from touching the ground, thus dissipating energy before it penetrates the earth, which results in no subsurface readings being taken (Conyers 2004; Oswin 2004).

Ground penetrating radar is most useful in contexts where materials are buried between 20 cm and 5 m and where the cultural features are large, hollow, linear, have a pattern (such as a dwelling floor or platform), and/or have significantly different physical properties from the surrounding soil. Ground penetrating radar survey settings can be changed in order to best suit the studied environment. For example, the speed which at the ground penetrating radar travel at can be calibrated based on the materials of the subsoil and the amount of ground water (Conyers 2006).

The main advantage of GPR surveying is the ability to record a vertical section through the ground; thus allowing archaeologists to map both the depth and the extent of subsurface features (Gaffney and Gater 2003; Conyers 2004). The development of time slices is also particularly useful in archaeological interpretation as it is a fast and comprehensive way of analyzing GPR data that covers a large area (Conyers 2006). Another important advance to GPR surveying is that it allows for the collection of large amounts of data during a short time (faster than excavating), with no ground disturbance (Conyers 2004).

3.5 Instrumentation

During the 2011 field season at Phillip's Garden we used a Sensors and Software GPR with a 500 MHz antenna and a GEM Systems Overhauser Proton Magnetometer. During the 2012 field season at Phillip's Garden we used a Sensors and Software GPR with a 500 MHz antenna. Both pieces of equipment are owned by the Port au Choix Archaeology Project.

3.6 Field Methods

3.6.1 2011 Field Season

The purpose of the 2011 field season was to test the efficacy of both magnetometry and ground penetrating radar on excavated and unexcavated dwellings. Following this aim, we surveyed H10, a previously excavated middle phase dwelling, and Feature 368, an unexcavated dwelling. Additionally, we excavated House 10 to ground-truth our findings and took topographic points on Feature 368 every 50 cm. Although excavating Feature 368 would have also strengthened our findings, it was not efficient in terms of time as it would have taken us at least two field seasons to excavate the dwelling. Additionally, as House 10 was previously excavated by Harp and Renouf we had a lot of information about its features and excavating it was not as time consuming. We conducted the geophysical survey during the first three weeks at the site. The 2011 field season was wet, with rainy weather. This affected the GPR survey as water slows down the electromagnetic waves as they penetrated the ground.

The survey grids were 20x20 m in order to survey the dwellings as well as the area around them. The grids were established in relation to the site datum (Figure 3.9 for the location of the grids).

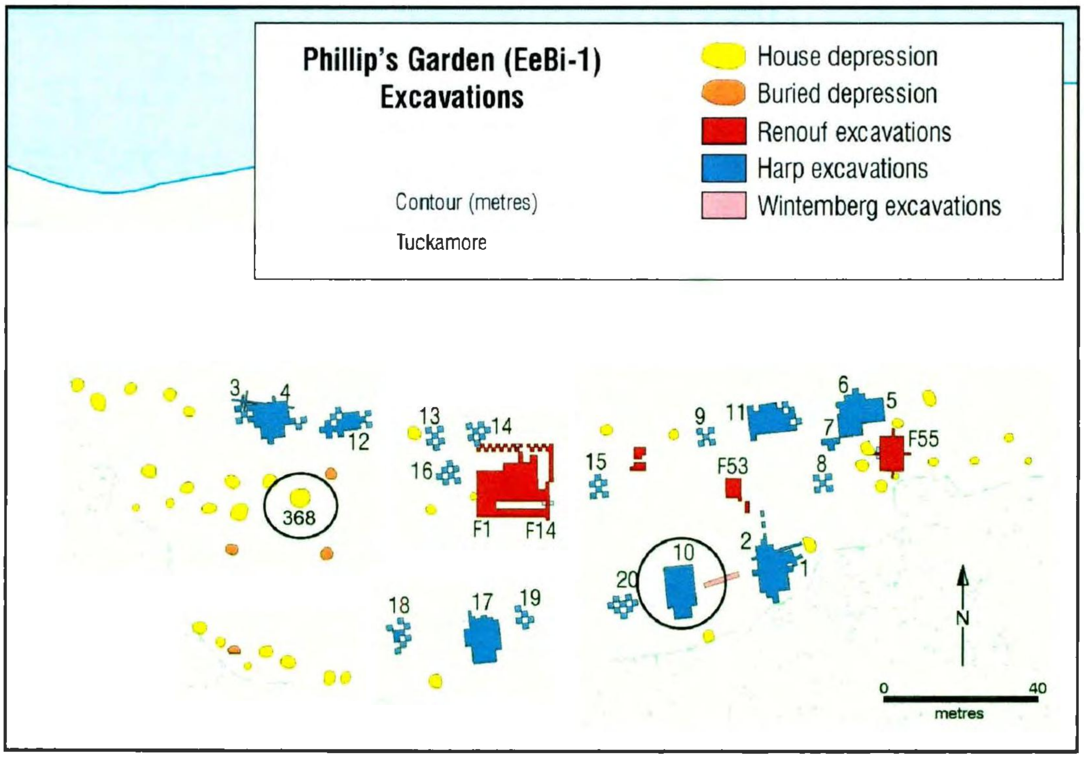

Figure 3.8: Map of Phillip's Garden showing dwelling depressions, buried depressions, and previous excavations (PAC Project). During the 2011 field season we surveyed House 10 and Feature 368 (Image courtesy of the PAC Project).

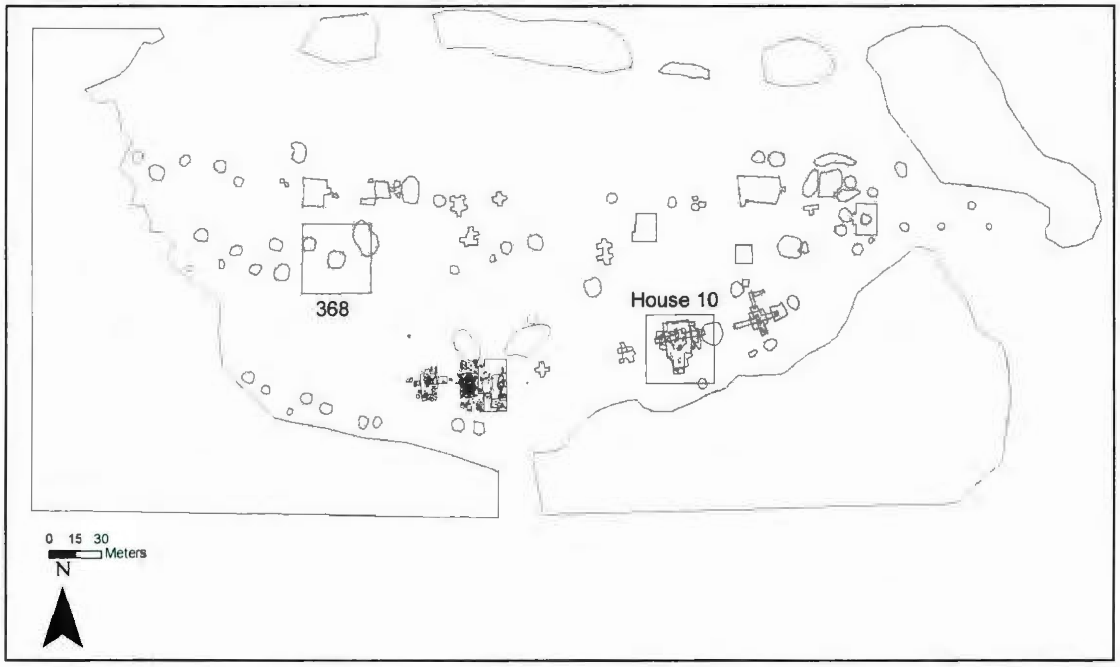

Figure 3.9: Location of survey grids at Phillip's Garden (Image courtesy of the PAC Project).

3.6.1.1 Magnetometry Survey

The GEM Systems Overhauser Proton Magnetometer system parameters are presented in Table 3.1. The survey mode we selected was walking magnetometer, which means that we ran a continuous survey and the machine took readings without operator triggers. The cycle time refers to how many readings are taken per second. Our cycle time of 0.2 seconds meant that we were taking about 5 readings per second. The AC filter, set to 60Hz was used to filter some anthropogenic electromagnetic noise, such as interference from power lines, cars, boats, cellular phones, etc.

The first surveyed feature was House 10. The grid was set up similarly to the GPR survey with traverses running east to west with a 10 cm spacing. The survey involved the operator strapping on the computer component around the torso and walking back and forth (zig-zag) along the traverses while holding the sensors in front away from the body (Figure 3.7). The surveying method proved to be difficult as the pace had to be slow enough to gather enough readings and consistent enough to collect the same number of readings per traverse. This was exacerbated by the fact that the pole with the sensors was heavy and difficult to hold vertically and still, especially continuously throughout the day. Following this surveying method, with 10 cm spacing within a 20 by 20 m grid, took us three to four days to survey one house feature. As we had limited time in the field, the surveying parameters were changed to 25 cm spacing between traverses, allowing us to survey one house feature in one to two days. We surveyed House 10 using the 10 cm spacing. We surveyed Feature 368 using the 25 cm spacing.

Menu Feature	**Parameter Selected**
Survey Mode	Walkmag
Cycle Time	0.2 second
AC Filter	60 HZ
Display Mode	Graph, No Text

Table 3.1: GEM Systems Overhauser proton magnetometer system parameters as set for data collection at Phillip's Garden during the 2011 field season.

The magnetic survey was hindered by debris from previous excavation, specifically iron and aluminum debris (such a nails, datum, and cigarette wrappers). These distorted the data by rendering highly magnetic anomalies and obscuring any other (weaker) anomalous features.

3.6.1.2 Ground Penetrating Radar Survey

The Noggin 500 system parameters that we set for the 2011 Phillip's Garden GPR survey are presented in Table 3.2. The cart parameters are presented in Table 3.3. We chose these parameters based on several test-runs in the field. Depth should mostly be thought of in terms of nanoseconds, especially during field measurement. It is important to note that just because a certain depth is set, the instrument does not necessarily penetrate to that depth. The extent of penetration is dependent on the material through which the waves are travelling and the set velocity. Although depth measurements are provided in meters, they are estimates based on the set velocity. The velocity was set to 0.040 m/ns as the ground moisture was high. The Stacks parameter refers to the amount of times a reading is re-taken in order to minimize noise interference and maximize accuracy. The Gain parameter refers to the visual augmentation of the data in order to enhance more subtle features. The cart's odometer was calibrated based on the conditions at the site.

The first dwelling surveyed was House 10. The survey was conducted in the Line mode along traverses spaced 10 cm apart running east to west. The readings were taken along parallel lines. This means that the survey rendered 200 lines for the whole grid and took between two and three days to complete. Feature 368 was surveyed with the same system parameters but with a 25 cm traverse separation, which allowed us to perform the survey in Grid mode and rendered 100 lines per grid. One important function in the Grid mode is that the lines can be collected in a zig-zag fashion (walking back and forth) thus speeding up the process. Because this surveying method still proved to be time-consuming we decided to change the system parameters: depth was decreased to 50.1 ns or roughly 1 m (see Table 3.2), which meant that the speed with which the operator walked could be increased.

Menu Feature	Parameter Selected
Depth	1.50 m (75.1 ns) – House 10 1.00 m (50.1 ns) – Feature 368
Velocity	0.040 m/ns
Depth Units	Meters
Noggin Unit	Noggin 500
Stacks	16
Linear Grain	2.0
Position Units	Meters

Table 3.2: Noggin 500 system parameters as set for data collection at Phillip's Garden during the 2011 field season.

Menu Feature	Parameter Selected
Cart Direction	Push
Trigger Method	Odometer
Auto Start	Off
Arrow Offset	0.00
Transfer Rate	8
Odometer #	Smart Cart #1 1072.800

Table 3.3: Cart system parameters as set for data collection at Phillip's Garden during the 2011 field season.

We encountered some problems. These were related to topography and subsurface debris. As the GPR is operated on wheels and the antenna must be very close to the ground roots, large rocks, and vegetation interfered with data collection. Additionally, earth mounds from previous excavations also hindered surveying. We accounted for these by recording their position along the traverses.

3.6.1.3 Topography Survey

During the 2011 field season we also conducted a topography survey of Feature 368. By this I mean we took x, y, and z points using a total station and the 3D topography maps were plotted in ARC GIS.

3.6.1.4 Excavation

House 10 was excavated in order to ground truth the magnetometry and GPR results. The 2011 excavation expands on Harp's excavation (field notes 1962) and the Port au Choix Archaeology Project (Renouf et al. 2005). While Harp (field notes 1962) focused primarily on the central depression, in 2004 Renouf et al. (2005) excavated an east-west trench through the northern part of the dwelling (Figure 3.10 for the location of previous excavations). The excavation was conducted in accordance with the Port au Choix Archaeology Project protocols (Renouf 1985, 1987, 1991, 1992, 1993, 2002). In 2011 House 10 was fully excavated with the exception of a small portion of the rear platform on the south-east side (Wells et al. 2012).

The stratigraphy of House 10 was complicated by Harp's excavation as he did not backfill. The soil accumulated over his exposed excavation was labeled as Level Modern (LM) while his back dirt and Renouf's backfilled excavation were labeled as back dirt (BD). Elsewhere, the stratigraphy of House 10 was characteristic of Phillip's Garden (Wells et al. 2012; Renouf 2007). Beneath the sod a pale organic soil was labeled Level 1, followed by a rich organic black soil: Level 2, a thin brown soil layer (Level 3), and the end of the occupation: Level 4, which is a sandy beach.

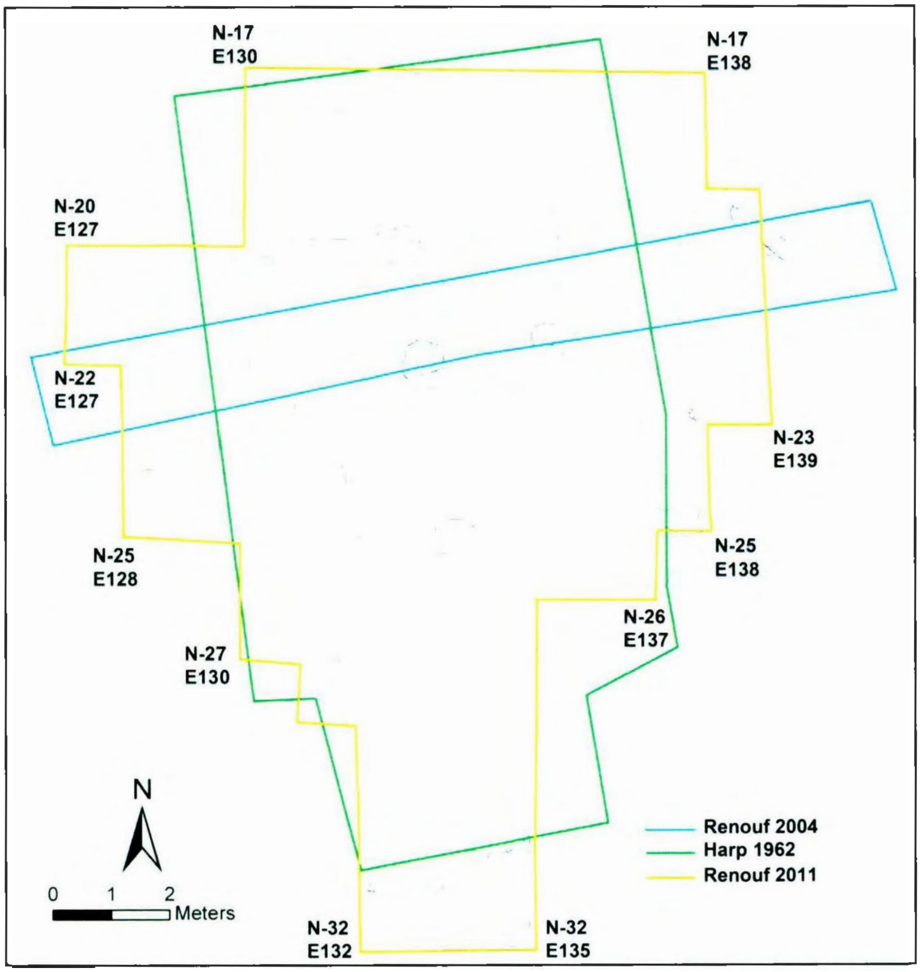

Figure 3.10: Outlines of Harp's 1962 excavation (green), Renouf's 2004 excavation (blue), and the 2011 excavation (orange) (Image courtesy of the PAC Project).

3.6.2 2012 Field Season

The purpose of the 2012 field season was to observe the effects of sampling resolution on non-excavated features. Therefore, we surveyed Feature 368 (an unexcavated dwellings chosen for the survey because it is very distinct on the surface) with the 500 MHz antenna at 10 cm increments. As we allotted more time during the 2012 field season for geophysical investigations we deemed it worthwhile to decrease surveying interval in the hopes of acquiring better quality data even though it may prove to be a lengthier process.

The system parameters are presented in Table 3.4. We conducted the survey in the Line mode with east to west traverses running parallel to each other. The cart parameters are presented in Table 3.5. This season was drier than the previous one; therefore, we decided to increase the velocity so that the electromagnetic waves could travel faster through the ground. We also decided to decrease the stack as there was little to no disturbance in the area and the vegetation had been mowed. This significantly increased the speed of surveying and decreased survey time.

Menu Feature	**Parameter Selected**
Depth	1.50 m (75.1 ns)
Velocity	0.050 m/ns
Depth Units	Meters
Noggin Unit	Noggin 500
Stacks	4
Linear Grain	2.0
Position Units	Meters

Table 3.4: Noggin 500 system parameters as set for data collection at Phillip's Garden during the 2012 field season.

Menu Feature	**Parameter Selected**
Cart Direction	Push
Trigger Method	Odometer
Auto Start	Off
Arrow Offset	0.00
Transfer Rate	8
Odometer #	Smart Cart #2 1069.100

Table 3.5: Cart system parameters as set for data collection at Phillip's Garden during the 2012 field season.

3.7 Processing

Processing geophysical data includes several steps: 1) downloading data onto a computer, 2) re-arranging the data in the same pattern as it was acquired, 3) making the data understandable (this involves removing imperfections that may have happened during data collection, such as anomalies created due to the operation process) (Oswin 2009). The 2011 and 2012 geophysical data were downloaded on a Toshiba laptop (Windows XP) and processed during and after the field season.

3.7.1 Magnetometry

The magnetometry data were processed using ArcheoSurveyor Version 2.5 (now known as TerraSurveyor http://www.dwconsulting.nl/TerraSurveyor.html). The data were processed to remove data acquisition effects (such as diurnal variation effects) and to enhance subsurface anomalies.

Figure 3.11a is an example of raw magnetometry data. Horizontal lines and striations are visible as well as several very strong point anomalies (Figure 3.11a). The horizontal striping is due to data acquisition practices such as tilting the magnetometer while walking. The dot anomalies are produced by discarded pieces of metal (such as nails).

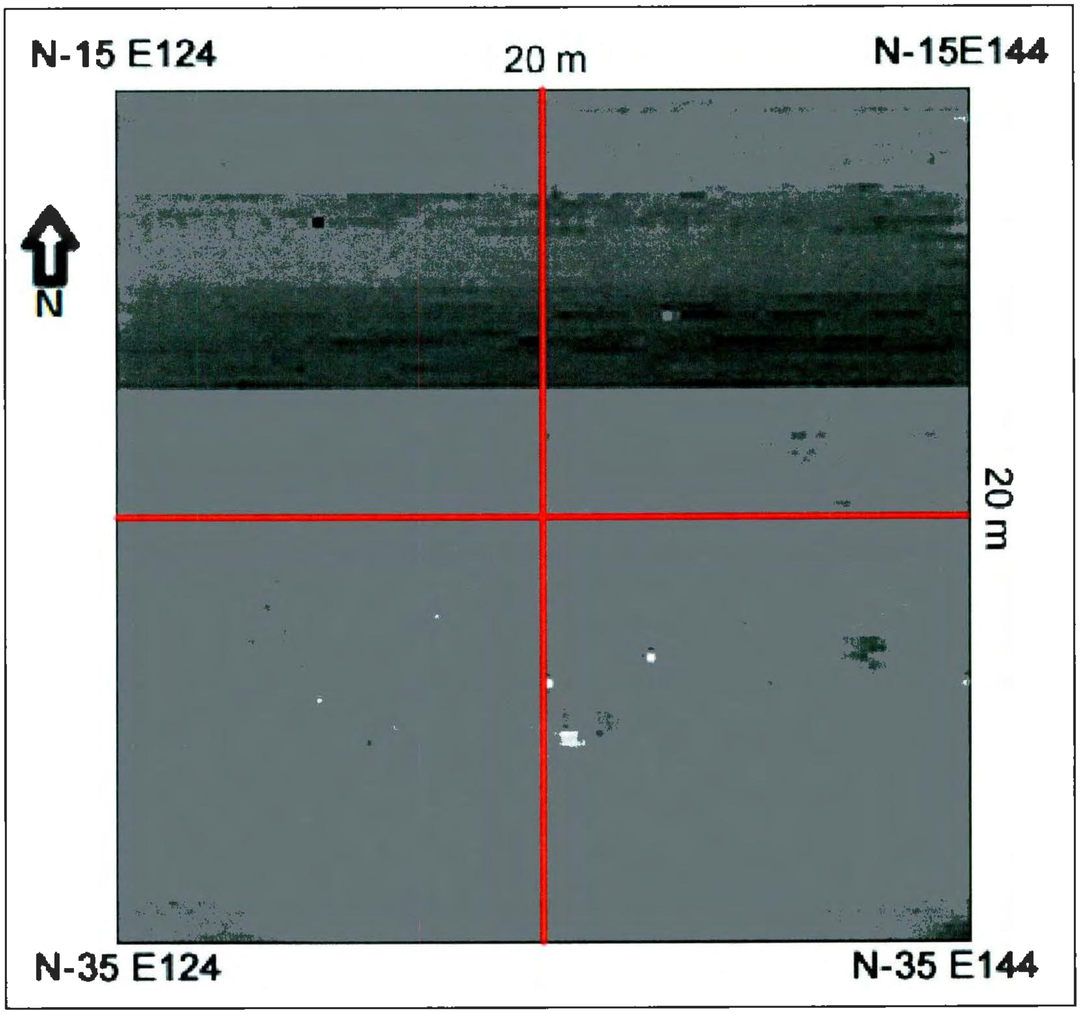

Figure 3.11a: House 10 raw magnetometry data. The red lines are used for reference as they divide the house approximately in quarters. Note the horizontal striping and the dot-like anomalies (white and black) which are most likely nails (excluding the large anomalies in the south-east quadrant).

Figure 3.11b is an example of processed magnetometry data. Clipping the data removes very high and very low measurements that are often not archaeologically significant. The Despike filter is used to remove very high measurements and replace them with neighboring readings. The Destripe filter removes the horizontal stripping caused by data collection. The High Pass filter increases high frequency information, enhancing anomalies that may be archaeologically meaningful (Kvamme 2006).

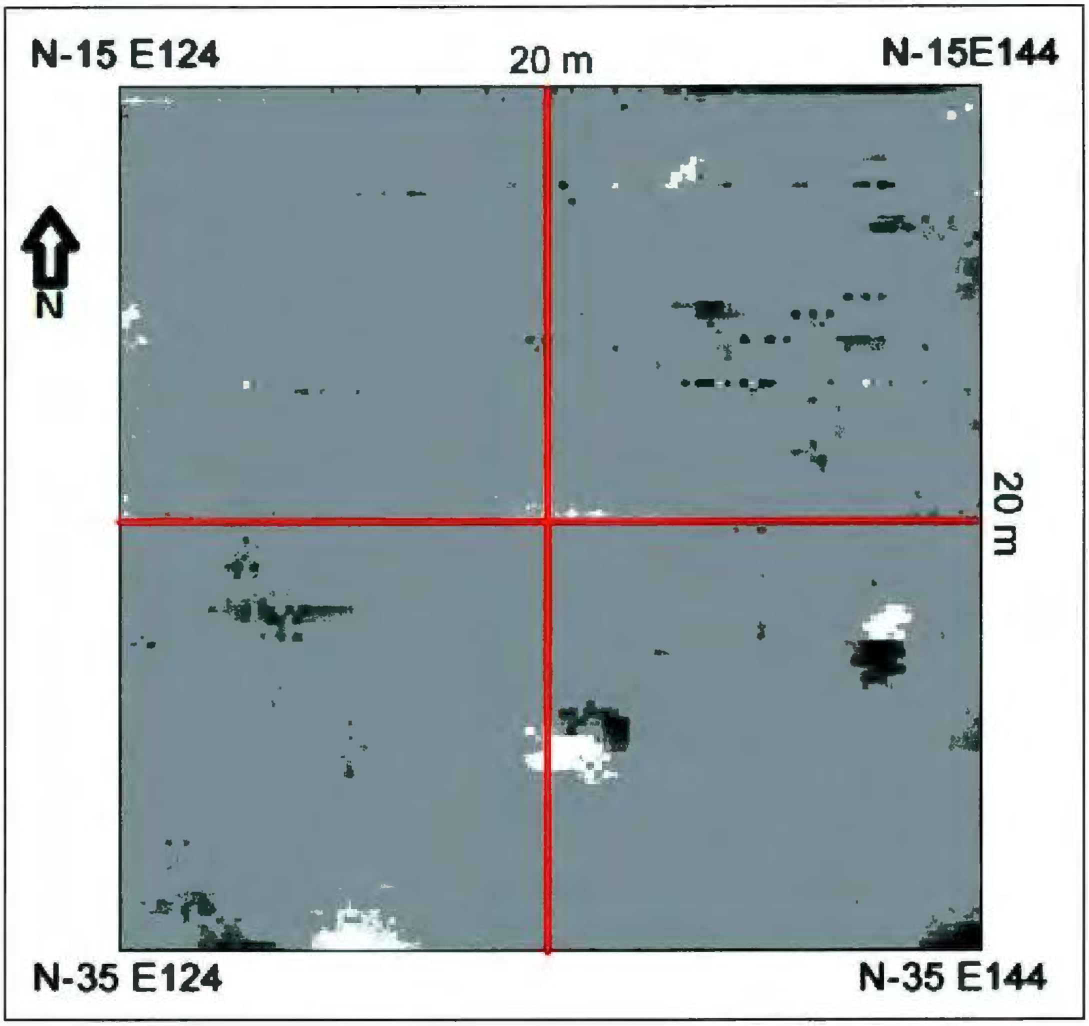

Figure 3.11b: House 10 processed magnetometry data, which has been clipped and run through Despike, Destripe, and High Pass filters.

3.7.2 GPR

The GPR results were processed using EKKO Mapper Version 4, provided by Sensors and Software (http://www.sensoft.ca/Products/Software/Details-Features.aspx#EKKOMapper). The data were processed to remove the effects of topography, to calculate penetration depth, and to enhance possible subsurface anomalies. See Figure 3.12a and 3.12b for an example of raw and processed data. The Dewow filter was used to get rid of noise associated with data collection (such as the movement of the antenna and the waves). The Background Subtraction filter was applied to remove noise associated with the movement of surface reflections and electromagnetic noise. The Gain filter was used to amplify signal strength, which decreases with depth (Dojak 2012). The GPR profiles were also used to create a GPR time slice (Figure 3.13).

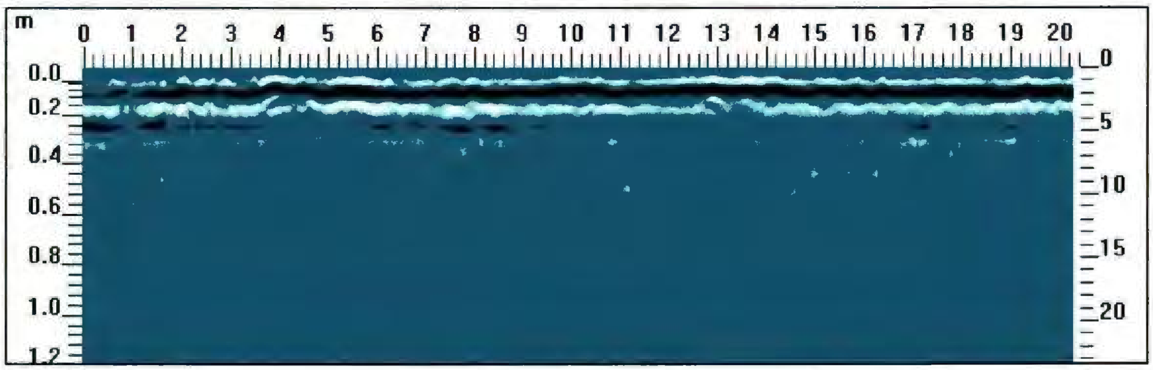

Figure 3.12a: House 10 GPR subsurface profile; raw data. Depth is along the y-axis and distance is along the x-axis

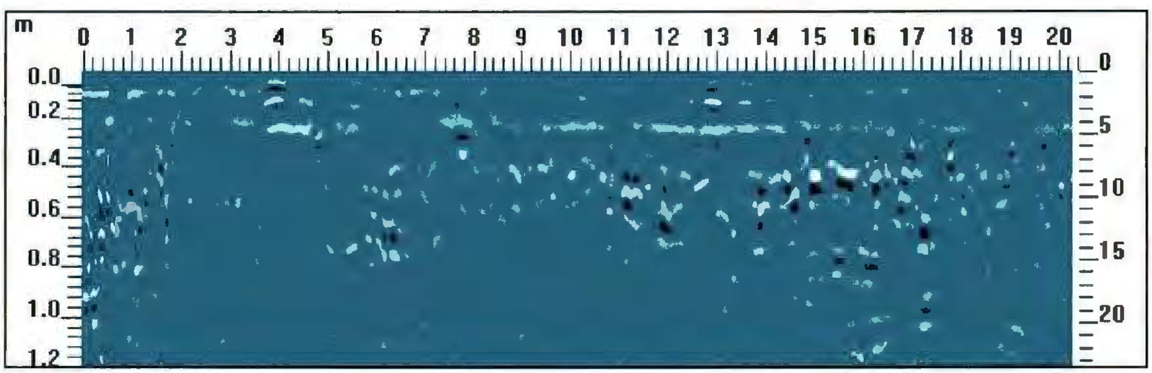

Figure 3.12b: House 10 GPR subsurface profile, with Dewow, Background Subtraction, and Gain processing filters applied. Depth is along the y-axis and distance is along the x-axis.

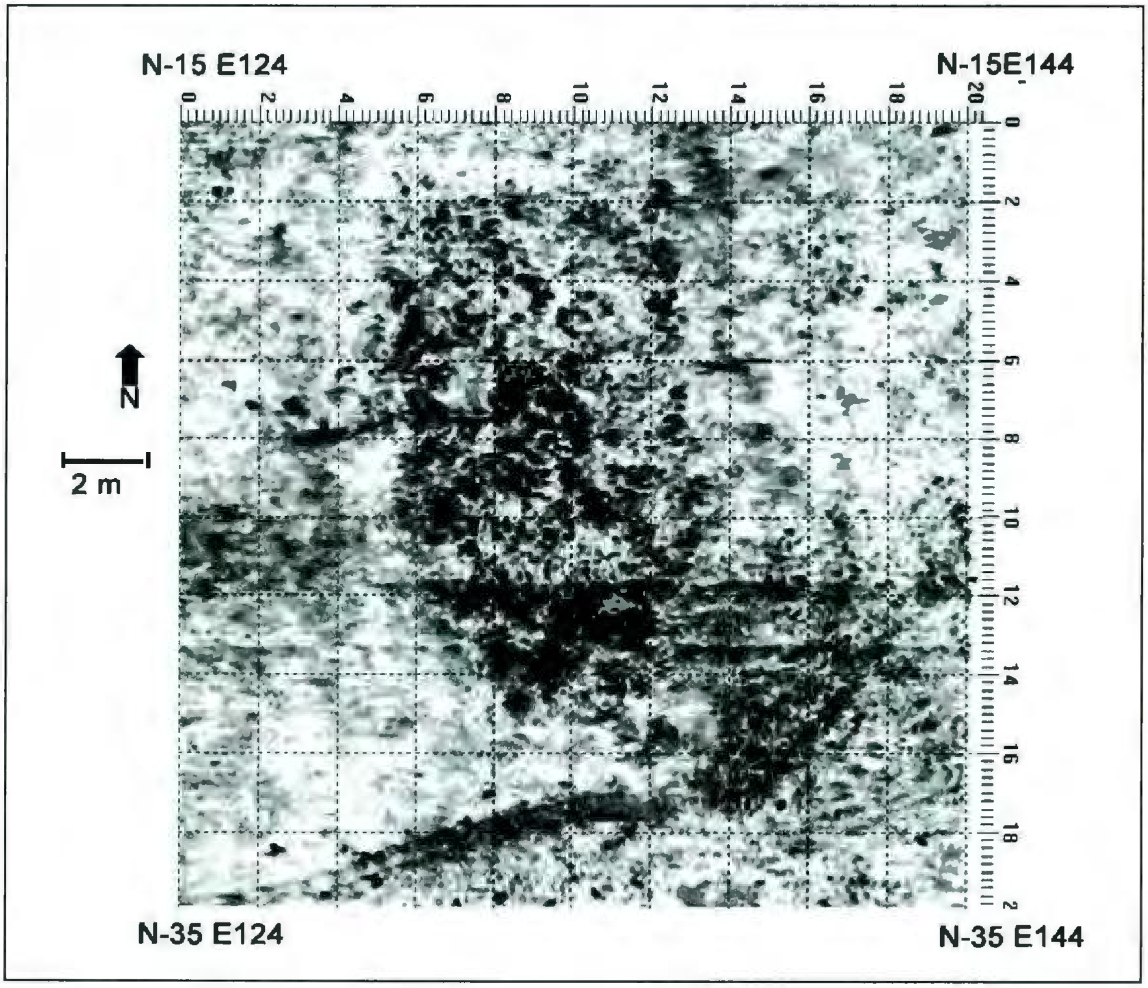

Figure 3.13: GPR time slice of House 10 at 40 cm depth. A time slice can be defined as a plan view map of all the readings at a specific radar return time (or depth) (Oswin 2009)

3.8 Summary

This chapter discusses the technical principles of magnetometry and ground penetrating radar. It also describes the way in which these methods were used during the 2011 and 2012 field seasons at Phillip's Garden. The results and interpretations are discussed in Chapters 4 and 5.

CHAPTER 4

House 10

4.1 Introduction

This chapter presents and compares the House 10 geophysical and archaeological results. House 10 was ground-truthed (fully excavated) during the 2011 field season; therefore, all of its features were mapped. This facilitates comparisons between archaeological features and geophysical anomalies, thus providing a picture of what specific archaeological features may look like in both magnetometry and ground penetrating radar data. The purpose of this is to identify whether dwelling features characteristic of other excavated middle phase dwellings (such as a large size, rear and side platforms, axial feature with associated post holes, rear pits, perimeter post holes, and entrances) can be identified in small-scale magnetometry and GPR surveys. Another reason for this to aid in the assessment of whether excavated and unexcavated dwellings render different geophysical survey results. This will be further discussed in Chapter 6.

4.2 Methodology

In order to interpret House 10 results, I review its architecture based on previous excavations data (Harp 1964; Renouf et al. 2005) and the 2011 field data. I compare House 10 feature characteristics such as size, shape, and depth (described below and also summarized in Table 1) as well as feature maps (Figure 4.2 and Figure 4.3) to the magnetometry and ground penetrating data anomalies. The purpose of this is to identify correlations between the excavation and geophysical data in order to identify specific archaeological features in the geophysical results.

4.3 House 10 Architecture

House 10 was excavated by Harp (1964) who primarily focused on the central depression where he identified an axial feature and several pits. In 2004 House 10 was trenched by the Port au Choix archaeology project under the supervision of Renouf (Renouf et al. 2005) whose excavation focused on a 1.5 m by 14.5 m east-west trench across the middle of the dwelling, exposing part of the axial feature. The trench also expanded past what Harp had identified as walls, which, during the 2004 excavation were found to be of unequal width: the western perimeter expanding 1.3 m (interpreted as a wall or a bench) and the eastern perimeter expanding 3.3 m (interpreted as a platform). The axial feature (Feature 116) excavation was expanded 50 cm to the south and 1 m to the north. Renouf et al. (2005) characterized the axial feature as a pavement of limestone slabs and cobbles measuring 1 m by 2.5 m. It was abutted by two pits. Renouf et al. (2005) suggest that these could have been post holes as the 2004 excavation revealed House 10 to be larger than previously thought and in need of interior supporting posts. Renouf et al. (2005) also identified a post hole (Feature 111) east of the axial feature. Anstey (2011) created a map of the dwelling (Figure 4.1) based on these previous excavations.

Figure 4.1: Plan of House 10, Phillip's Garden (Anstey 2011) based on Harp's notes. Renouf's et al. (2005) trench runs east-west (From Anstey 2011:70).

During the 2011 field season, the Port au Choix Archaeology Project re-excavated 103 m^2 of House 10 expanding beyond Harp's (1964) and Renouf's (Renouf et al. 2005) excavation boundaries. This excavation encompassed most of the dwelling with the exception of a small area in the south-eastern portion in the rear. The dwelling was also dismantled post-excavation (Wells et al. 2012).

Based on the 2011 excavations House 10 is the largest dwelling excavated at the site, measuring approximately 121.5 m^2 or 13.5 m north to south and 9 m east to west (Wells et al. 2012:7). House 10 is similar to other middle phase dwellings: it is large and it has a central depression bisected by an axial feature with associated post holes; two large pits towards the rear; and well defined perimeter walls and platforms (Wells et al. 2012:7)

A summary of House 10 features is presented in Table 4.1. This includes their type, shape, dimensions, location, and any additional comments. Their type and location in the dwelling are also presented in Figure 4.2.

For the purpose of the current research, in this chapter I will focus primarily on features clearly identified in previously excavated Dorset Palaeoeskimo middle phase dwellings at Phillip's Garden (Cogswell et al. 2006; Renouf 2007, 2009, 2011). These include the central depression, rear and/or side platforms, axial feature with associated post holes, rear storage pits, perimeter post holes, and the entrance.

Table 4.1: House 10 Feature list including feature number, type, shape, size, depth, and comments. The table is based on excavation reports (Renouf et al. 2005), 2011 excavation notes and Wells et al. 2012. Note L.M. is modern level.

Feature	Type	Shape	Dimensions	Depth	Comments
100	post hole	circular	40 x 40 cm	37 cm	lined with sand and small rocks central post hole
104	pit	circular		L2 to L4	circular arrangement of stones yield: bone
111	post hole	square	15 x 53 cm	10 cm	found near large whale bone slab
116	axial feature	oval	2.25 x 0.75 m		
115	post hole	oval	15 x 15 cm	45 cm	surrounded by flat stones flat stone at its base central post hole

Feature	Type	Shape	Dimensions	Depth	Comments
100	post hole	circular	40 x 40 cm	37 cm	lined with sand and small rocks central post hole
104	pit	circular		L2 to L4	circular arrangement of stones yield: bone
111	pit	square		L3	found near large whale bone slab
116	axial feature	oval	2.25 x 0.75 m		
115	post hole	oval	15 x 15 cm	LM 45 cm	surrounded by flat stones flat stone at its base central post hole
369	pit	circular	45 x 45 cm	40-45 cm	associated with F370 generally in line with house center, N of rear platform yield: flakes, faunal, artefacts
370	pit	oval to circular	55 cm N/S 80 cm E/W	LM 55 cm	20 cm from F369 central part of house depression N of rear platform near tree trunk yield: flakes, faunal - disturbed context dug beyond original base
371	post hole	circular	15 x 15 cm	LM 25 cm	small depression surrounded by rocks NW corner of W wall
372	pit	circular	outer 50 x 50 cm inner 20 x 20 cm	LM 30 cm	shallow pit lined with pebbles outer area lined with palm sized rocks filled with Harp's back dirt may be natural
373	pit	circular	35 cm N/S 40 cm E/W	LM 30 cm	shallow pit lined with pebbles natural or storage
374	pit	oval	25 cm N/S 40 cm E/W	LM 20 cm	shallow pit different colour sand
375	possible post hole	square	7 cm N/S 10 cm E/W	LM L4	determined as unlikely feature
376	possible post hole	oval	25 cm N/S 10 cm E/W	LM 10 cm	discountinued
377	possible post hole	oval	8 cm N/S 7 cm E/W	LM 10 cm	discountinued

387	charcoal concentraton	circular	50 cm N/S 70 cm E/W	L2	within midden feature
388	midden	triangular	80 cm N/S 60 cm E/W	L2	contains articulated seal bones
389	flake concentraton		20 x 20 cm	L3	
390	post hole	circular	15 x 15 cm	L3 approx. 45 cm	surrounded by stones
391	post hole	circular	18 x 18 cm	L4 20 cm	below motted soil surrounded by sand
392	flake concentraton	circular	15 cm N/S 18 cm E/W	L2	
393	motted soil	amorphous	48 cm N/S 76 cm E/W	L3	multi coloured
394	soapstone concentraton	oval		L3	granulated, reddened
395	entrance stones	oval	80 cm N/S 70 cm E/W	L4	arrangement of stones in front of the house
396	post hole	circular	20 x 20 cm	L4 20 cm	below motted soil bottom had beach pebbles possible for a light post
397	motted soil	square	20 x 20 cm	L3 L4	
398	possible post hole	circular		L4 approx. 25-30 cm	divot, not post hole
399	dwelling interor	square to circular	6 m N/S 5 m E/W	45-70 cm	dwelling interior outline area at the foot of walls and platforms
400	midden	circular	60 x 60 cm	L4	
401	possible post hole	square	17 cm N/S 20 cm E/W	L4 approx. 10-15 cm	discountinued
402	whale bone	rectangular	32x12 cm	L2	slab of whale bone
403	post hole	square	24 cm N/S 21 cm E/W	L4 approx. 20 cm	shallow stones arranged to form a post hole
404	motted soil	amorphous	60 cm N/S 80 cm E/W	L3	
405	pit	circular to oval	30 cm N/S 60 cm E/W	L.4 approx. 25 cm	part of 2 pit feature initially identified by Harp
406	pit			L4 approx. 25 cm	
407	post hole	square	15 cm N/W 10 cm E/W	L4 approx. 35 cm	stones arranged to form a post

408	possible post hole	circular		L4	divot, not post hole under motted soil
409	possible post hole	circular	10 x 10 cm	L4	discontinued
410	post hole	circular	40 cm N/S 33 cm E/W	L4 approx. 5 cm	underneath stones may not be associated with H10
411	post hole	circular	10 x 10 cm	15-20 cm	
412	post hole	circular	10 cm N/S 15 cm E/W	L4 approx. 35 cm	
413	pit	circular	42 cm N/S 20 cm E/W	L4	shallow pit yield: bone
414	post hole	square	15 x 15 cm	L4 approx. 20 cm	
415	eastern platform		7.5 m N/S 3-3.3 m E/W* 1.4-1.6 E/W**		* platfom wider in the middle ** platform narrow at north and south ends
416	western perimeter		7 m N/S 1.2-16 E/W*		* there was a small indentation in the wall where it measured 60-60 cm in width
417	entrance		80 x 70 cm		break in the front perimeter berm
418	rear platform		4 m N/S > 7 m E/W*		*excavation did not continue east of the platform

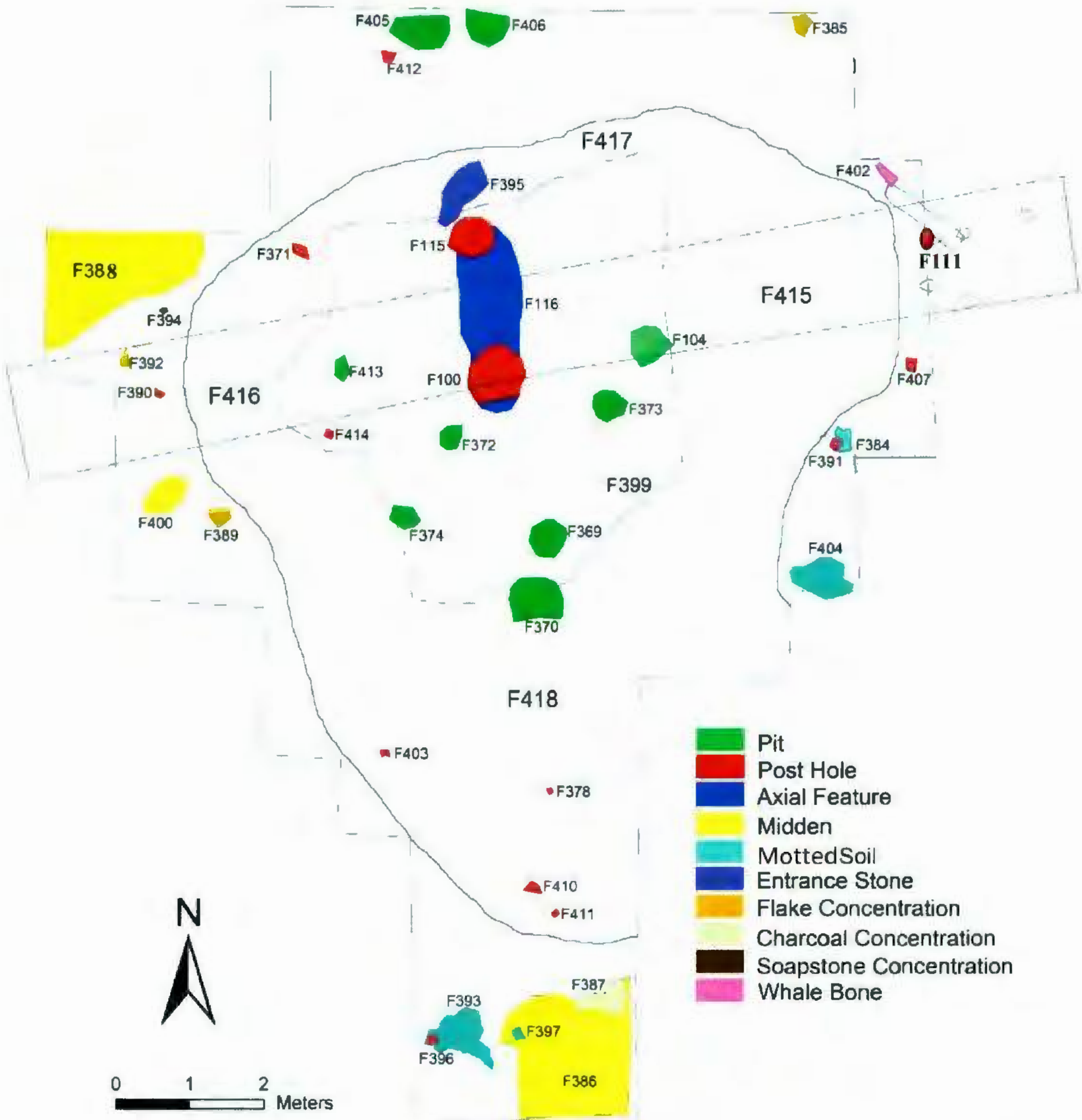

Figure 4.2: House 10 Features: type and location within the dwelling based on the 2011 excavation. Feature 399 is the central depression, Feature 415 is the eastern platform, Feature 416 is the western perimeter, Feature 417 is the entrance, and Feature 418 is the rear platform (Wells et al. 2011:9). Note Renouf's (2005) trench running east to west through the dwelling (Image courtesy of the PAC Project).

Wells (Wells et al. 2012) identified a platform (Feature 415) in the eastern perimeter of the dwelling. It was constructed out of two layers of flat stones embedded in the soil. The eastern platform extended from the rear platform southward, curving towards the front of the dwelling. It was 7.5 m long and it was widest in the middle measuring between 3 and 3.3 m and between 1.4 and 1.6 m at its southern and northern ends (Wells et al. 2012:13).

The 2011 excavations confirmed Renouf's descriptions of the western perimeter as narrower than the eastern one. It was constructed out of two layers of stone: the top ones were larger and flatter and those beneath. The western wall was between 1.2 and 1.6 m wide (Wells et al. 2012:14). Its interior length was 5.2 m and its exterior length was 7 m (Wells et al. 2012:14). The rear of the western perimeter curved towards the rear platform. Its inner and outer edges were relatively straight with the exception of a 60 to 70 cm wide inner indentation. Wells (Wells et al. 2012) suggests this was a result of Harp's excavation.

House 10 rear platform (Feature 418) extended south of the central depression (Figure 4.2 and Figure 4.3) and was 4 m long (Wells et al. 2012:15). Its width could not be determined as the excavation did not extend past the eastern edge of the platform. The Port au Choix Archaeology Project excavated an area 7 m wide (Wells et al. 2012:15). It was characterized by a flat area constructed of flat stones.

The central depression (Feature 399) was generally square and measured 6 m north to south and 5 m east to west (Figure 4.2 and Figure 4.3) (Wells et al. 2012:12). It was constructed 70 cm below the eastern platform and 45 cm below the western perimeter. The central depression was bisected by the axial feature (Feature 116) and its associated pits (Feature 100 and Feature 115) (Figure 4.2) (Wells et al. 2012:12).

Figure 4.3: House 10 excavation with Features 399, 415, 416, 417, and 418 highlighted (Image courtesy of PAC Project).

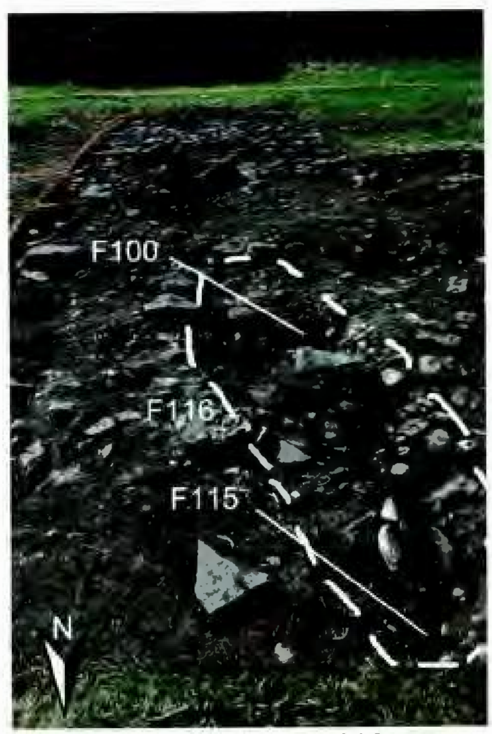

Figure 4.4: Image of House 10 axial feature (Feature 116, dotted line) with 2 pits abutting it (Features 100 and 115) ; north is pointing down (Image courtesy of PAC Project)

The axial feature was characterized by an oval depression lined with flat stones in the center of the dwelling. It measured 2.25 m by 0.75 m (Wells et al. 2012:16). It had two post holes abutting its southern and northern ends (Figure 4.4). Feature 100 was a circular post hole measuring 40 cm in diameter and 37 cm in depth (Wells et al. 2012:16). It was lined with sand and small rocks. It also had two large stones around the northern side of its opening. Feature 115 was also circular post hole measuring 15 cm in diameter and 45 cm in depth (Wells et al. 2012:17). Its opening was surrounded by flat stones curving towards the center and its base was lined with a flat stone (Wells et al. 2012).

Two substantial pit features (Feature 369 and Feature 370) were also located towards the rear of the central depression (Figure 4.2). Feature 370 measured 55 cm by 80 cm and it was 55 cm deep (Wells et al. 2012:20). Its opening was lined with rocks; the western edge was lined with larger rocks while the other sides were lined with smaller ones. The interior of the pit was lined with small beach cobbles. Feature 369 was located 20 cm north of Feature 370. It measured 45 cm in diameter and between 40 and 45 cm in depth (Wells et al. 2012:20). Its sides were lined with small stones and its bottom was lined with beach cobbles and sand (Wells et al. 2012).

Several perimeter post holes were identified during the 2011 excavations (Features 410, 411, 403, 378, 396, 391, 497, 111, 412, 390, 371, and 414) (see Figure 4.2). These were surrounded by firmly packed stones and contained little to no artefacts. Most post holes were found in Level 4 (with the exception of Features 111 and 390 which were first identified in Level 3) (Wells et al. 2012).

Feature 410 was a large post hole in the middle of the rear platform. It measured 20 cm in diameter and 30 cm in depth (Wells et al. 2012:18). Feature 411 was 25 cm east of Feature 410. It measured 10 cm in diameter and 15-20 cm in depth (Wells et al 2012:18). Features 403 and 370 were also found on the rear platform. Feature 403 was reinforced by stones and it measured 24 cm by 21 cm and 20 cm in depth (Wells et al. 2012:18). Feature 378 was a small post hole surrounded by stones and measuring 15 by

10 cm and 10 cm in depth. Feature 396 was identified outside the rear of the dwelling. It was a stone-lined circular post hole measuring 20 cm in diameter and 20 cm in depth.

Three post holes (Features 391, 407, and 111) were found in the perimeter of the eastern platform (Figure 4.2). Feature 391 measured 18 cm in diameter and 15 cm in depth (Wells et al. 2012:19). Feature 404 measured 15 cm by 10 cm and 35 cm in depth (Wells et al. 2012:19). Feature 111 measured 23 cm by 15 cm and 10 cm in depth (Wells et al. 2012:19).

One post hole was found in front of the dwelling towards the west side (Feature 412). It measured 10 cm by 15 cm and 35 cm in depth (Wells et al. 2012:19). Its northern edge was stone lined and the hole was angled. Wells (Wells et al. 2012) suggests its possible use as supporting a whale rib post.

Three post holes were found close to the western wall (Features 390, 371, and 414). Feature 390 measured 15 cm in diameter and 40 cm in depth. Feature 371 measured 15 cm in diameter and 25 cm in depth. Feature 414 measured 15 cm in diameter and 20 cm in depth (Wells et al. 2012:19).

The entrance to the dwelling was located in the front perimeter (Feature 417) (Figure 4.2 and Figure 4.3). It was characterized by an east to west berm constructed out of differently sized stones set into the sandy matrix. Halfway through the berm the entrance was marked by a large flat stone demarking the threshold. It was lower than then surrounding areas and measured 80 cm by 70 cm (Wells et al. 2012:10).

4.4 Data Analysis and Interpretation

House 10 data analysis is presented below divided into two sections: magnetometry and GPR. Each section presents the plan-view geophysical results without interpretation which follows in a separate section. The data analysis will only focus on features identified as characteristic of middle phase dwellings at Phillip's Garden: rear and/or side platforms, the central depression, the axial feature and associate post holes, rear pits, perimeter pits, and dwellings entrance.

4.4.1 Magnetometry Analysis and Interpretation

Three magnetic plan-view maps are presented below: magnetometry results (Figure 4.5a), magneometry results with visible anomalies circled (4.5b), and magneomtry results with the overlain excavation map (Figure 4.6). Each map represents the 20 by 20 m grid within which we surveyed the dwelling. The un-interpreted data is divided into four quadrants by a cross running through the center of the dwelling. This was done in order to increase the readability of the images.

The magnetomery results appear slightly pixilated. This is due to a relatively small area being presented at a close range, similarly to zooming into a photograph. The pixilation is dependent on our data collecting including the spacing between the transects (10 cm) and how often the magnetometer took a reading (every 10 cm). Each pixel represents a 10 x 10 cm area on the ground. While the maps could have been smoothened out more, this would have changed the data, obscuring some features.

Below is an image of the magnetometry data presented in plan view without any interpretations (Figure 4.5a). Several features stand out to the naked eye even without a comparison with the excavation data (Figure 4.5b).

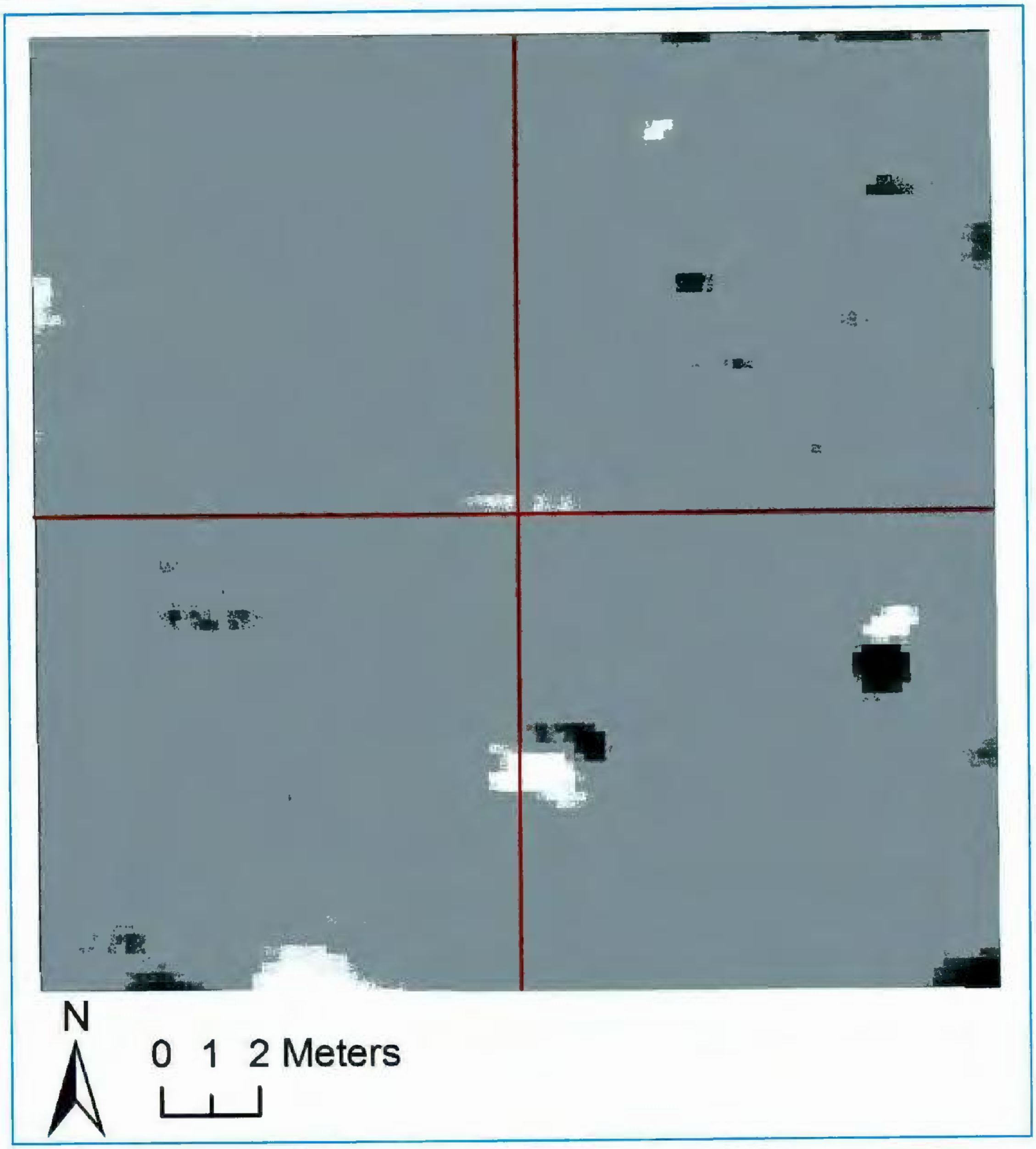

Figure 4.5a: House 10 magnetometry results presented in plan view with no interpretations.

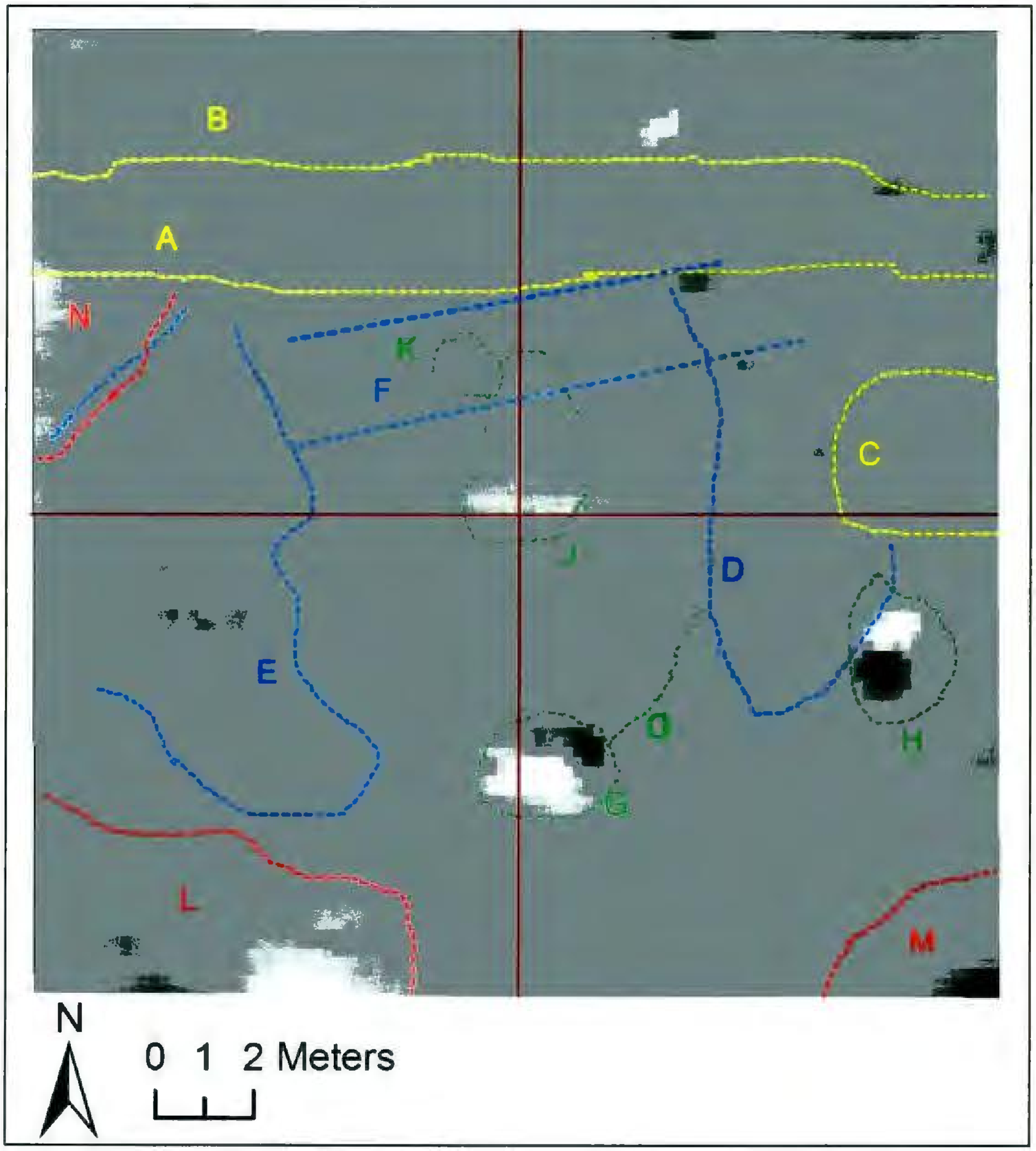

Figure 4.5b: House 10 magnetometry results presented in plan view with easily indefinable magnetic anomalies circled. These are discussed below

Anomalies A, B, and C (Figure 4.5b, yellow) are most likely due to data acquisition error (such as walking too fast/too slow or holding the magnetometer improperly). Anomalies L, M, N (Figure 4.5b, red) are not within the excavation area (Figure 4.6) and therefore cannot be interpreted as there is no basis for comparison.

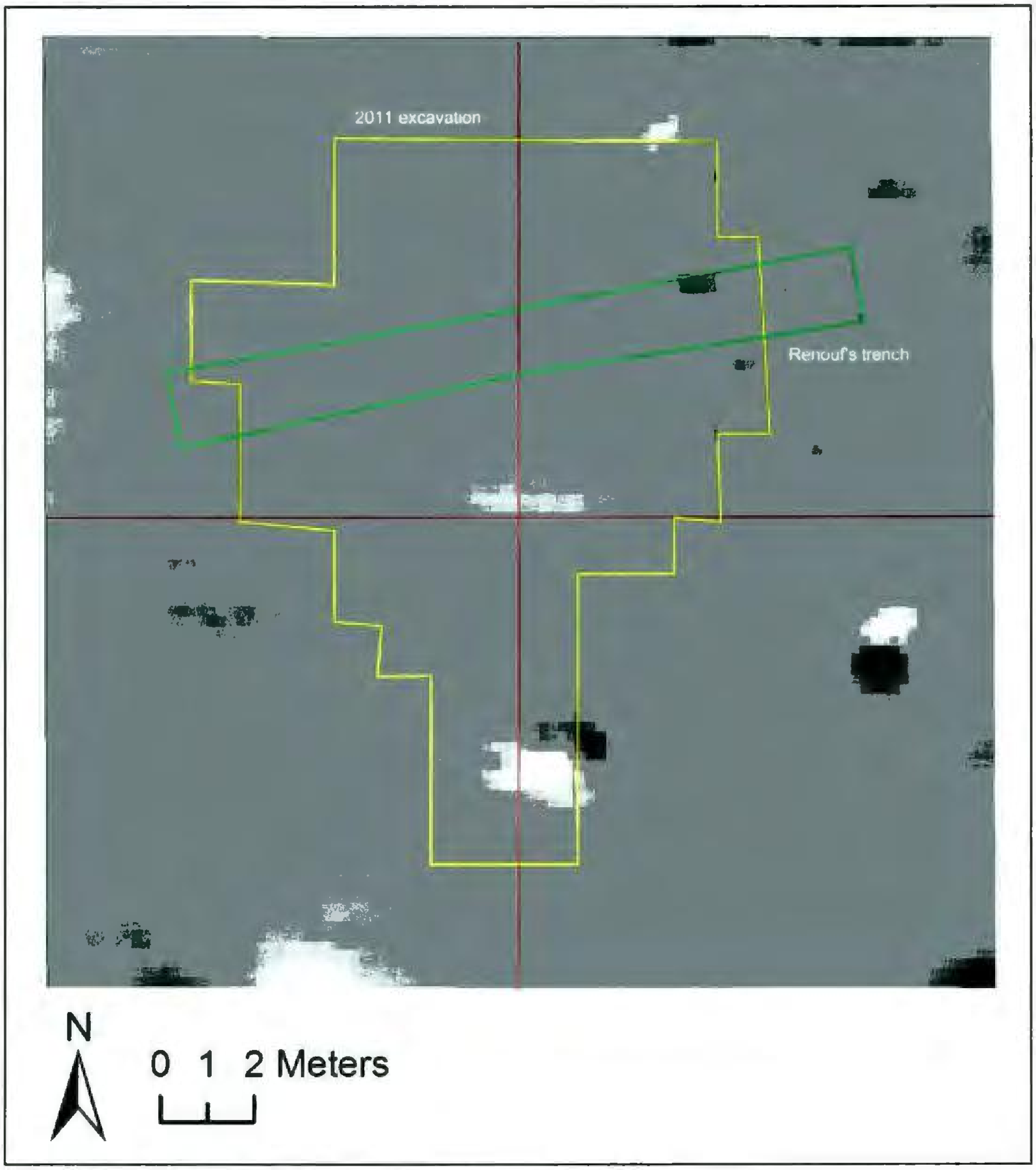

Figure 4.6: House 10 magnetometry results with overlain excavation area: the 2011 excavation (yellow) (Wells et al. 2012) and Renouf's trench (green) (Renouf et al. 2005)

Anomalies E and D (Figure 4.5b, blue) correlate with Harp's back dirt piles, which flanked House 10 on its western and eastern sides. Anomaly F (Figure 4.5b, blue) correlates with part of Renouf's trench (Renouf et al. 2005) (Figure 4.6).

The most striking anomalies are G and H (Figure 4.5b, green). Anomaly G correlates with a charcoal concentration (Figure 4.7, Feature 387). It was uncovered at the rear of the dwelling within a midden feature, south of the rear platform. It was circular and it measured roughly 50 cm by 80 (Wells field notes 2011). Although anomaly H falls outside of the excavation area (Figure 4.6), based on its resemblance to anomaly G I suggest this is also a charcoal concentration.

Anomaly O falls outside out the excavation area (Figure 4.6). It does correlate in shape and direction (curving north-east and running north to south) with the eastern edge of the rear platform (Feature 418) (Figure 4.7, anomaly O in light blue). If this is part of the rear platform, it would make it approximately 8 m east to west at its widest point.

Anomaly J does not correspond with any excavation feature – it could be a result of previous excavation or natural soil changes.

Anomaly K corresponds with Feature 100 (a post hole abutting the axial feature on its southern end). It was circular, measuring 40 cm in diameter and 37 cm in depth. It was lined small rocks and sand (Wells et al. 2012:16).

No other correlations between excavated features and magnetic anomalies were identifiable in the data. This could be due to a combination of the instrument not being sensitive enough to pick these features up, not enough of a contrast between the features and the surrounding matrix, the size of some features, and previous excavations. The instrument was very good at picking up charcoal concentrations, even below midden deposits.

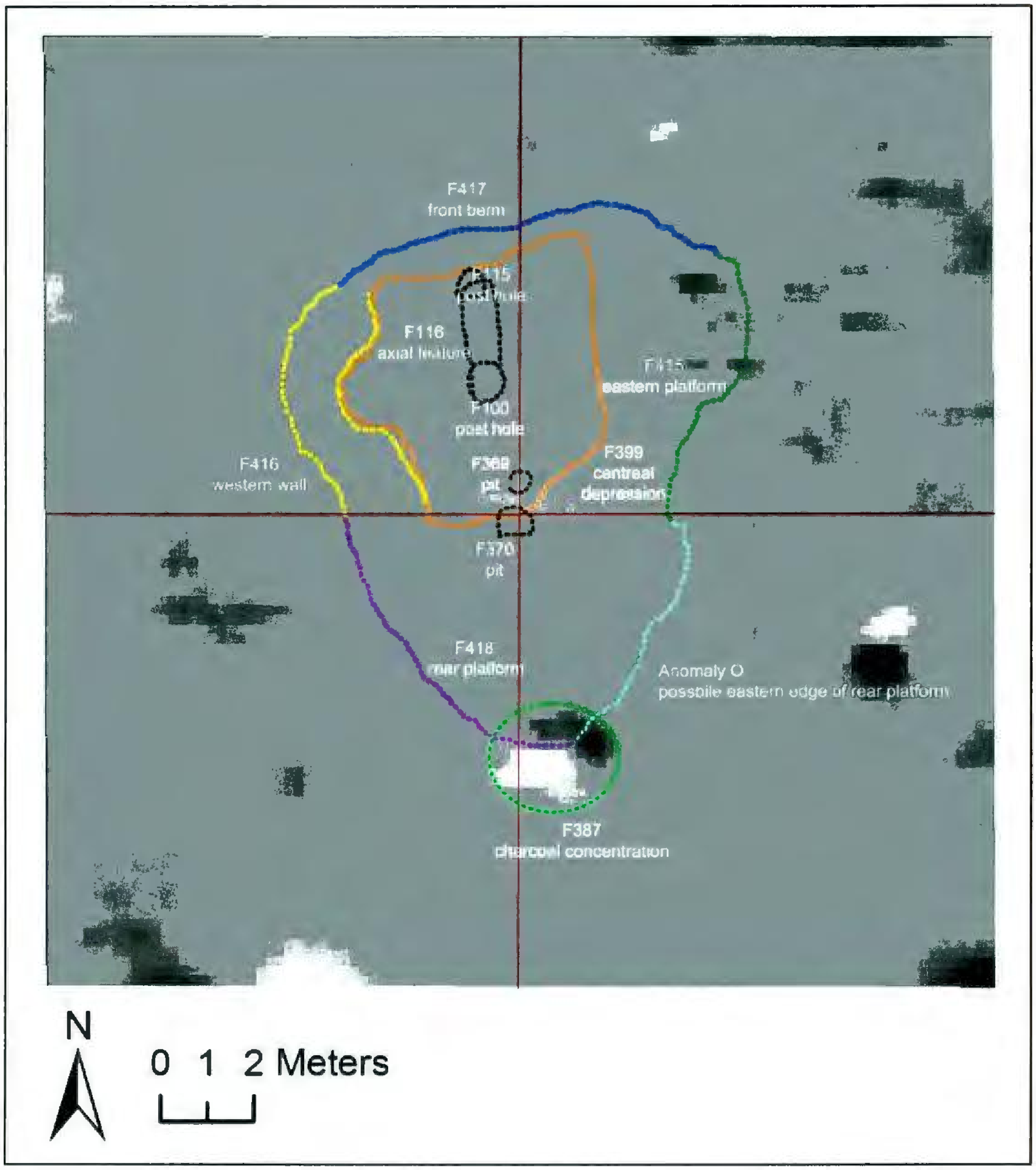

Figure 4.7: House 10 magnetometry results with overlain features excavated during the 2011 field season (after Wells et al. 2012:9). Note Anomaly O as a possible continuation of Feature 418's outline.

4.4.2 GPR Analysis and Interpretation

House 10 GPR results are divided into time slices and profiles. The time slices are divided based on their depth in nanoseconds. Nanosecond depth was chosen instead of depth in meters due to the fact that the signal traveled at different speeds throughout the grid, making it difficult to determine an accurate depth in meters. This was further complicated by Harp's back dirt piles, which appeared as mounds on the relatively flat surface.

Most of the archaeological features in House 10 are obscured by Harp's excavation, including both his excavation area and his back dirt piles. One back dirt pile west of Harp's excavation is disturbed by Renouf's trench (Renouf et al. 2005) (Figures 4.8, 4.9, 4.10). However, there are some correlations between archaeological features and anomalies in the GPR data for House 10.

The correlations between archaeological features and GPR anomalies were first identified on times slices. I did this by comparing the archaeology feature map with time slices at different nanosecond depths and identifying possible matches. I further suggest these in the GPR profiles of the lines bisecting the anomalies. Other correlations between archaeological features and GPR anomalies were done by only analyzing GPR profiles. I did this by comparing the location and size of GPR anomalies to the location and size of identified archaeological features.

Three correlations between archaeological features and GPR anomalies were made using these methods. These include Feature 100 (post hole), Feature 399 (central depression), and Feature 418 (rear platform).

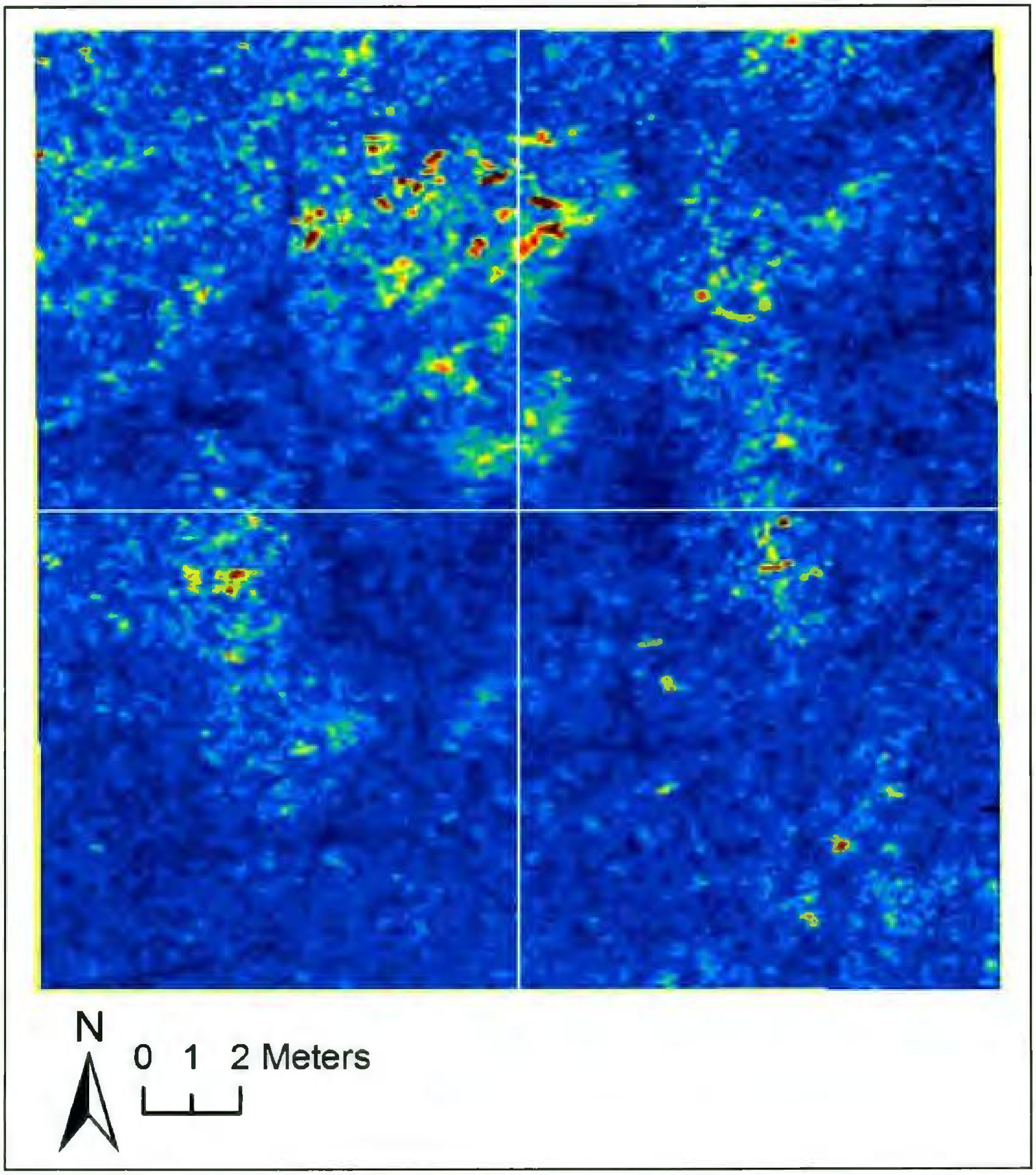

Figure 4.8: House 10 GPR results with no interpretation presented at a depth between 15 and 17 nanoseconds.

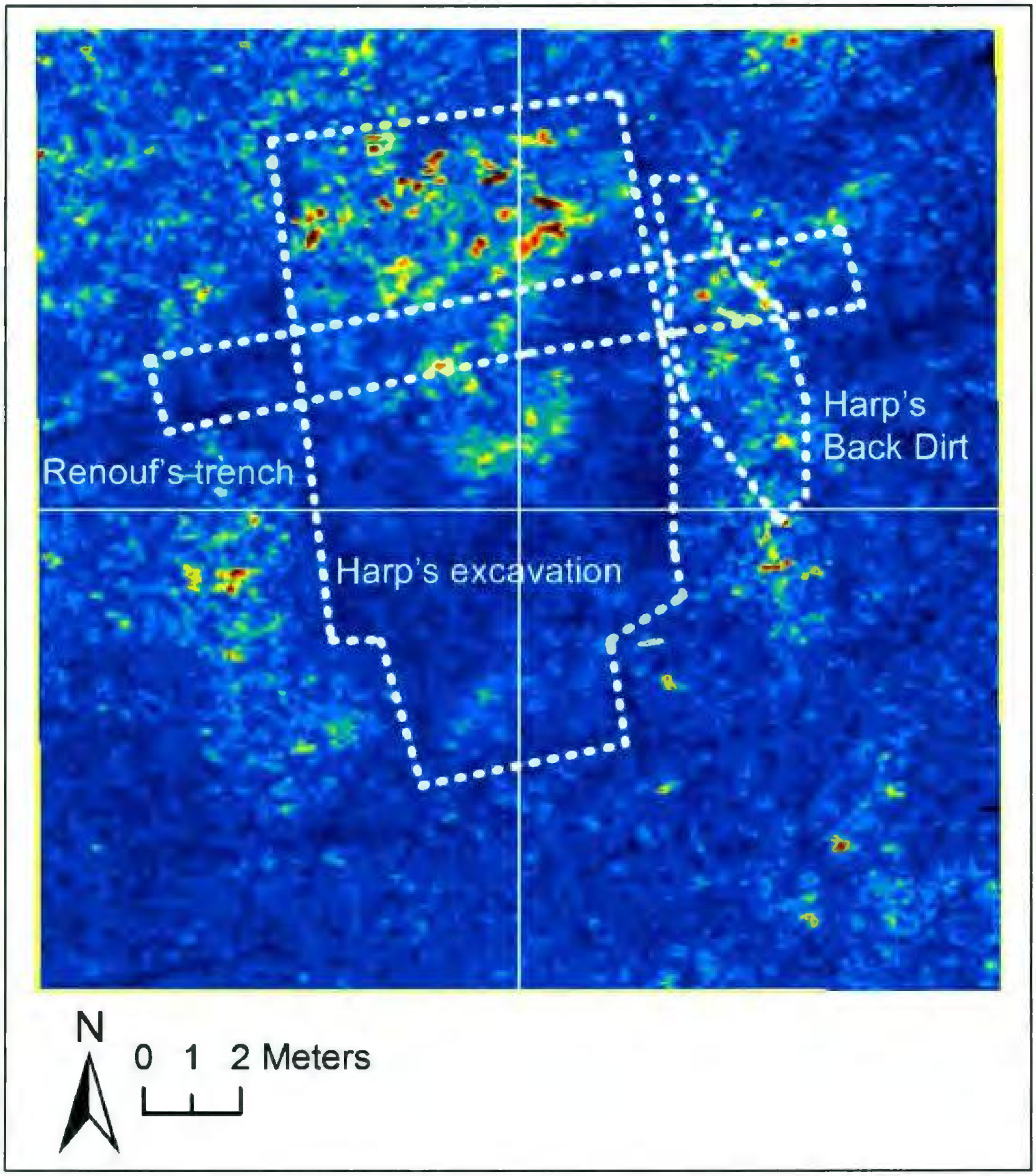

Figure 4.9: House 10 GPR results presented at a depth between 15 and 17 ns. Note Harp's excavation and back dirt and Renouf's trench (Renouf et al. 2005).

Feature 100, the southern post hole abutting the axial feature correlates to an anomaly apparent in several time slices (Figure 4.10 and Figure 4.11). Feature 100 was a circular post hole 40 cm in diameter and 37 cm deep (Wells et al. 2012:16).

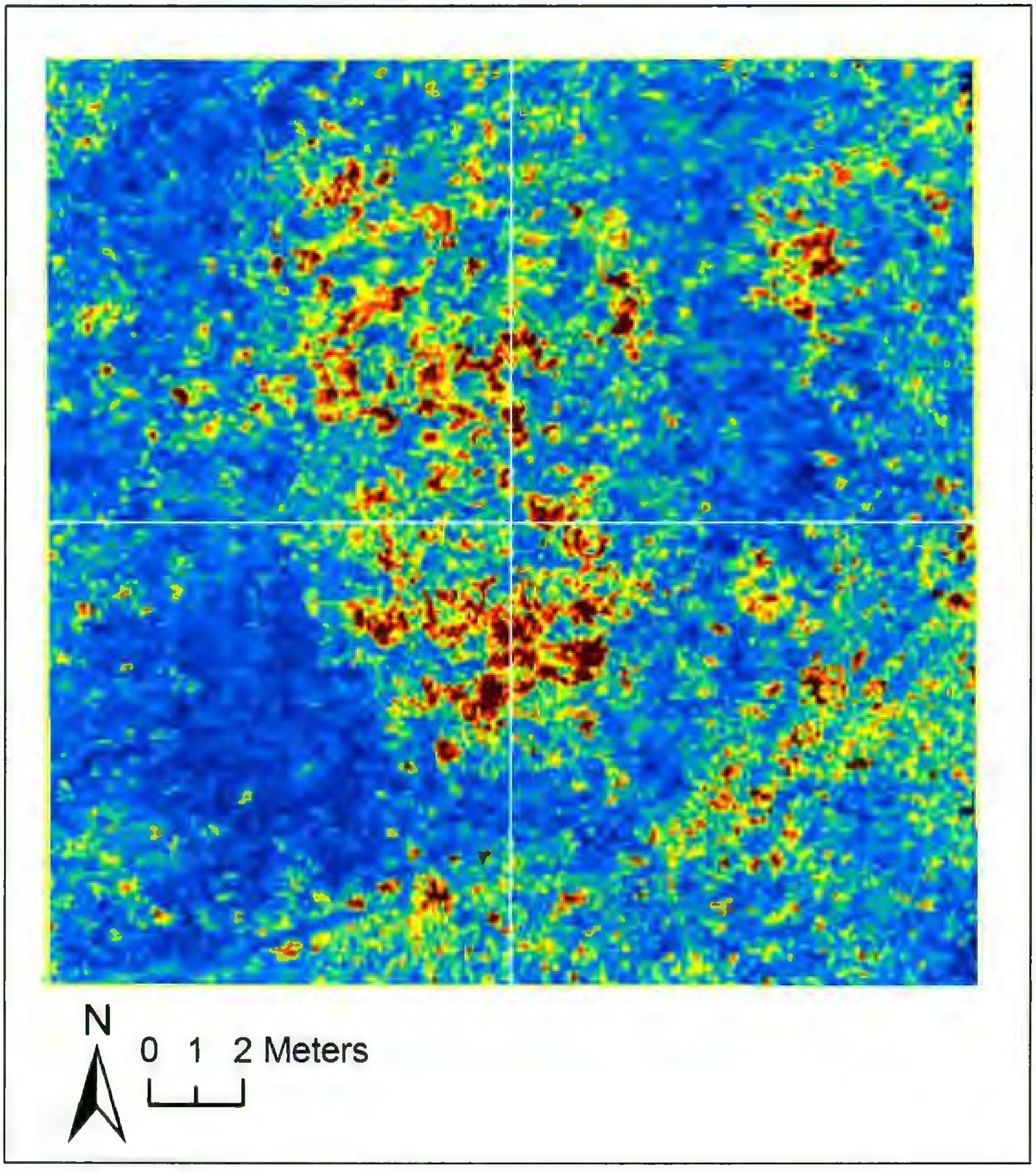

Figure 4.10: House 10 GPR results presented with no interpretation at a depth between 5 and 7 ns.

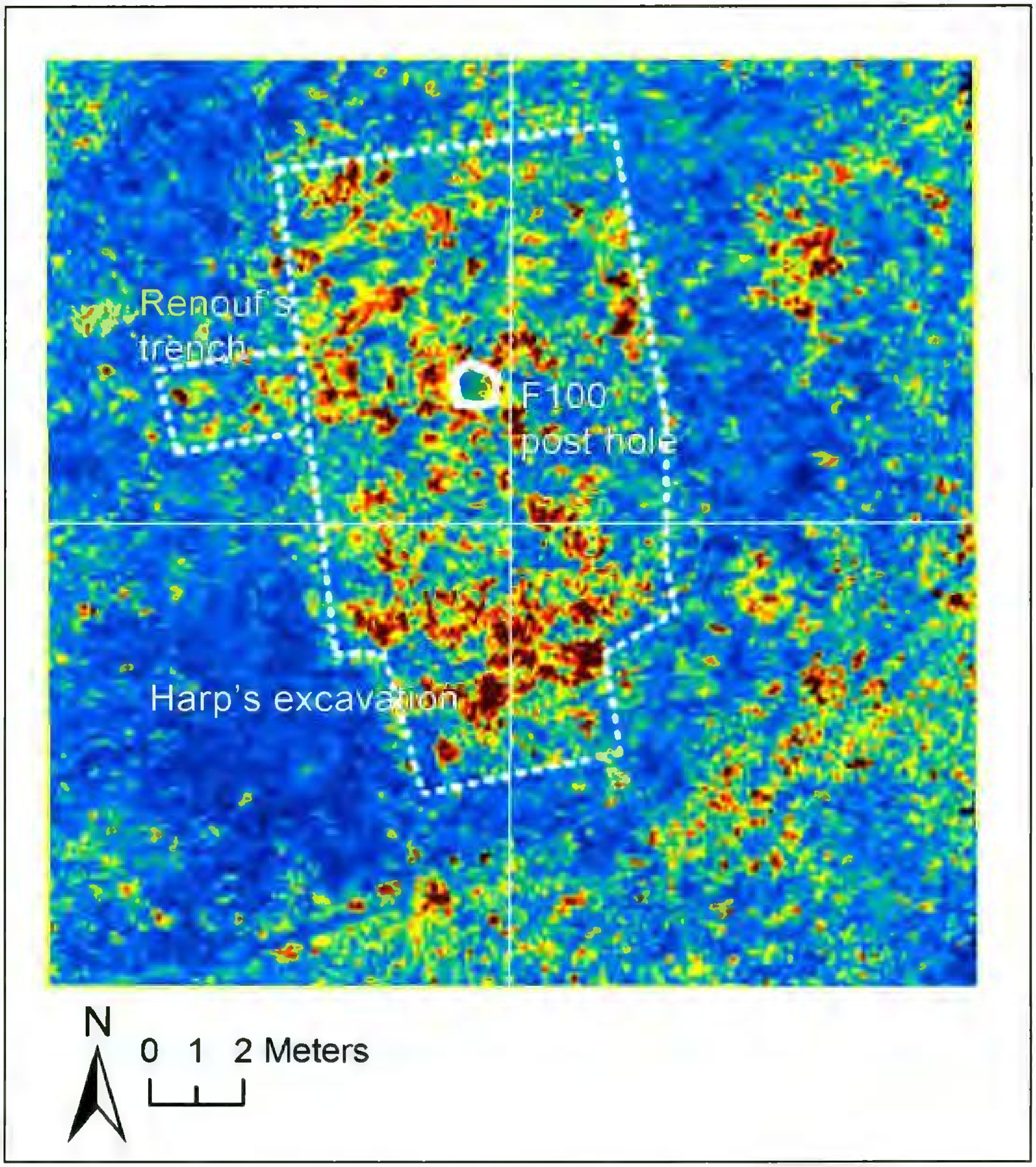

Figure 4.11: House 10 GPR results presented with no interpretation at a depth between 5 and 7 ns. Note Harp's excavation and the western part of Renouf's trench (Renouf et al. 2005). Also note Feature 100 (post hole).

Its location and size correlate with the location of a small round anomaly in a GPR time slice between 5 and 7 ns. The anomaly measures roughly 40-45 cm in diameter. This anomaly can also be identified on a GPR profile of line 71, which runs west to east bisecting the anomaly (Figure 4.12 and Figure 4.13). The anomaly can be found between

8.8 m and 9.2 m on the x-axis at a depth of 14 ns. Based on its location on the line (coinciding with the location of Feature 100) and its size (around 40 cm) I suggest this anomaly is analogous with the bottom of Feature 100.

Another anomaly stands out in the GPR profile of line 71 which occurs between about 6 m to 11 m (Figure 4.12 and Figure 4.13) and can be seen most clearly around a depth of 5 ns. Based on its length (about 5) and location on the line I suggest this anomaly is analogous with Feature 399 – the central depression of House 10 which measures 5 m east to west (Wells et al. 2012:12).

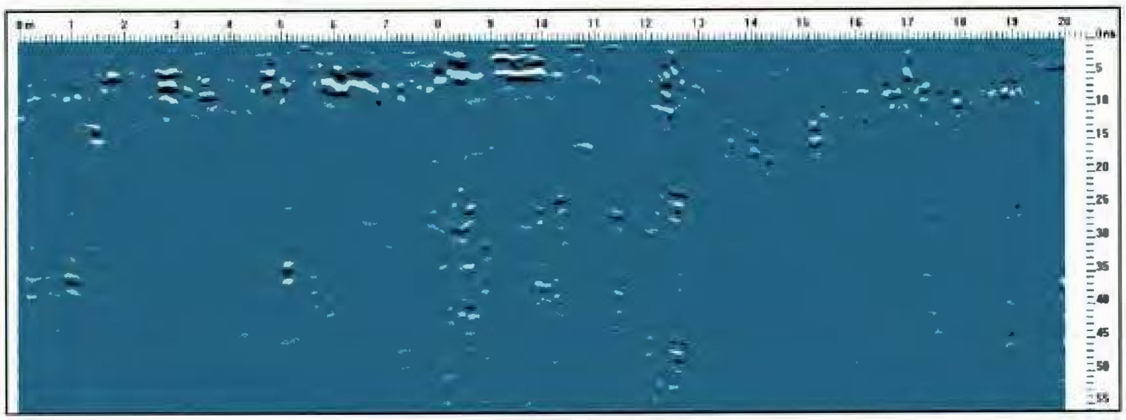

Figure 4.12: House 10 GPR profile of line 71 with no interpretations.

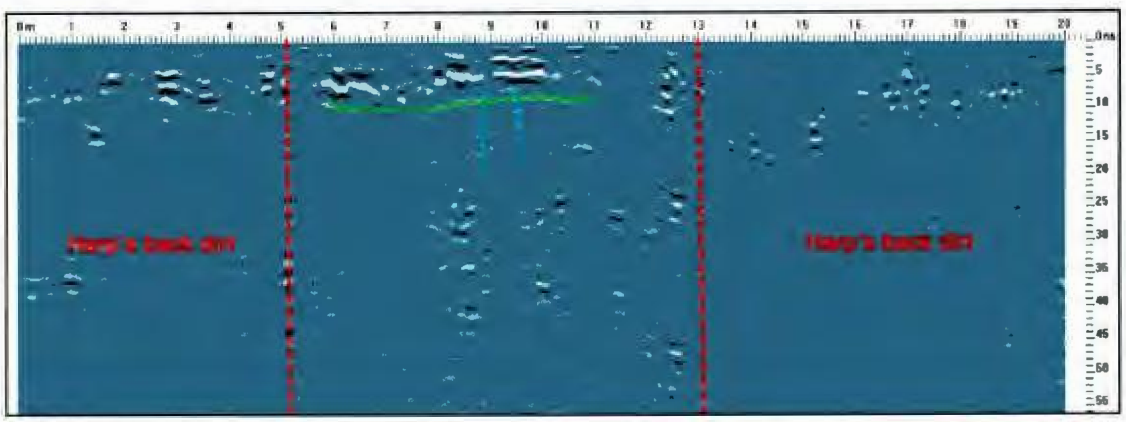

Figure 4.13: House 10 GPR profile of line 71. Harp's back dirt piles (red) flank the western and the eastern end of the line. Note the anomaly outlined in blue analogous with Feature 100 (post hole) and the anomaly outline in green analogous with Feature 399 (central depression)

No other anomalies analogous to archaeological features could be identified on the House 10 time slices. Since an anomaly correlating to Feature 399 was identified in a GPR profile I decided to further inspect the GPR profiles. This was a limited search due to previous excavations and back dirt piles, which means I could only look for well defined anomalies outside of the back dirt piles. For these reasons I decided to focus on anomalies possibly correlating to Feature 418, the rear platform.

Feature 418 measured 4 m north to south and more than 7 m at its widest east to west (Wells et al. 2012:16). The rear platform is analogous to a large anomaly located in the bottom half of the House 10 survey, in-between the two lower quadrants. While this is not visible in the time slices it can be identified in 39 profiles (lines 98 to 136). This means that the anomaly is approximately 3.9 m north to south. At its widest the feature measures approximately 8 m (Figure 4.14 and Figure 4.15). At its narrowest it measures approximately 4 m (Figure 4.16 and Figure 4.17). I suggest this anomaly correlated to Feature 418 (rear platform) based on its location and north to south length. If this is correct, it would extend the east to west dimension of Feature 418 to 8 m.

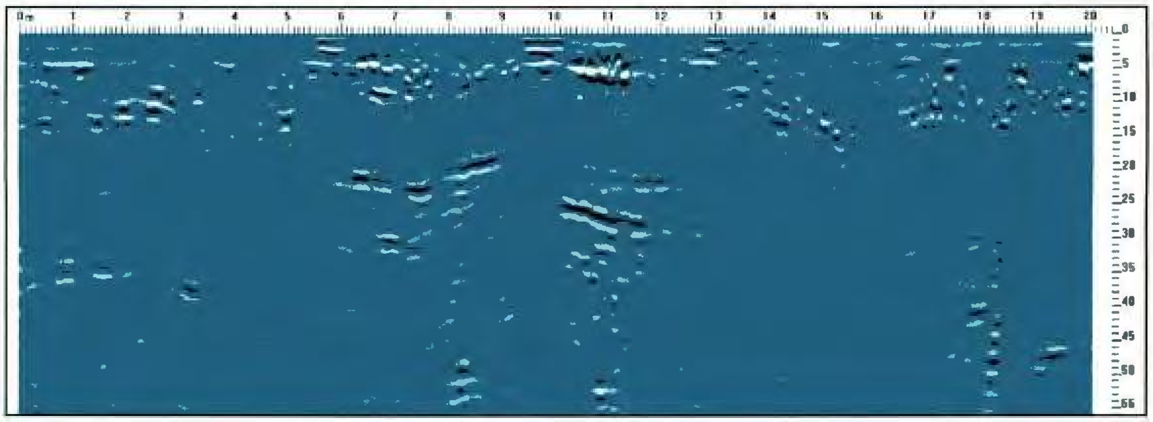

Figure 4.14: House 10 GPR profile of line 98, no interpretation.

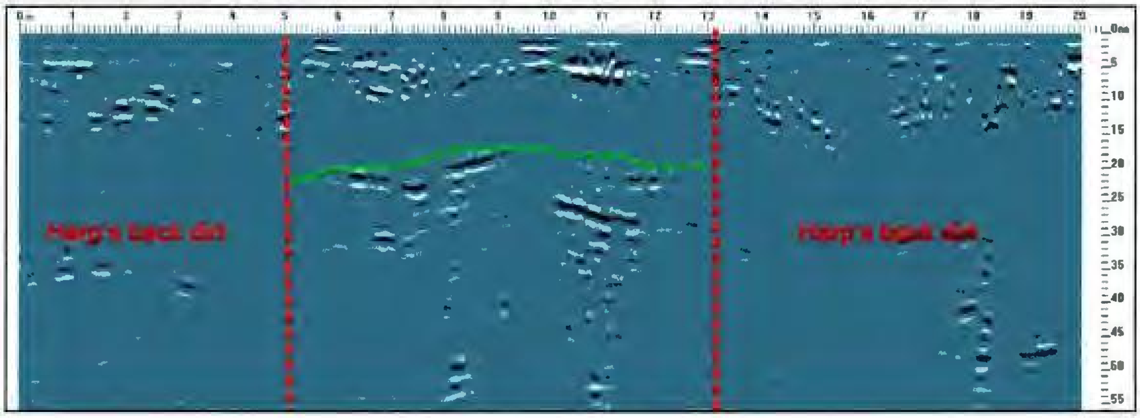

Figure 4.15: House 10 GPR profile of line 98. Note Harp's back dirt (red) and an approximately 8 m wide anomaly (green).

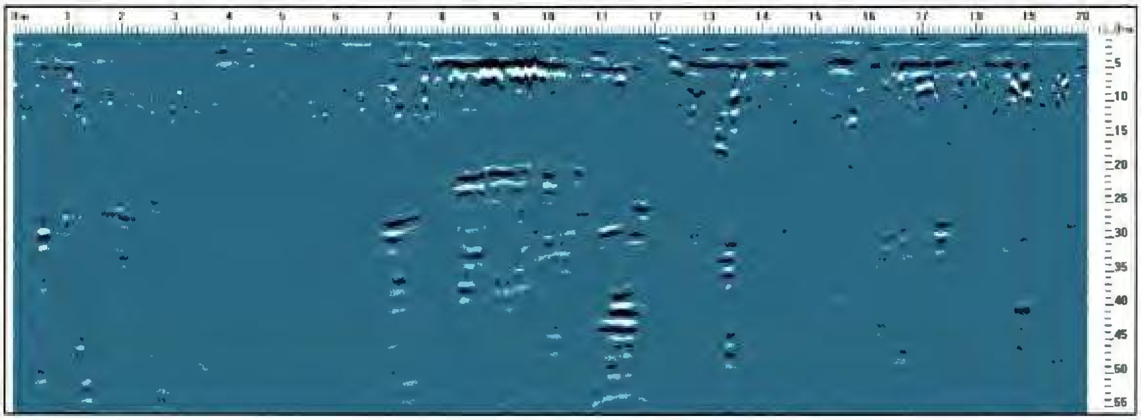

Figure 4.16: House 10 GPR profile of line 136, no interpretation.

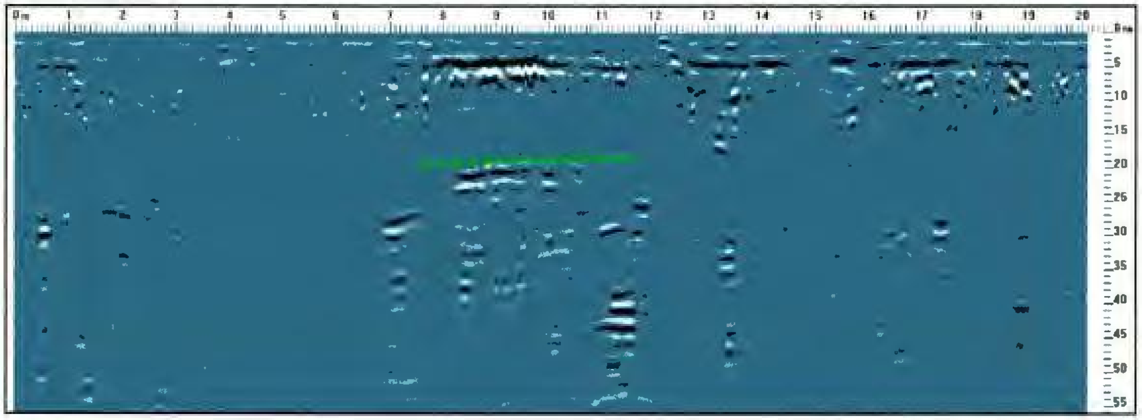

Figure 4.17: House 10 GPR profile of line 136. Harp's back dirt piles are no longer present on this portion of the survey grid. Note the approximately 4.5 m wide anomaly (green).

The GPR survey was beneficial at identifying some anomalies correlating with archaeological features in both time slices and profiles. I suggest this survey would have been more successful had it not been hindered by previous excavations.

4.5 Synthesis of Results

Several archaeological features were identified in both the magnetometry and GPR surveys of House 10 (see sections 4.3 and 4.4). The identified features tend to be large and/or deep. Both surveys were hindered by previous excavations (including excavation, back dirt, and related refuse such as nails), which disturbed the surveys by interfering with the ability of the instruments to pick up archaeological features.

Magnetometry was particularly useful in detecting charcoal piles. We were also able to use it to identify an anomaly correlating to a large and deep post hole (Feature 100, central post hole). The results also show a faint anomaly possibly correlating with the eastern perimeter of Feature 418 (rear platform). This anomaly measured 8 m east to west at its widest part (its narrowest part was obscured by the strong charcoal anomaly). These measurements correspond with an anomaly correlating with Feature 418 in the GPR data.

A large GPR anomaly measuring 3.9 m north to south and between 4 and 8 m east to west correlated with Feature 418. Based on the magneomtry and GPR results I suggest that Feature 418 extended 4 m east at its southern end and curved to its widest (8 m) before it joined with Feature 417 (eastern platform).

This was the most significant anomaly identified in the House 10 GPR data and it had strong correlations with Feature 418 (rear platform). While this anomaly was also identifiable in the magnetometry data, it was much weaker, suggesting GPR is better suited at picking up large architectural features at Phillip's Garden.

4.6 Summary

This chapter characterized House 10 in terms of previous excavations. House 10 magneomtery and GPR results were presented in this chapter and compared to previous excavation results. The significance of the results in terms research questions *1) can features within dwellings be identified through small scale magneometry and GPR surveying at Phillip's Garden?* and *2) is there a difference between geophysically surveying excavated versus unexcavated dwellings?* is discussed in Chapter 6.

CHAPTER 5

Feature 368

5.1 Introduction

This chapter presents data analysis and interpretation of the unexcavated depression, Feature 368, surveyed as part of this research. Feature 368 was chosen in order to test the efficacy and accuracy of small-scale magnetometry and GPR surveying on unexcavated and therefore undisturbed dwellings at Phillip's Garden. The topography, magnetometry, and GPR analysis and interpretation are presented below. The synthesis of the results section compares the magnetometry and GPR results.

5.2 Methodology

Feature 368 data is compared with geophysical data from House 10 and excavation data from House 10. The topography results are interpreted in relation to previously excavated dwellings at Phillip's Garden (House 10, House 17, and House 18). By topography I mean an elevation map of points in a 10 by 10 m grid encompassing Feature 368. The magnetometry results are interpreted in relation to the topography results and comparison with magnetometry data from House 10 and archaeological data from excavated dwellings at Phillip's Garden (House 10, House 17, and House 18). This entails comparing magnetic anomalies in Feature 368 (size, shape, relation to each other) to the topographic map features, magnetic features in House 10, and archaeological features identified in previous excavations (including platforms, central depressions, axial features, post holes, pits, perimeter post holes, and entrances). Feature 368 GPR results at 25 cm spacing between transects and 10 cm spacing between transects are compared in order to assess which data has a better resolution. Feature 368 GPR results are then interpreted similarly to the magnetometry results.

5.3 Feature 368 data Analysis and Interpretation

Feature 368 was neither test-pitted nor dated. Its interior depression is clearly visible on the surface of the meadow (Figure 5.1) and its outline was mapped using a total station.

Figure 5.1: Feature 368 is visible on the surface of the meadow as a depression. Note the north arrow.

The data are presented into four sections: topography, magnetometry, GPR resolution comparison, and GPR. Each section presents the results without interpretation first; the interpretation follows in a separate figure. The data analysis will only focus on features identified as characteristic of middle phase dwellings at Phillip's Garden: rear and/or side platforms, the central depression, the axial feature and associate post holes, rear pits, perimeter pits, and dwellings entrance.

5.3.1 Topography Data and Interpretation

Feature 368 elevation was mapped with a total station in a 10 by 10 m grid (Figure 5.2) with points taken every 25 cm. Prior to the topography survey, two features were mapped (Figure 5.3: B and C), which appeared as depressions on the meadow.

Several features similar to Phillip's Garden dwellings features were identified on the topography map (Figure 5.3). Anomaly A corresponds to the Feature 368 depression. It measures approximately 4.9 m east to west and approximately 4.4 m north to south. Based on its size, shape, and surrounding features I suggest this is the central depression.

Anomaly D looks like the entrance to the dwelling. Anomaly F appears as a wide eastern platform while anomaly G appears as a narrow wall or platform. Anomaly E appears as a well defined large rear platform. These anomalies are similar to archaeological features identified in House 10.

The topography survey was very useful in identifying several features corresponding in location, size, and shape to architectural features found in House 10 at Phillip's Garden.

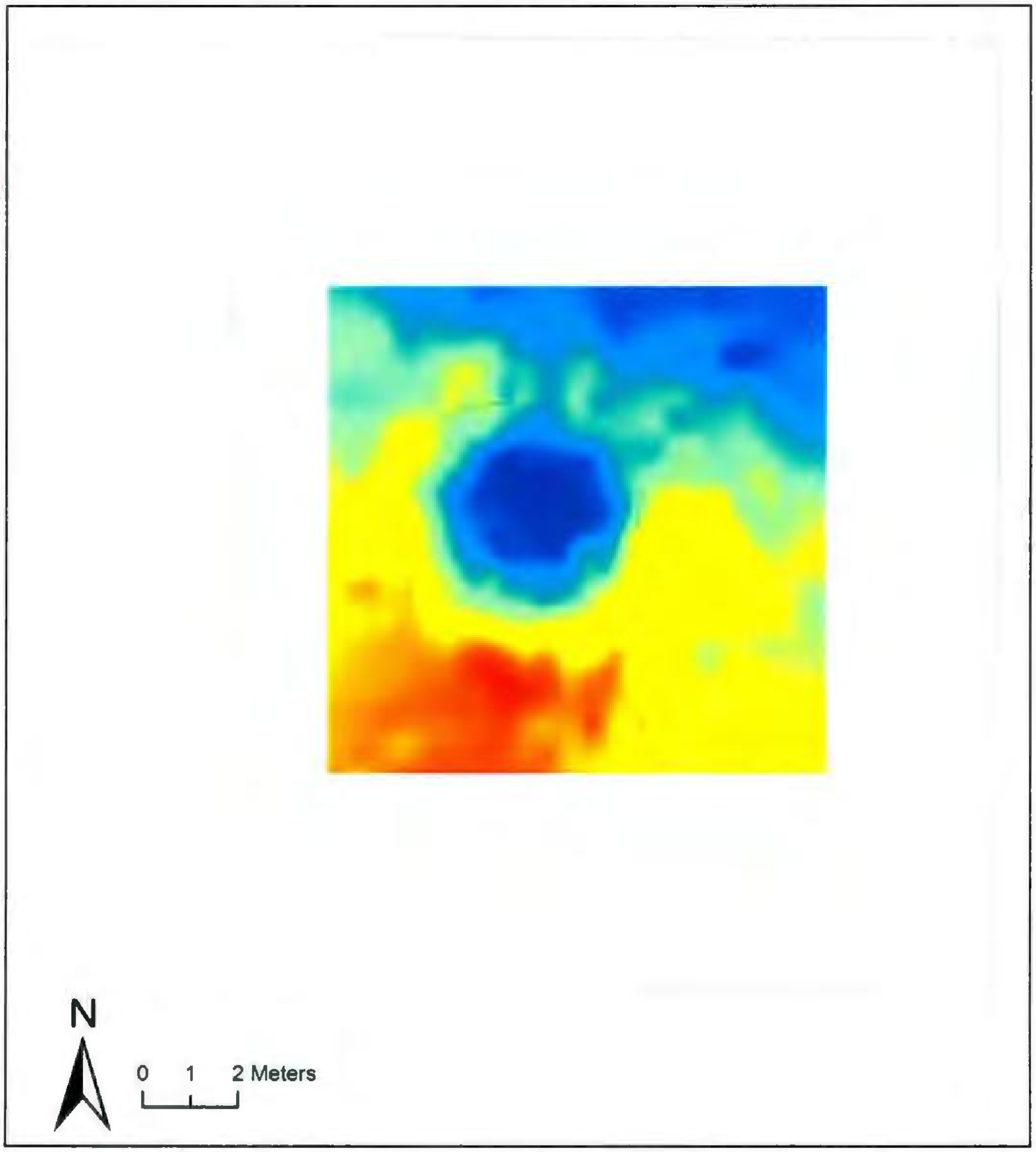

Figure 5.2: Feature 368; a 10 by 10 m topography map created by taking elevation points every 25 cm (warm colour = high elevation, cold colours = low elevation). The topography map is presented in relation to the geophysical survey 20 by 20 m grid.

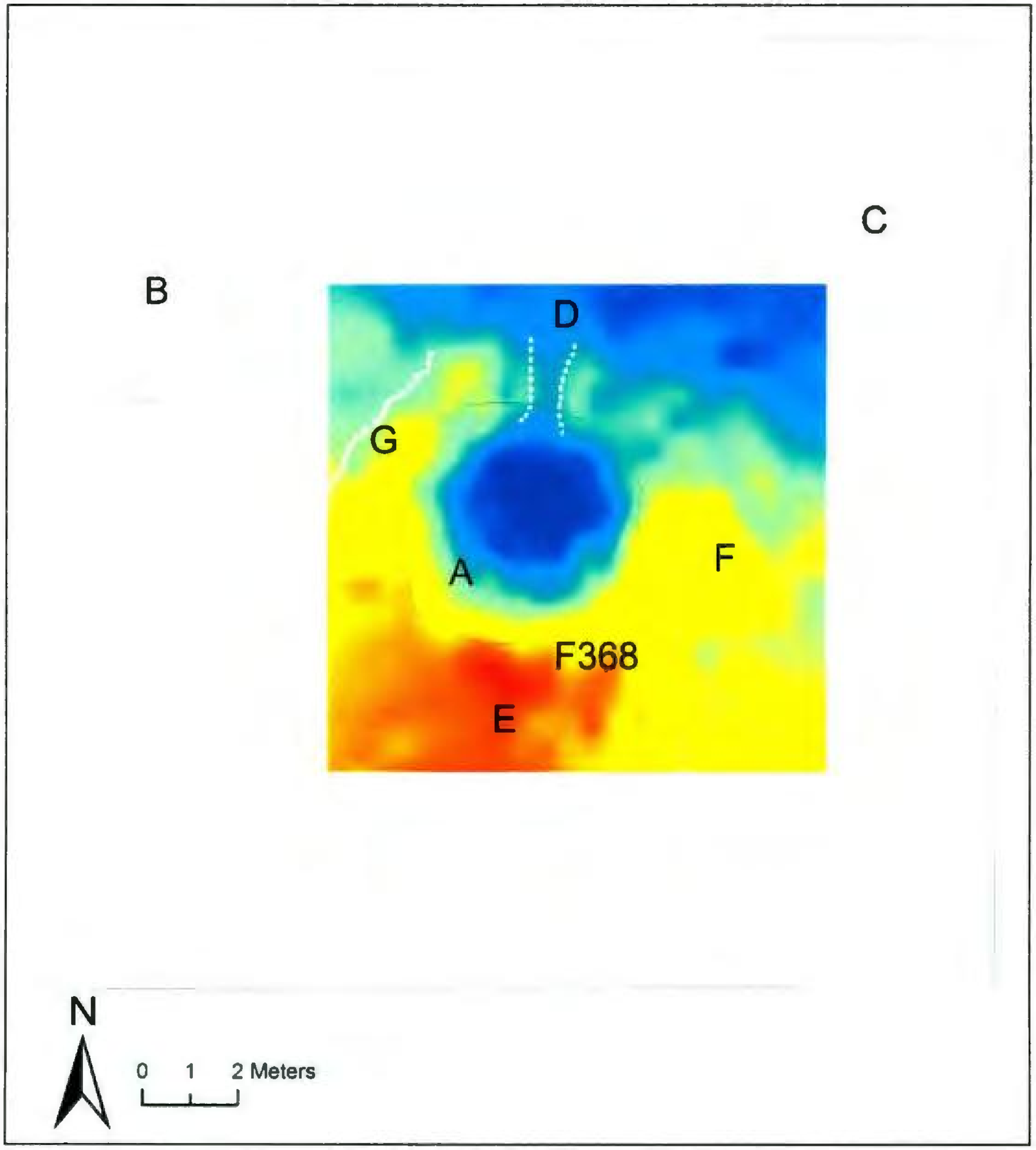

Figure 5.3: Feature 368 10 m by 10 m topography map. Feature 368 and depressions B and C were identified during a surface survey. Topographic anomalies A, D, E, F, and G appear to be architectural features related to Feature 368.

5.3.2 Magnetometry Data and Interpretation

Four magnetic plan-view maps are presented below: magnetometry results (Figure 5.4), magnetometry results with significant visible anomalies circled (Figure 5.5), and magnetometry results with the overlain topography map (Figure 5.6). Each map represents the 20 by 20 m grid we surveyed around the dwelling. The topography map is a 10 by 10 m grid. The data are divided into four quadrants by a cross running through the center of the dwelling. This was done in order to increase the readability of the images.

Several anomalies were identified in the Feature 368 magnetometry results (Figure 5.5). Anomaly A (Figure 5.5, yellow) represents an anomaly most likely caused during data collection due to improper handling of the magnetometer (position too close to operator, sensors being out of line, etc.). Anomalies C, D, and E (Figure 5.5, red) cannot be interpreted due to the lack of sufficient data (i.e. due to their shape, size, and location there is no basis for comparison).

Anomaly B (Figure 5.5, green) is similar to anomaly G (Chapter 4, House 10, Figure 4.5b) which corresponded to Feature 387 (charcoal concentration in House 10). I suggest that this could be another charcoal concentration, although not as well defined as Feature 387. This could be because it is at the edge of the survey grid and only part of the anomaly shows up in the results.

Anomalies F, G, H, I, J, K, L, M, N, O, P, Q, R, S (Figure 5.5, orange) appear to correlate (based on their location) to features identified in other Phillip's Garden dwellings (House 17 and House 18). Anomalies F, G, H, I and J are interpreted based on a comparison with Feature 368 topography map (Figure 5.6).

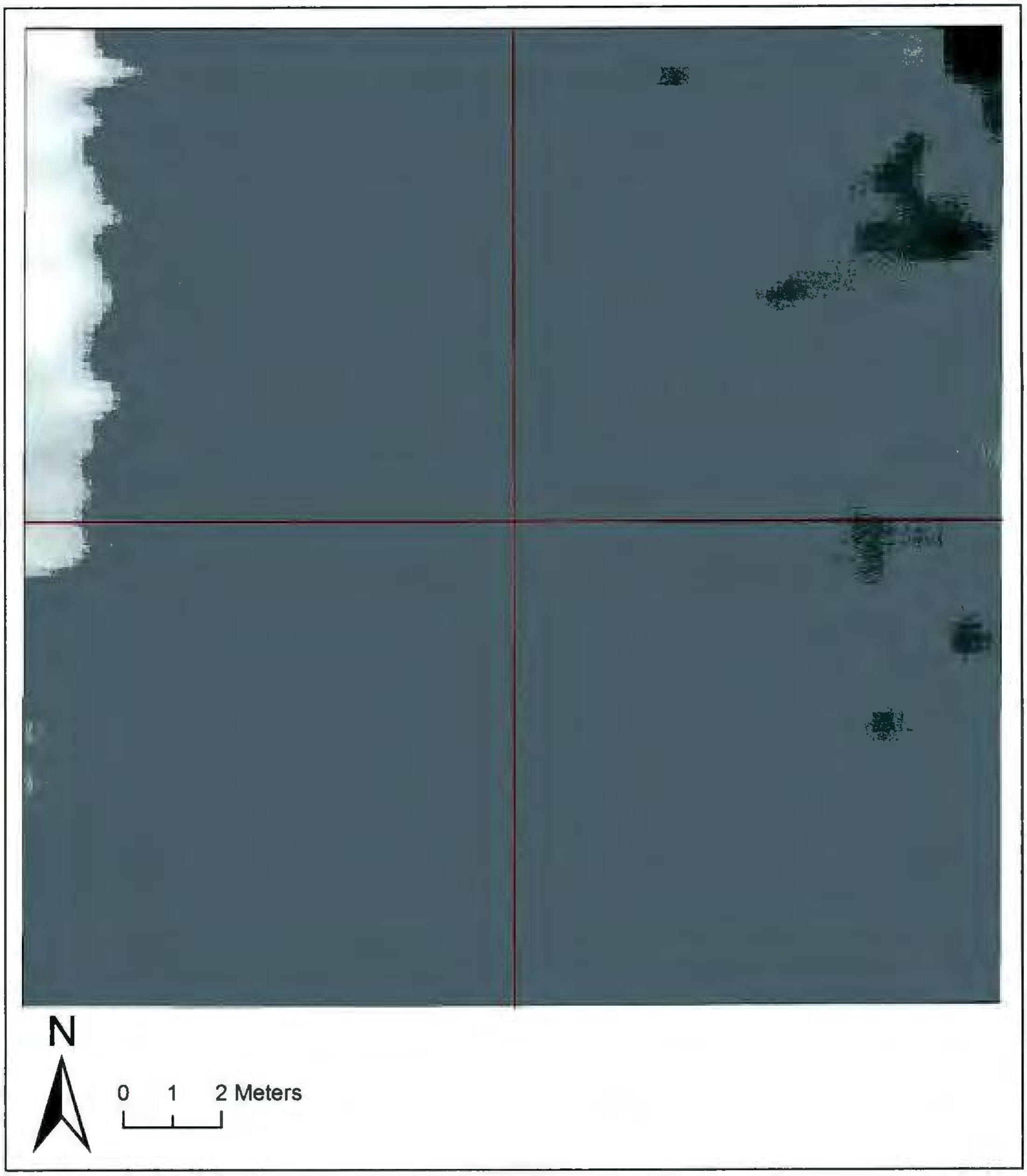

Figure 5.4: Feature 368 magnetometry results presented in plan-view.

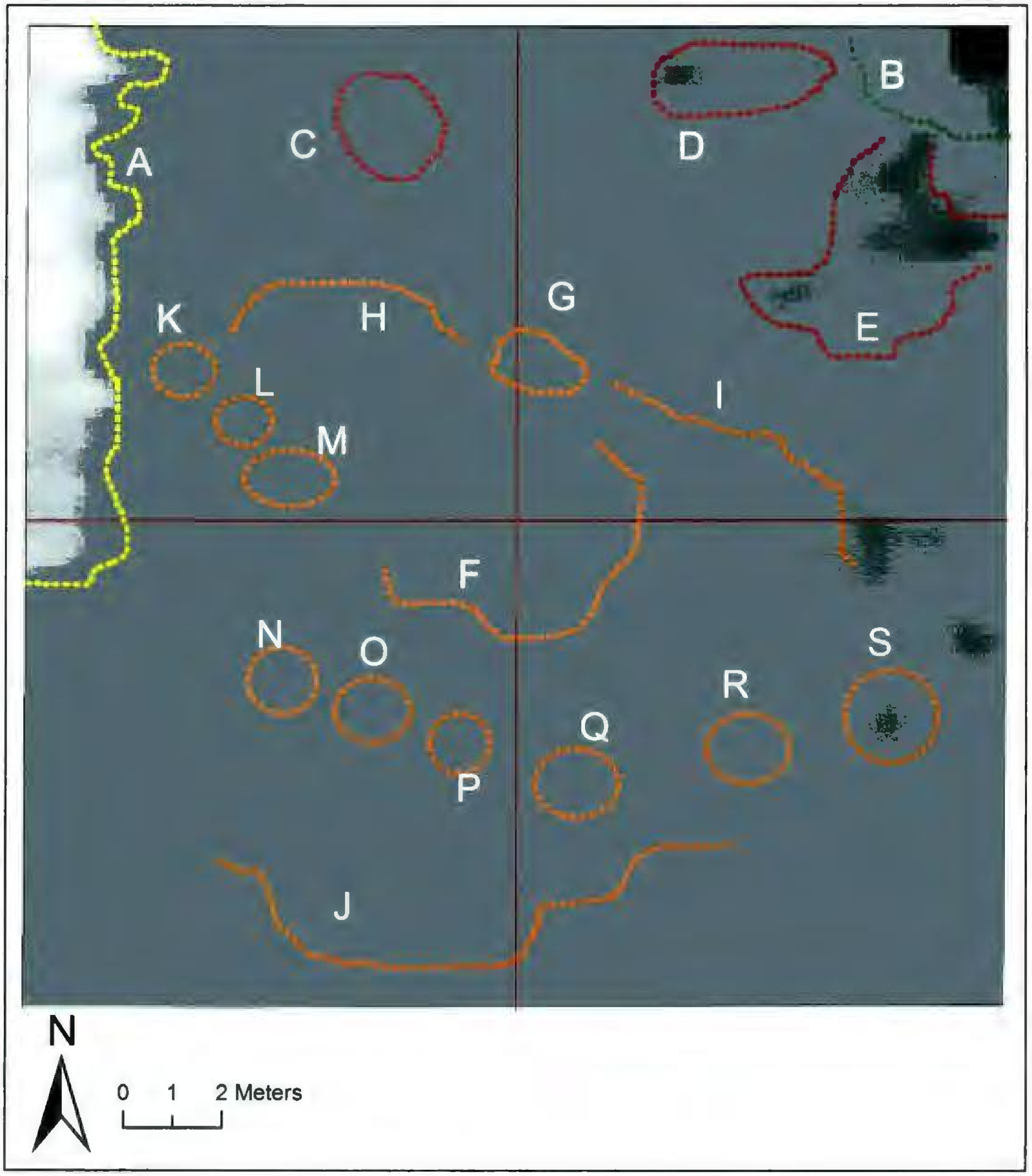

Figure 5.5: Feature 368 magnetometry results with magnetic anomalies circled. Anomaly A (yellow) most likely represents an error during data collection. Anomalies C, D, and E (red) cannot be interpreted based on the data available. Anomalies B, F, G, H, I, J, K, L, M, N, O, P, Q, R, S correlate to known archaeological features.

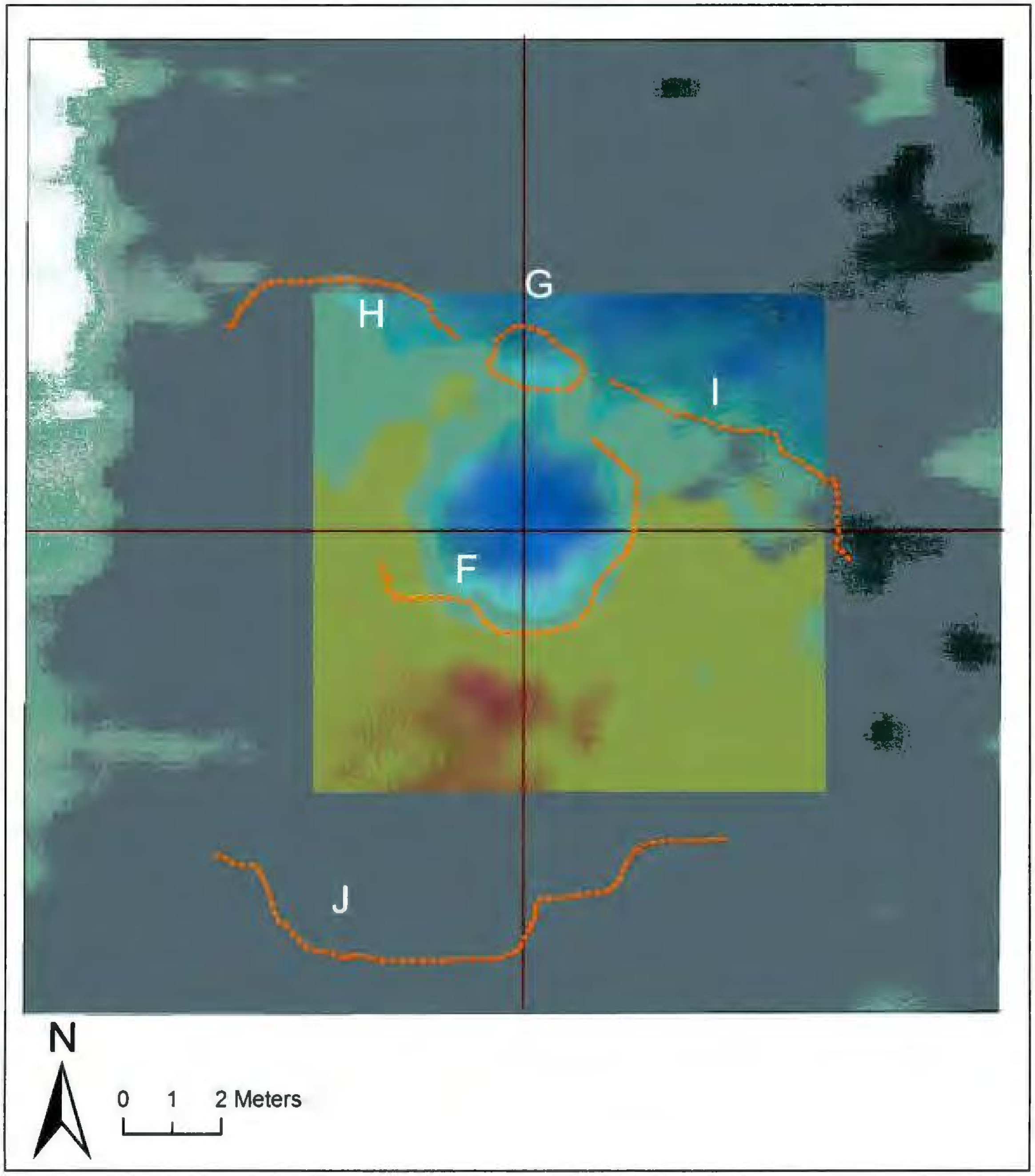

Figure 5.6: Feature 368 magnetometry results with the 10 by 10 m topography map superimposed (topography map has a transparency of 79%). Note magnetic anomalies F, G, H, I, and J.

Magnetic anomaly F correlates to the central depression identified in the topography map (Figure 5.6, orange). I suggest this to be part of the Feature 368 central depression. Its shape and size do not correspond exactly to the shape and size of the depression identified in the topography results. I suggest this is due to the fact that magnetometers are not very accurate at identifying shape and size of feature, but rather their magnetism, which shows up as an aura. Therefore, in one magnetic survey very magnetic small features can appear much larger than large weakly magnetic objects. Another point to note is that some parts of a feature may have a higher magnetic signature than others. In this case only the higher magnetic feature would show up. I suggest that, in this case, only part of the central depression is picked up by the magnetometer.

Magnetic anomaly G correlates to the area in front of the identified entrance in the topography map (Figure 5.6, orange). It has a similar magnetism as anomaly F (Figure 5.4 and Figure 5.5; light grey shading in both anomaly F and G). I suggest these could be areas that have been stepped on frequently and where organic material was deposited (organic material would have been brought in from outside into the central depression area) while the house was in use. This could have changed the magnetism of the soil, differentiating it from the surrounding matrix.

Anomalies H and I correlate to a raised area in front of the central depression on the topographic map (Figure 5.6, orange). I suggest that they at least partially correspond to the front perimeter berm in Feature 368.

Anomaly J lies outside of the topography map (Figure 5.6, orange); however, based on its length (approximately 5.5 m north-west to south-east) and location (it seems to extend from the rear platform identified in the topography map) I suggest this could represent the southern extent of the rear platform.

Anomalies K, L, M, N, O, P, Q, R, and S (Figure 5.5, orange) also lie outside the topography map. Their size could not be determined but their patterned spacing (between 1.5 and 2.2 m apart) suggest that they could be post holes intentionally spaced to support a roof structure. This is based on comparison with similar perimeter of pits demonstrated for House 17 and House 18, noted in Chapter 2.

The magnetometry data results of Feature 368 were more informative than the House 10 results. I suggest this is due to the lack of previous disturbance. Unlike House 10, magnetometry surveying for Feature 368 was conducted at a 25 cm spacing between transects. I suggest that had we used a 10 cm spacing our results would have been clearer.

5.3.3 GPR Resolution Comparison

Feature 368 resolution comparison is presented as two sets of time slices. The first time slice was created from the 25 cm increment GPR survey, the second times slice was created from the 10 cm increment GPR survey. Each time slice is presented first without any annotations and then with annotations. This analysis focuses on how well defined the central depression is at both resolutions. This is done in order to determine which sampling resolution has the potential to pick up more archaeological features and see them more clearly.

The GPR survey completed at 10 cm spacing between transects was more time consuming; however, it also provided higher quality results. This can be seen in both sets of GPR time slices (Figure 5.7b versus Figure 5.8b and Figure 5.9b versus Figure 5.10b) (Figures 5.7a, 5.8a, 5.9a, and 5.10 a represent the data without interpretation); note the central depression (black dashed outline). Figures 5.8a 5.8b, 5.10a, and 5.10b also have west to east lines running across the survey grid (white dashed lines). I suggest these are caused by glitches during data collection (such as a root catching on the antenna).

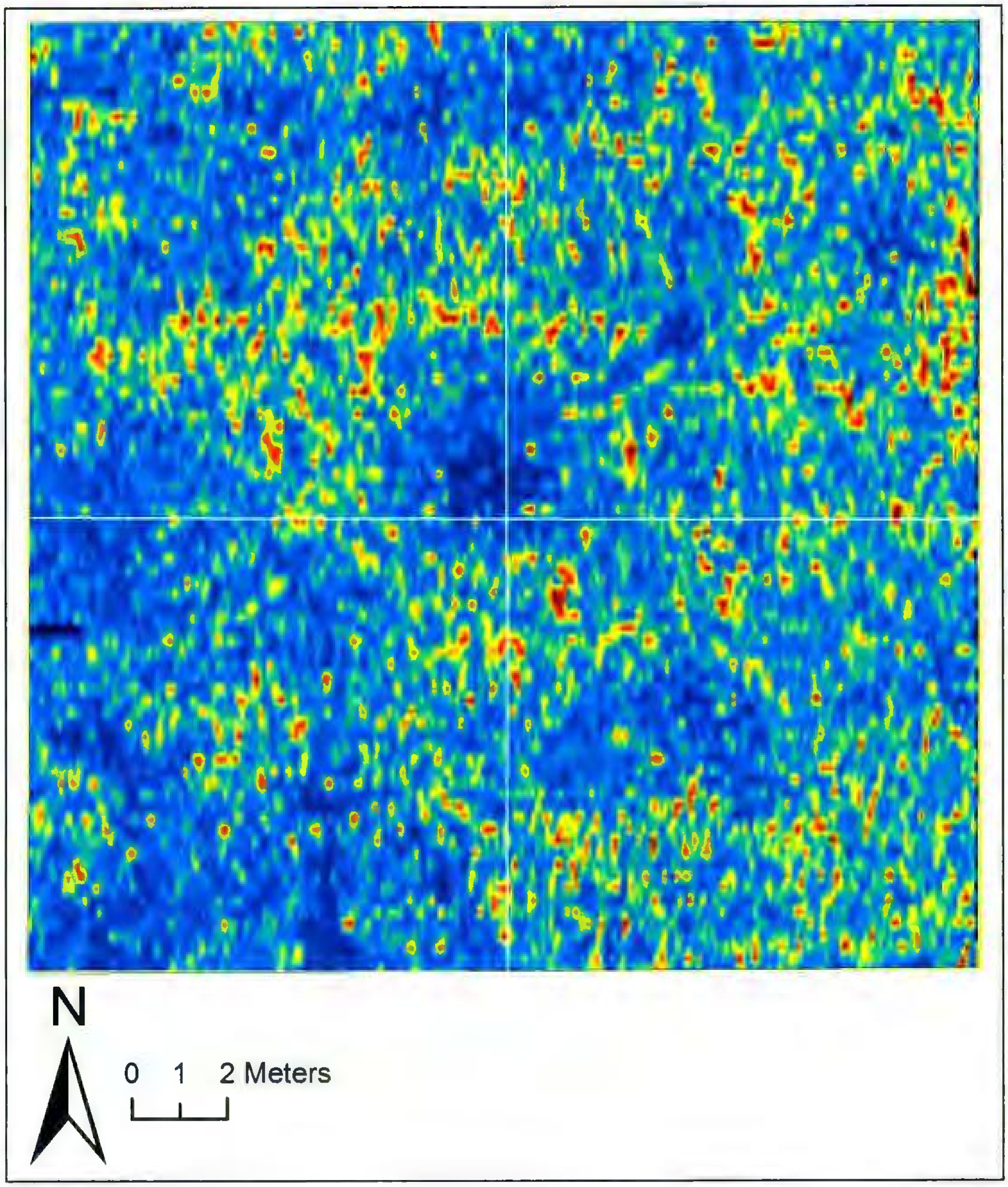

Figure 5.7a: Feature 368 GPR time slice between 4 and 5 ns. Survey done at 25 cm spacing between transects.

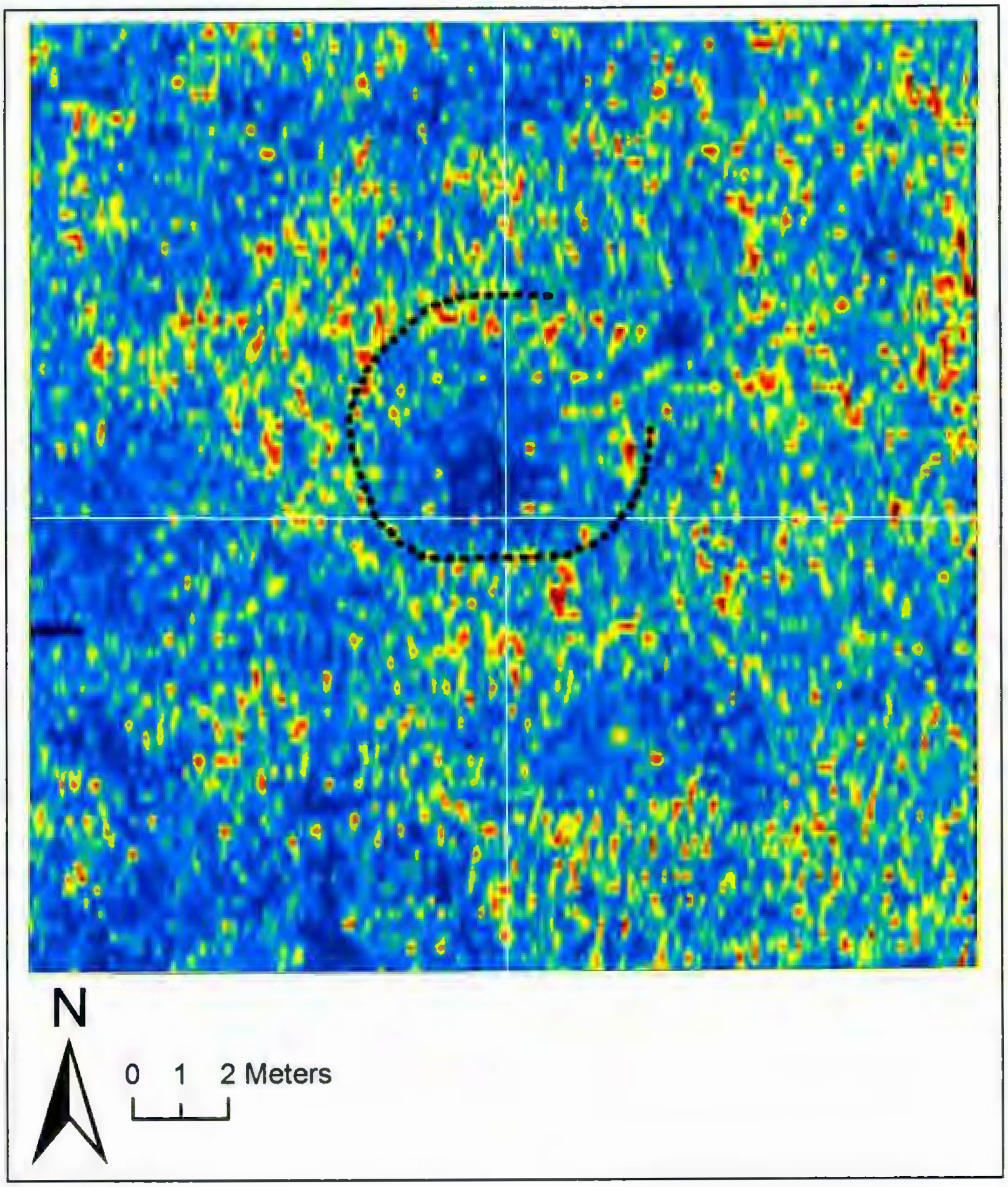

Figure 5.7b: Feature 368 GPR time slice between 4 and 5 ns. Survey done at 25 cm spacing between transects. Note the central depression (dashed black outline).

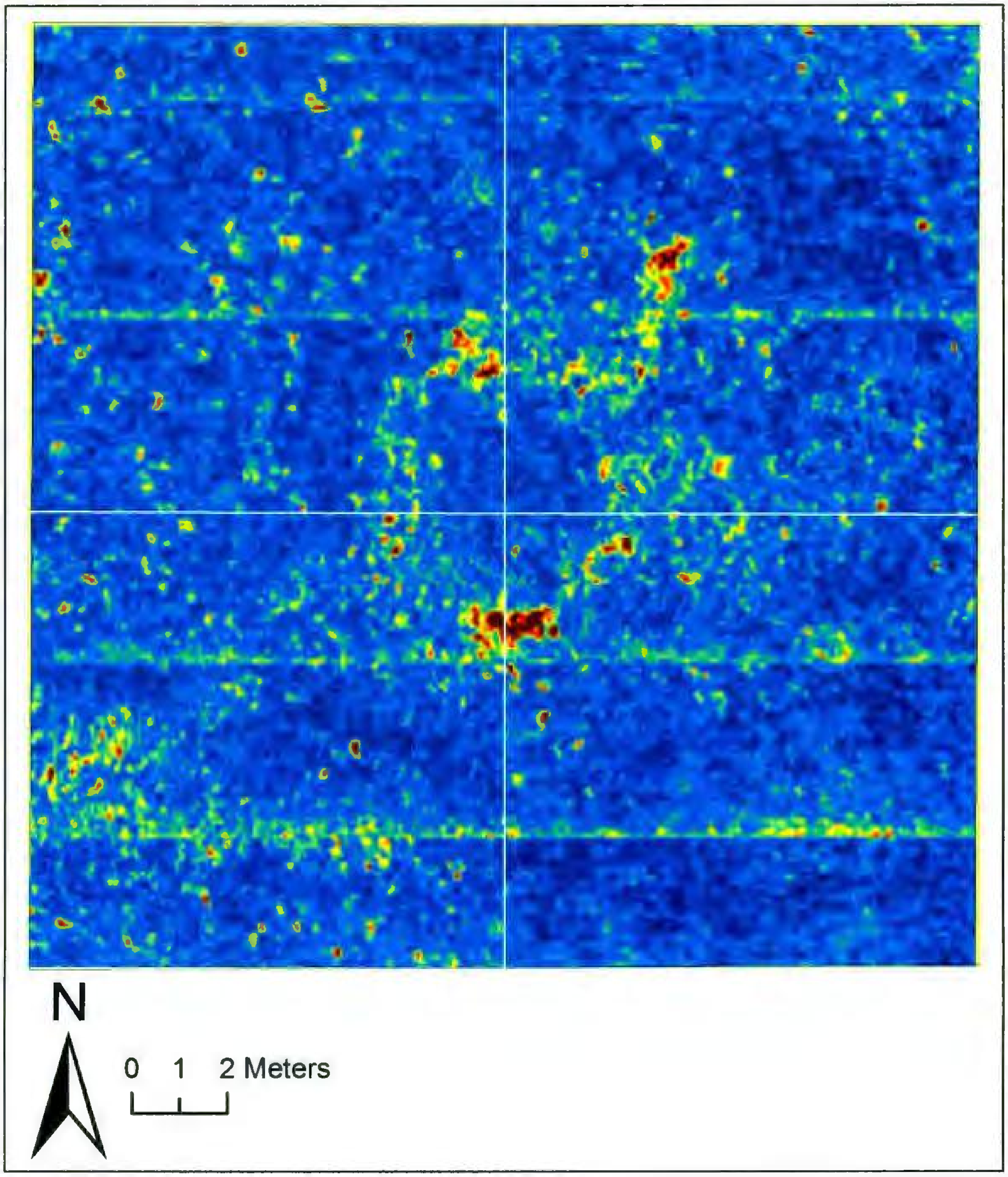

Figure 5.8a: Feature 368 GPR time slice between 4 and 5 ns. Survey done at 10 cm spacing between transects.

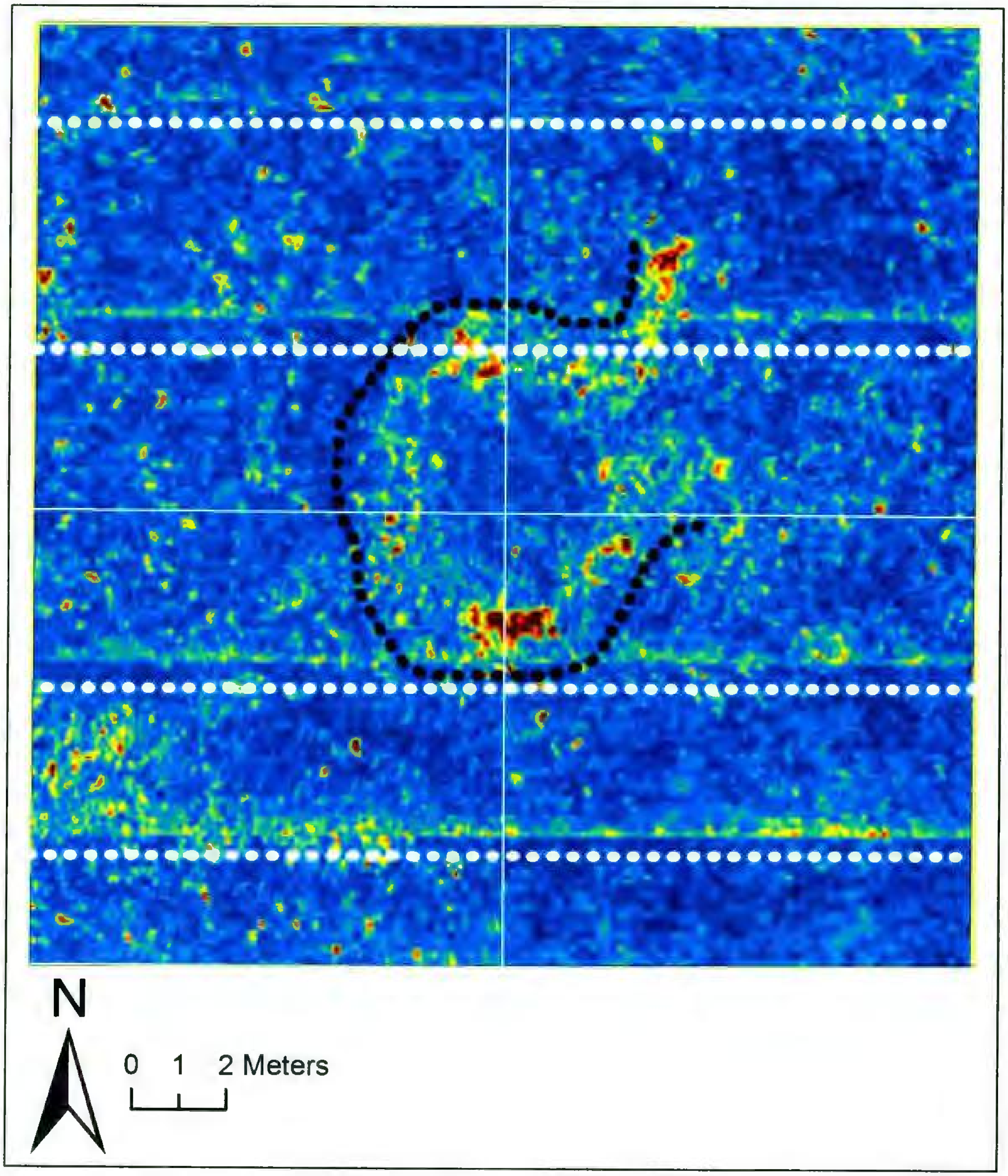

Figure 5.8b: Feature 368 GPR time slice between 4 and 5 ns. Survey done at 10 cm spacing between transects. Note the central depression (dashed black outline) and glitches during data collection (dashed white outline).

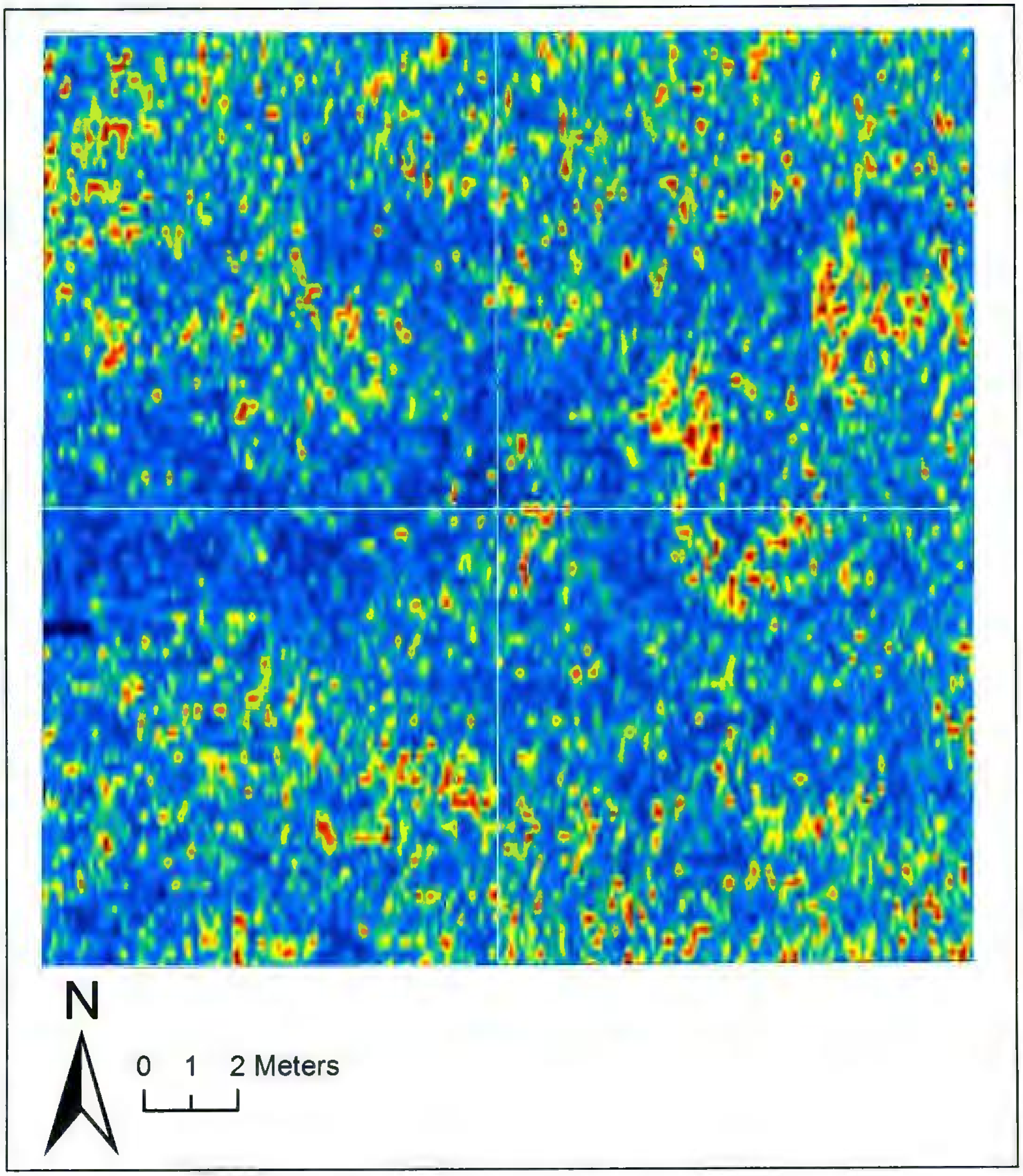

Figure 5.9a: Feature 368 GPR time slice between 5 and 6 ns. Survey done at 25 cm spacing between transects.

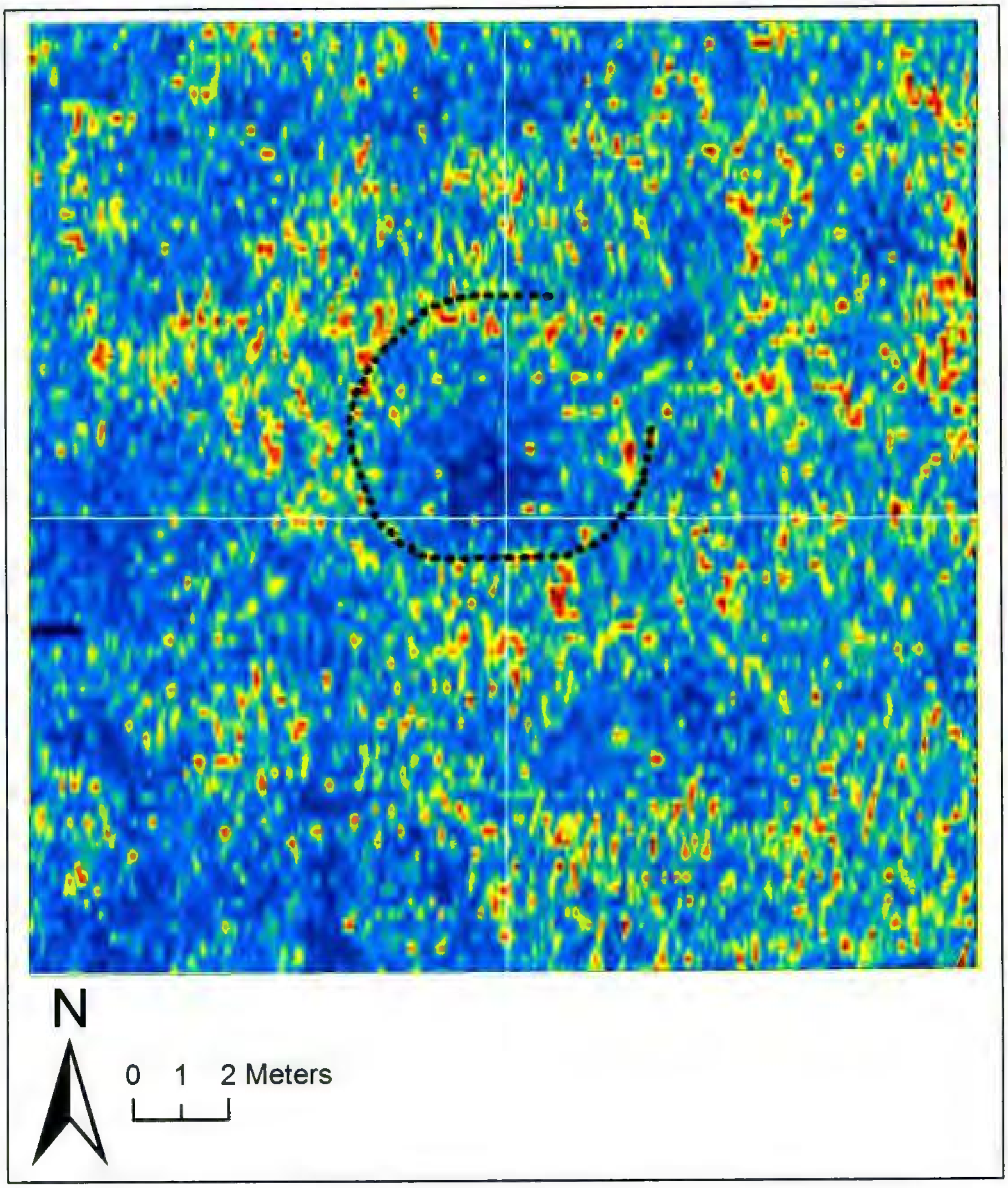

Figure 5.9b: Feature 368 GPR time slice between 5 and 6 ns. Survey done at 25 cm spacing between transects. Note the central depression (dashed black outline).

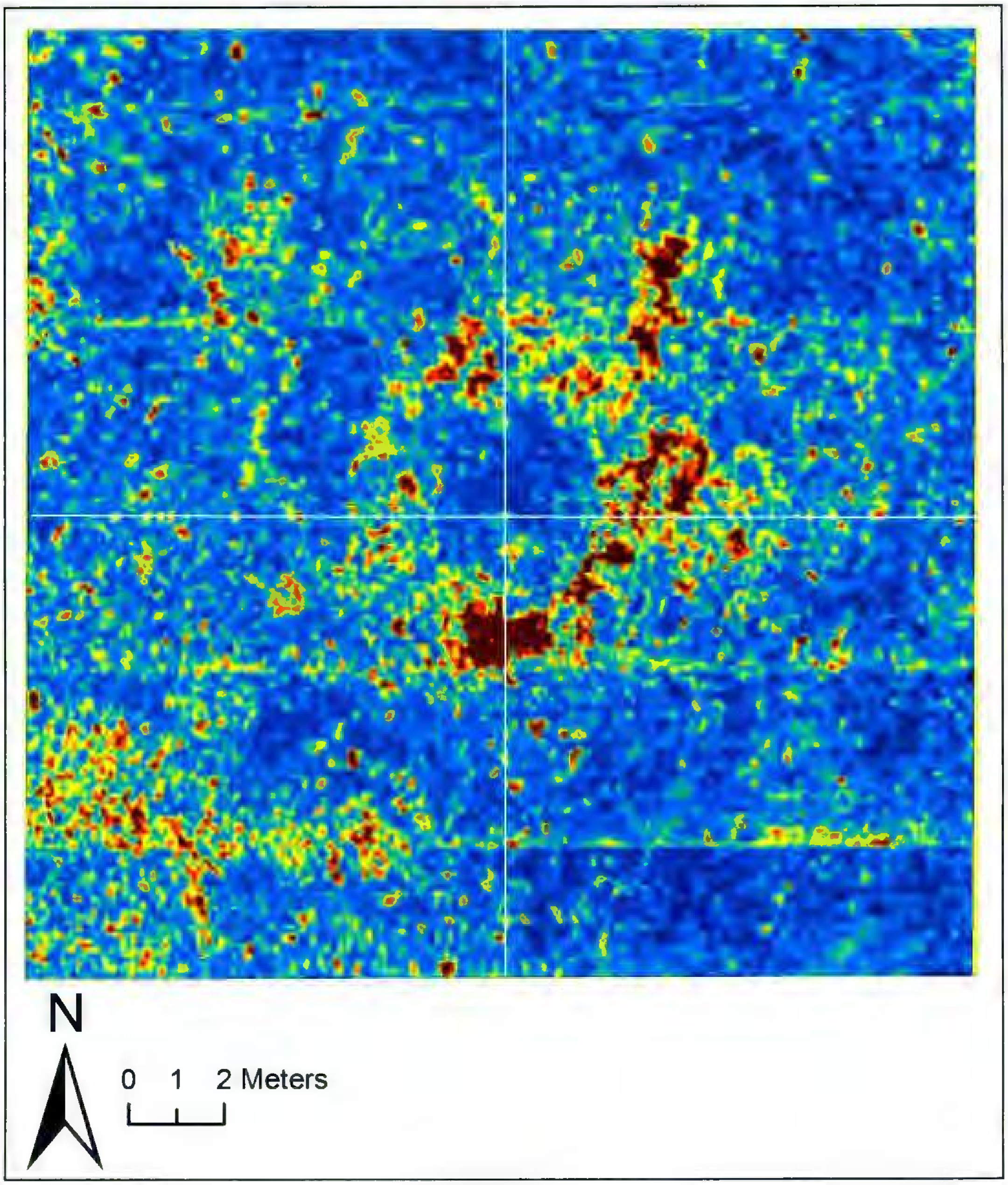

Figure 5.10a: Feature 368 GPR time slice between 5 and 6 ns. Survey done at 10 cm spacing between transects.

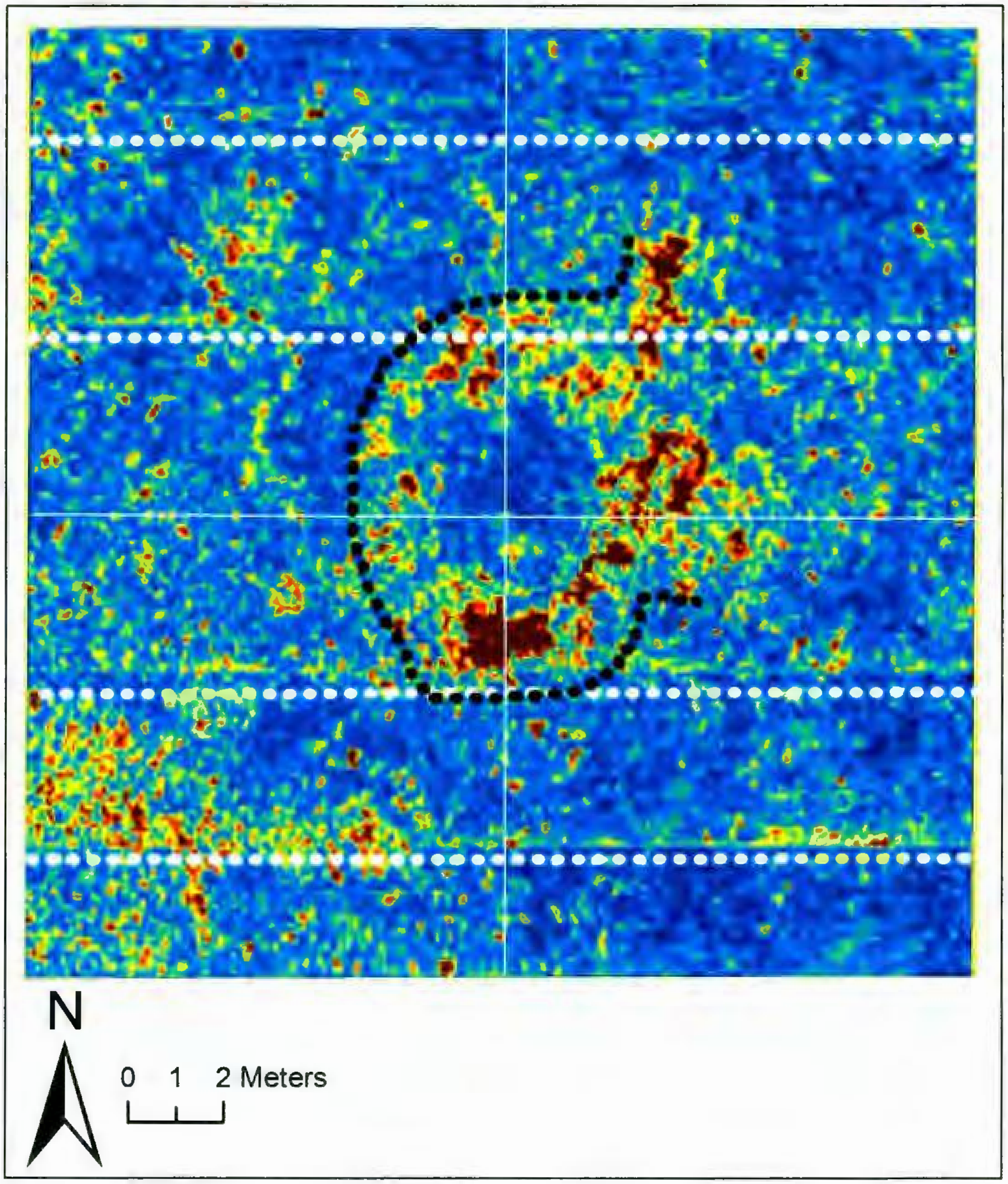

Figure 5.10b: Feature 368 GPR time slice between 5 and 6 ns. Survey done at 10 cm spacing between transects. Note the central depression (dashed black outline) and glitches during data collection (dashed white outline).

The central depression is visible in both sets of time slices; however, it is more clearly defined in both time slices where surveying was done with 10 cm increments between transects (Figures 5.8b and 5.10b). I suggest this is due to the fact that surveying at 10 cm increment between transects allows us to gather more data. This increases resolution and provides a more accurate image of the subsurface (in creating the time slices, having more data means that less data has to be inferred between transects).

As the survey using 10 cm increment spacing between transects was more successful, the data it produced were chosen for the GPR interpretation of Feature 368. This follows in the next section.

5.3.4 GPR Data and Interpretation

Feature 368 GPR results are divided into time slices and profiles. The time slices are divided based on their depth in nanoseconds. An approximation in centimeters is provided. This is possible due to the lack of ground disturbance in this survey grid. For each analyzed time slice and profile, the data with no interpretation are also provided.

GPR time slices are compared with the topography and magnetometry data in order to infer correlations between anomalies and archaeological features. These are further investigated in profiles. Other correlations between archaeological features and GPR anomalies were done by analyzing GPR profiles and the magnetometry data. I did this by identifying the location of magnetometry anomalies (which may correlate with archaeological features) on the grid and on GPR profile lines.

Six correlations between GPR anomalies and topographic features corresponding to archaeological architectural elements were identified in the Feature 368 time slices (Figures 5.11, 5.12, 5.13, and 5.14). These include the central depression, a possible entrance, a possible front berm, a possible western wall/platform, a possible rear platform, and a possible eastern platform.

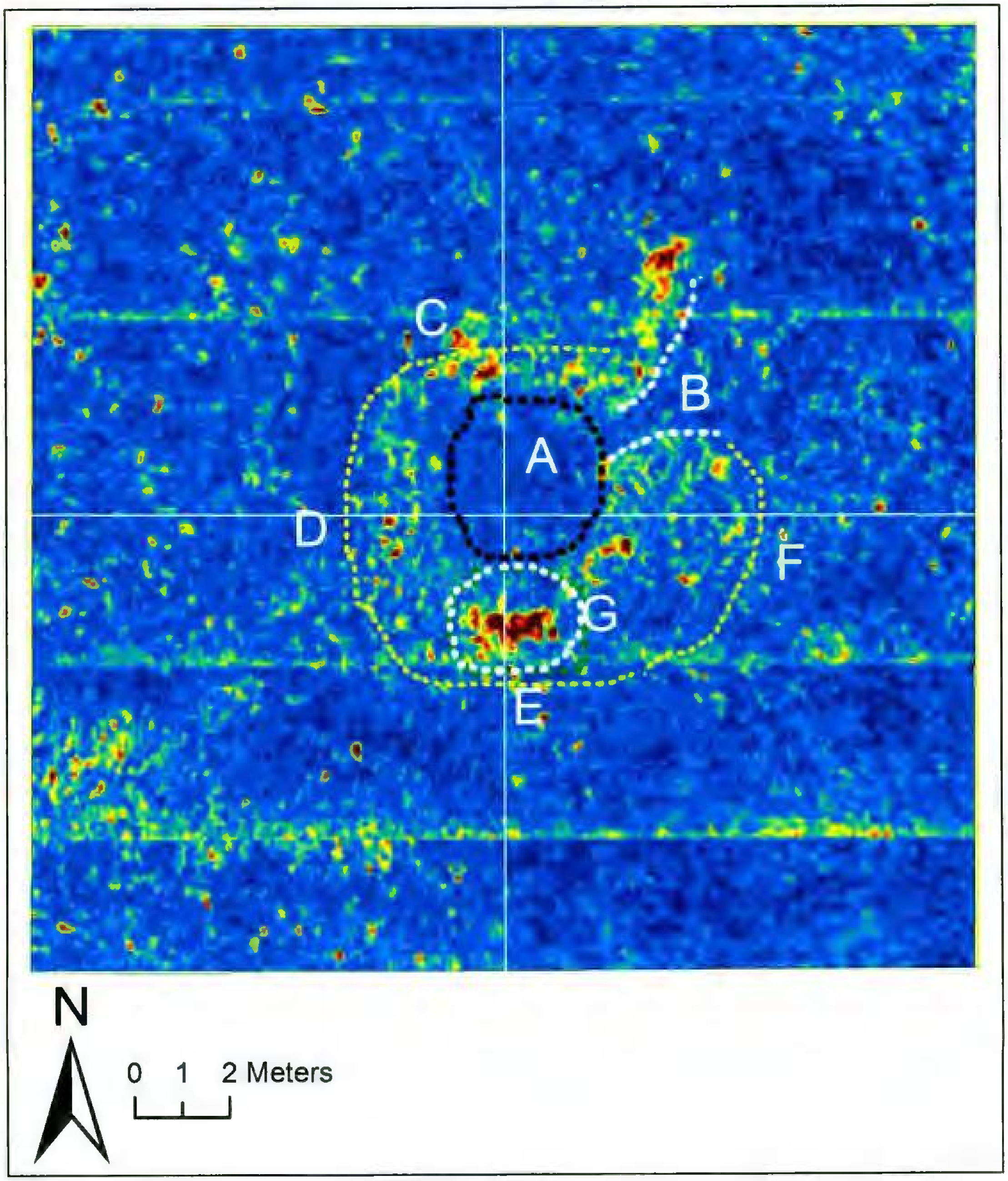

Figure 5.11: Figure 368 GPR time slice at a depth between 4 and 5 ns (approximately 15 and 20 cm). Note anomalies A (black outline), B (white outline), C, D, E, F (yellow outline), and G (white outline). See Figure 5.8a for the un-interpreted data.

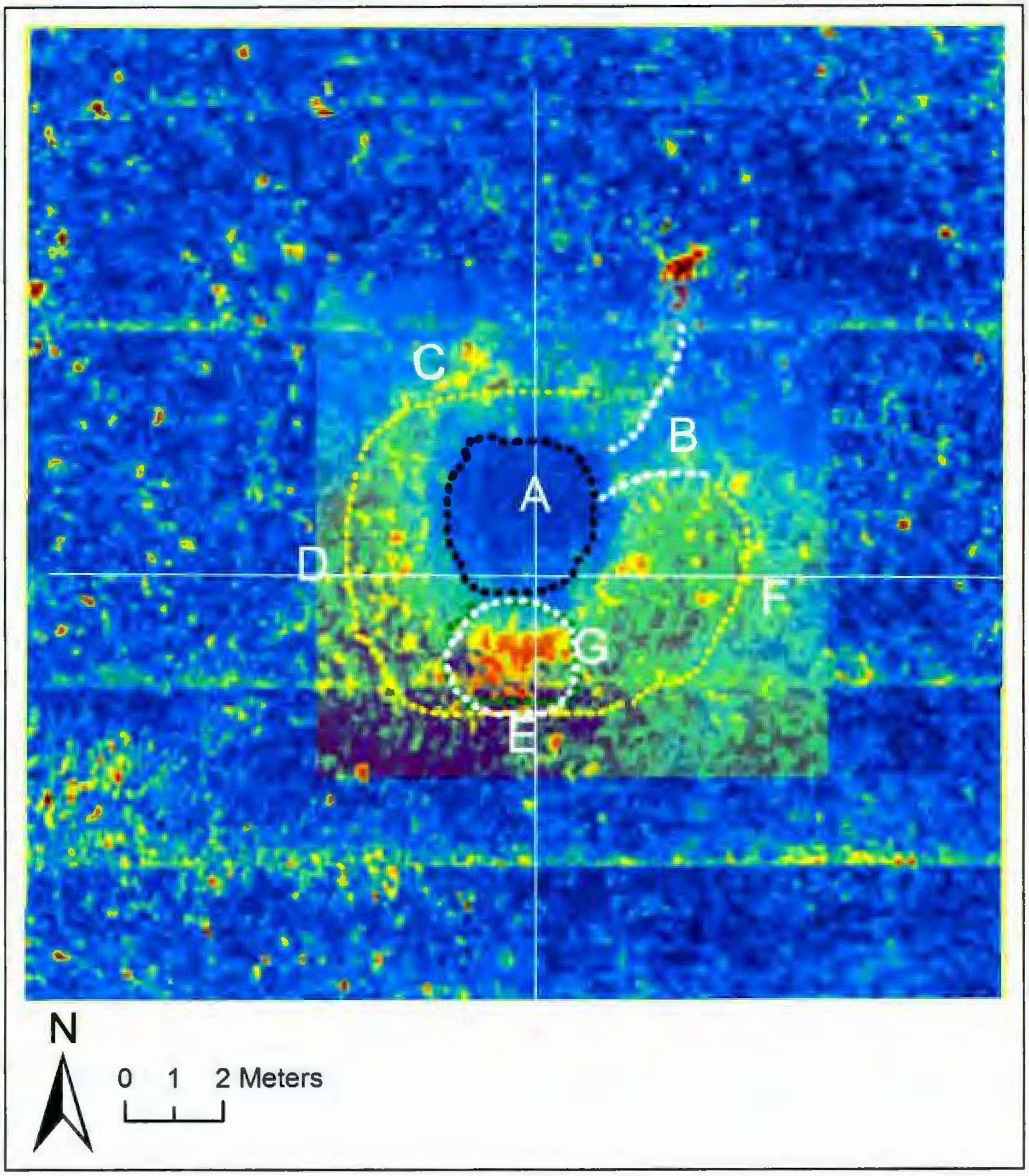

Figure 5.12: Figure 368 GPR time slice at a depth between 4 and 5 ns (approximately 15 and 20 cm). The 10 x 10 m topography map is superimposed with a 50% transparency. Note anomalies A (black outline), B (white outline), C, D, E, F (yellow outline), and G (white outline).

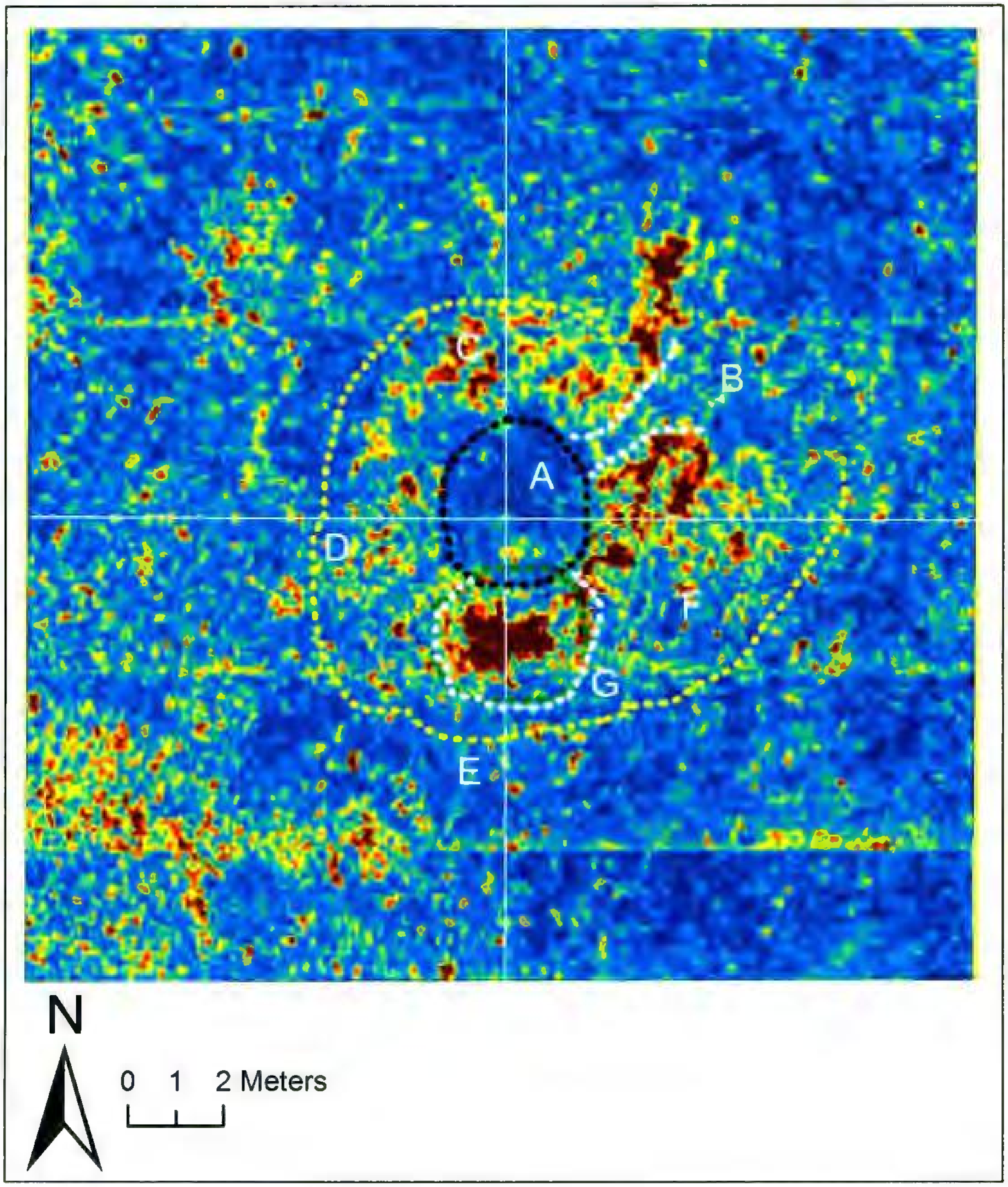

Figure 5.13: Figure 368 GPR time slice at a depth between 5 and 6 ns (approximately 20 and 25 cm). Note anomalies A (black outline), B (white outline), C, D, E, F (yellow outline), and G (white outline). See Figure 5.10a for the un-interpreted data.

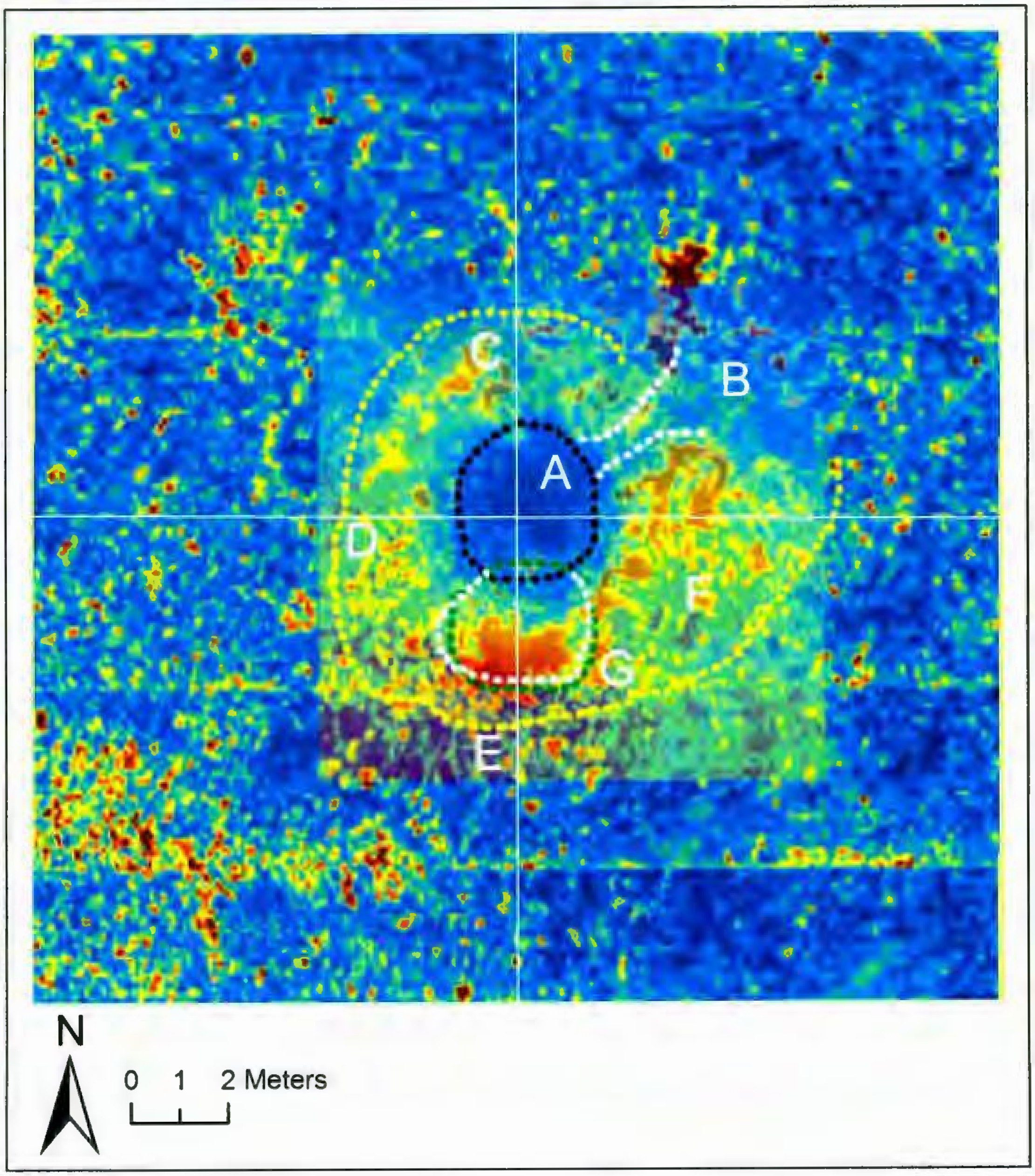

Figure 5.14: Figure 368 GPR time slice at a depth between 5 and 6 ns (approximately 20 and 10 cm). The 10 x 10 m topography map is superimposed with a 50% transparency. Note anomalies A (black outline), B (white outline), C, D, E, F (yellow outline), and G (green outline).

Anomaly G correlates with an elevation on the topography map (Figures 5.11, 5.12, 5.13, and 5.14). A large stone was identified on the surface on the meadow the location of which also correlates with this area, suggesting the anomaly and the rise in elevation was caused by the rock found on the surface of the ground.

Anomaly B corresponds to an area of lower elevation on the topography map (Figures 5.11, 5.12, 5.13, and 5.14). A possible entrance facing north was already identified on the topography map and it does not correspond to the entrance-like anomaly B. This anomaly is 80 cm wide – similarly to the entrance to House 10, which was approximately 70 cm wide (Wells et al. 2012:10). I suggest this could have been a secondary entrance, as some Phillip's Garden dwellings had two entrances (Renouf 2003).

Anomaly C is located where a possible entrance was identified on the topography map (Figures 5.11, 5.12, 5.13, and 5.14). However, it does not look like an entrance on the GPR time slices; however, it does look like a defined border around the central depression. Anomaly C can also be identified on the GPR profile of line 132, which passes through it (Figure 5.15 and Figure 5.16). It measures approximately 4 m east to west and it is approximately 20 cm wide. Wells (Wells et al. 2012:10) described the front perimeter of House 10 as a berm made of different sized stones and sand. I suggest anomaly C is the front perimeter berm of the dwelling.

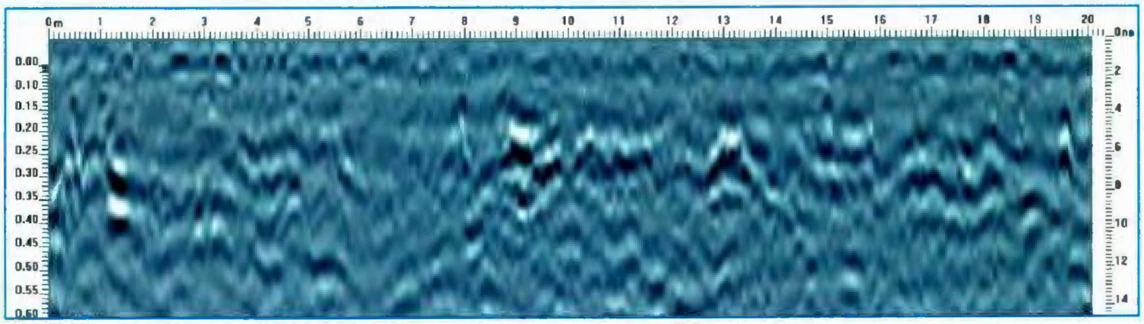

Figure 5.15: Feature 368 GPR profile of line 132 with no interpretation.

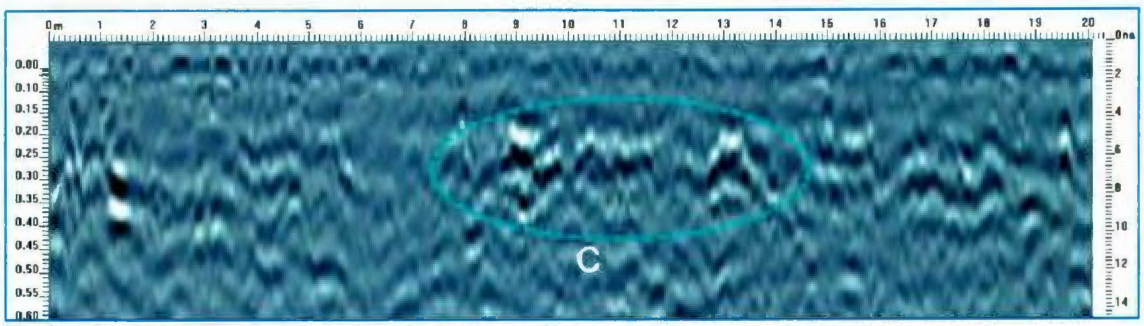

Figure 5.16: Feature 368 GPR profile of line 132. Note anomaly C circled in blue

Anomaly A correlates with the central depression identified on the surface of the meadow and on the topography map (Figures 5.11, 5.12, 5.13, and 5.14; black outline). It measures approximately 3.4 m east to west and 3.5 m north to south. It is also visible on GPR profile of line 112, which passes through the middle of it (Figure 5.17 and 5.18). Based on its shape, size, and correlation with the topography map I suggest this is the part of the central depression of Feature 368.

Anomalies D, E, and F correlate with the western, rear, and eastern perimeter respectively. Anomalies D and F can also be found on the GPR profile of line 112 (Figure 5.17 and 5.18). According to the GPR profile, anomalies D and F are approximately 20 cm higher than anomaly A (central depression). This number is misleading as the GPR profile does not take into account topographical changes (i.e. that anomaly A was a depression on the surface on the meadow).

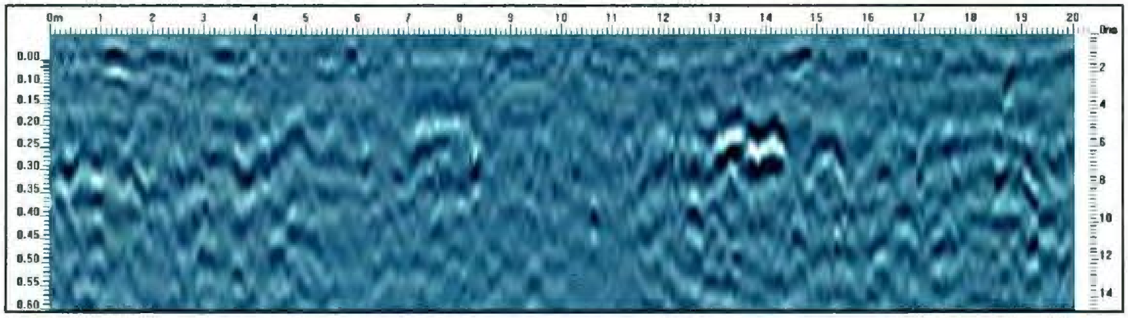

Figure 5.17: Feature 368 GPR profile of line 112 with no interpretation.

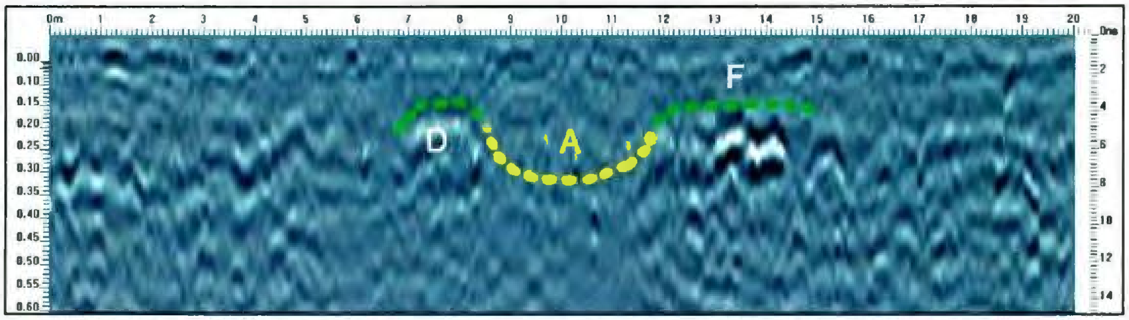

Figure 5.18: Feature 368 GPR profile of line 112. Note anomalies D and F (green) and A (yellow)

Based on GPR profile of line 112, anomaly D is approximately 1 m east to west. House 10 Feature 416 (western perimeter) measured 1.2-1.6 m east to west (Wells et al. 2012:14). House 2 eastern perimeter measured 1.34 m east to west and was interpreted as a wall or a bench (Renouf et al. 2005:4). Based on its location (west of the central depression) and its size, I suggest that the western perimeter of Feature 368 (anomaly D) is also a wall/small sitting platform.

Anomaly F measures approximately 2.5 to 3 m east to west. House 10 Feature 415 (eastern platform) measured between 3 and 3.3 m east to west at its widest part (Wells et al. 2012:13). The eastern perimeter of House 2 measured 4.19 m east to west and was interpreted as a platform (Renouf et al. 2005:6). The eastern perimeter of House 18 measured 2.94 m east to west and was interpreted as a platform (Cogswell et al. 2006:18). The western perimeter of House 17 measured 2.93 m east to west and was interpreted as a platform (Renouf 2007:14). Based on these previous excavations, and anomaly F location and size, I suggest this to be an eastern platform.

Anomaly E correlates with the possible rear platform identified on the topography map (Figures 5.11, 5.12, 5.13, and 5.14). Anomaly E is also visible on GPR profile of line 63, which runs across it close to central depression (Figure 5.19 and 5.20).

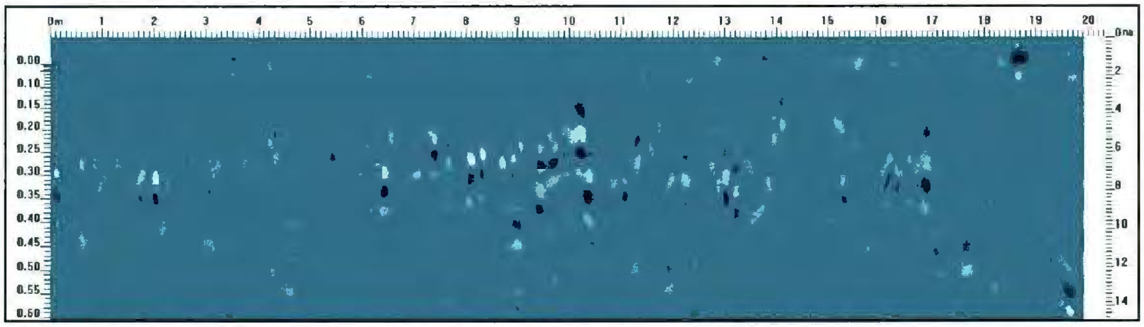

Figure 5.19: Feature 368 GPR profile of line 63 with no interpretation.

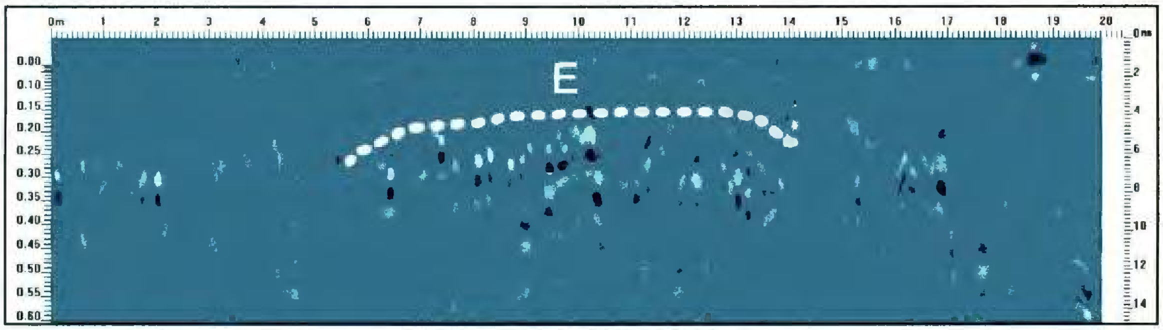

Figure 5.20: Feature 368 GPR profile of line 63. Note anomaly E

Anomaly E measures approximately 7 m east to west. House 10 Feature 418 (rear platform) measured more than 7 m east to west (Wells et al. 2012:15). House 17 rear platform measured 7.9 east to west (Renouf 2007:12). Based on its location (north of the central depression) and its size, I suggest anomaly E to be the rear platform.

Interestingly, on a deeper time slice – approximately between 8 and 9 ns or between 35 and 40 cm three features became apparent within the central depression (Figure 5.21 and 5.22).

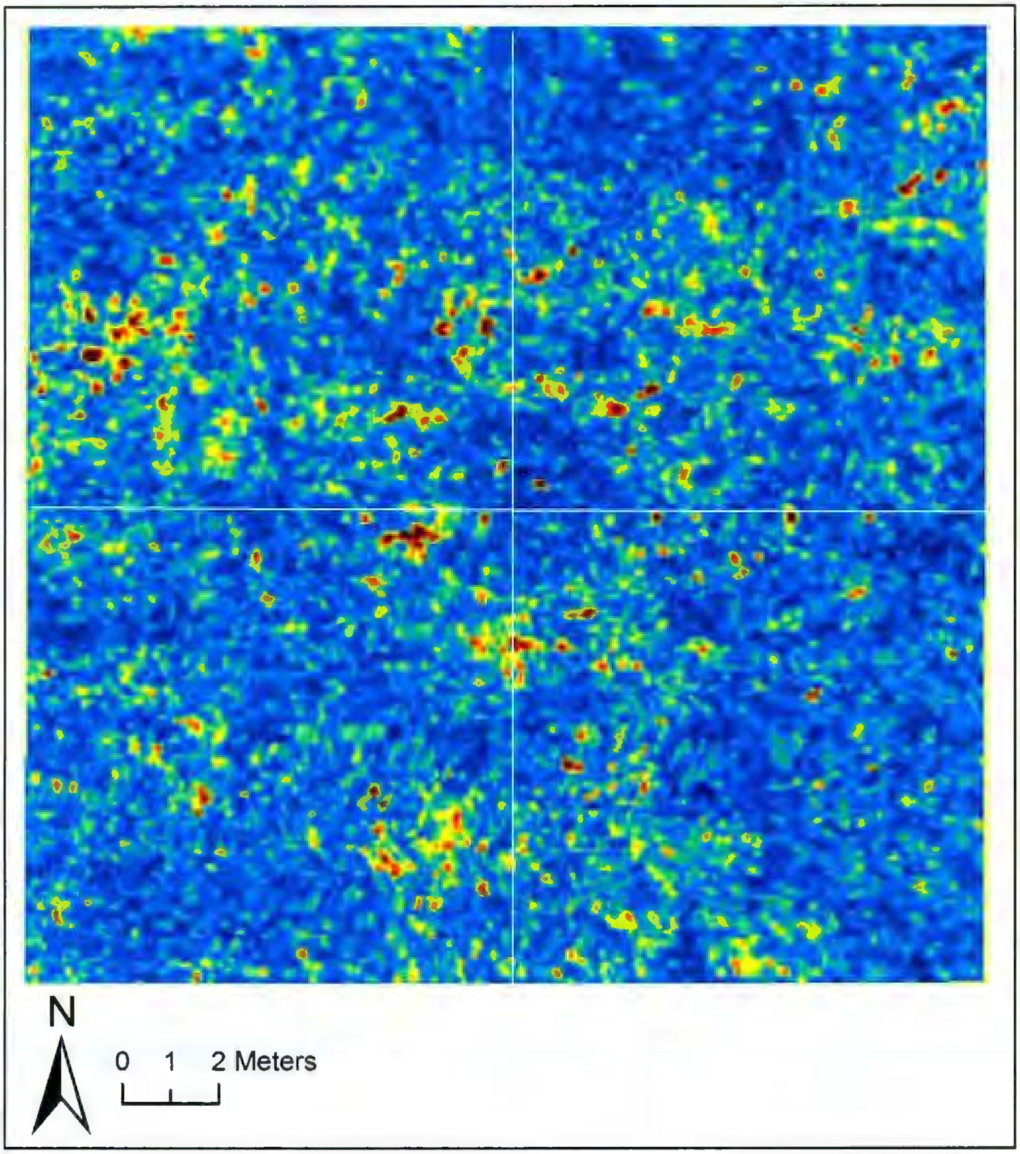

Figure 5.21: Feature 368 GPR time slice at a depth between 8 and 9 ns (approximately 35 to 40 cm). Without interpretation.

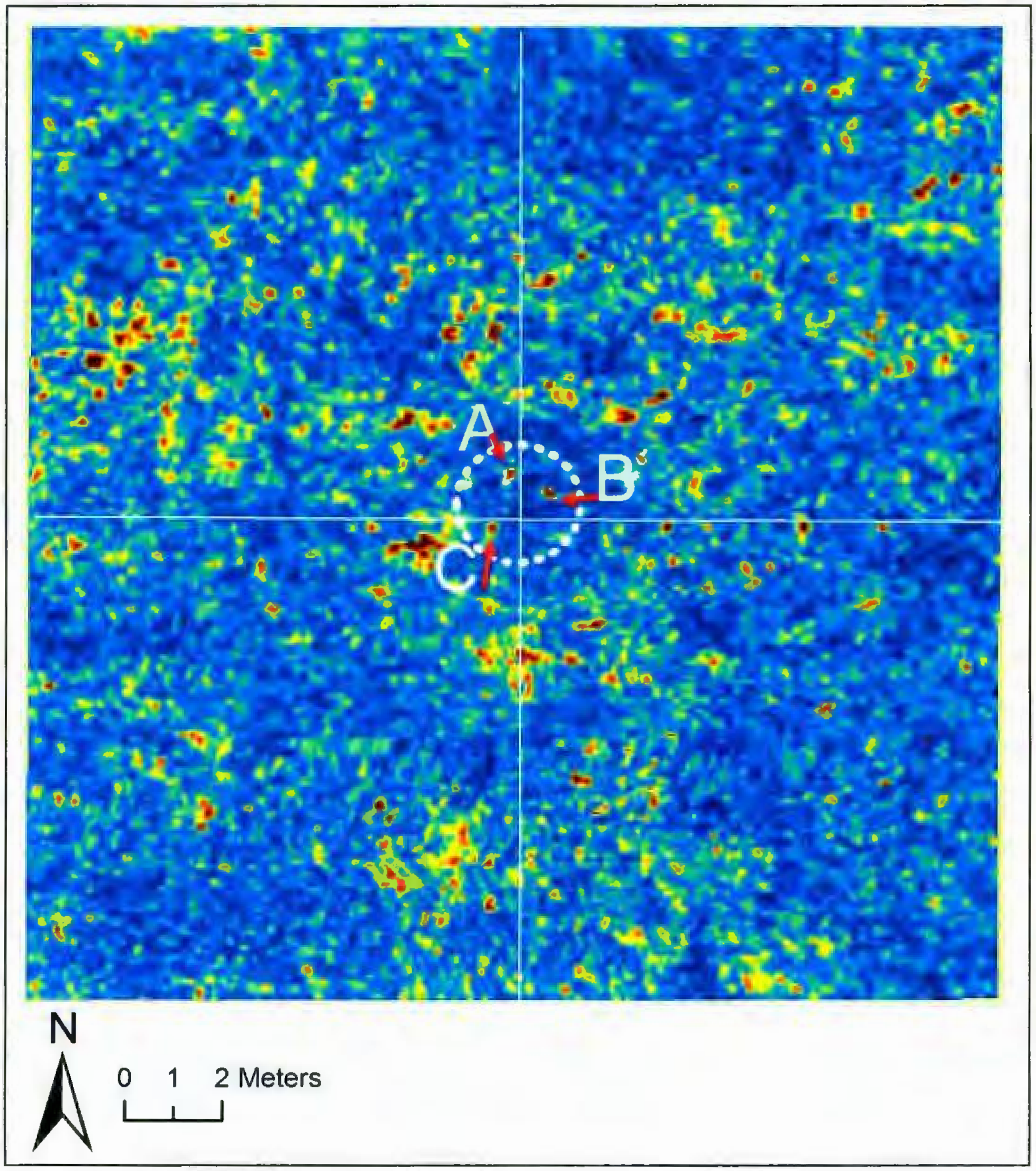

Figure 5.22: Feature 368 GPR time slice at a depth between 8 and 9 ns (approximately 35 to 40 cm). Note anomalies A, B, and C (white) within the central depression area.

Anomalies A, B, and C are very well defined at this depth. It is important to note that these anomalies are within the central depression, and therefore, their depths are inaccurate as the time slices and profiles do not correct for topography and assume that the grid was conducted on entirely flat ground.

The distance between anomalies A and C is approximately 1 m. The distance between anomalies C and B is approximately 1.3 m. The distance between anomalies A and B is 0. 9 m. The distance between the north and south post holes abutting the axial feature in House 10 was approximately 1.2 m. The distance between the post holes abutting the axial feature in House 18 is less than 1.9 m (Cogswell et al. 2006:9). The distance between the post holes abutting the axial feature in House 17 was also less than 1.9 m (Renouf 2007:5). In House 2, this distance measured approximately 75 cm (Renouf et al. 2005:8).

Based on these measurements and the two possible entrances identified in topography map and the GPR data (as at Phillip's Garden, axial features tend to be oriented towards the entrance), I suggest that either anomaly pair A and C or anomaly pair C or B are the two post holes abutting the axial feature.

No perimeter post holes or pits were identified in the GPR data. The GPR was very useful in identifying possible architectural features and some possible post holes. I suggest that as we fine tune geophysical surveying methodology at Phillip's Garden, we may be able to identify more features.

5.4 Synthesis of Results

Several possible archaeological features were identified for Feature 368 using the topography, magnetometry, and GPR results (Section 5.3). Both magnetometry and GPR were much more efficient in picking up possible archaeological features in the Feature

368 survey. Interestingly, the topography survey was also very useful in identifying possible archaeological features.

The topography survey was useful in identifying and outlining the central depression, a possible entrance, and the front, west, rear, and east perimeter of the dwelling. These results correlated with the both the magnetometry and GPR results.

Magnetometry was useful in identifying the central depression, possible part of the front, west, rear, and east perimeters of the dwelling, the possible threshold of the dwelling's entrance, and several possible perimeter post holes.

The perimeter post holes were not identified in the GPR data. Another possible entrance (different than the ones indentified in the topography and magnetometry data) was identified in the GPR data. The central depression, a possible western wall, a possible rear platform, and a possible eastern platform were also identified with the GPR data. These correspond to an extent to the topography and magnetometry data. Two possible sets of post holes abutting the central depression were also found in Feature 368 GPR data. Interestingly, each pair of possible indentified post holes faces each of the identified entrances.

5.5 Summary

Feature 368 results were presented and interpreted in this chapter. This included Feature 368 topography results, magnetometry results, and GPR results. This interpretation will be further discussed in Chapter 6, which seeks to answer the research questions presented in Chapter 1: 1) *can features within dwellings be identified through small scale* *magnetometry and GPR surveying at Phillip's Garden?*, 2) *is there a difference between surveying excavated versus unexcavated dwellings?*, and 3) *what effect does surveying interval have on feature visibility in GPR data?*

CHAPTER 6

Discussion and Conclusion

6.1 Introduction

This chapter revisits the research questions presented in Chapter 1 in light of the results and their interpretation. The research questions at the center of this thesis were *1) can features within dwellings be identified through small scale magnetometry and GPR surveying at Phillip's Garden?*, 2*) is there a difference between surveying excavated versus unexcavated dwellings?*, and 3) *what affect does surveying interval have on feature visibility in GPR data?* These questions are answered separately below using the research results. This is followed by a discussion of the results and a conclusion to the research.

6.2 Can features within dwellings be identified through small scale magnetometry and GPR surveying at Phillip's Garden?

Based on the research results, some features within dwellings can be identified through small scale magnetometry and GPR surveying. As magnetometry and GPR operate using different geophysical principles and test different properties, they do not necessarily identify the same features; however, in some cases both methods identify large architectural and well defined features.

The magnetometry survey of House 10 was primarily successful in identifying charcoal deposits. It also detected Harp's back dirt piles. In terms of archaeological features, the magnetomtry survey of House 10 was successful in identifying one post hole (Feature 100, the post hole abutting the axial feature on its north side) and the possible eastern extension of the rear platform (Feature 418).

The magnetometry survey of Feature 368 displayed some possible archaeological features. As Feature 368 was not excavated, all the geophysical interpretations are based on correlations with the topography map, House 10 magnetometry data, and previous knowledge about Phillip's Garden Dorset Palaeoeskimo dwellings, specifically House 2, House 17, and House 18.

The identified anomalies in Feature 368 magnetometry data include the central depression, a possible entrance threshold, part of the front perimeter, and part of the possible rear platform. These features were identified by comparison with the 10 by 10 m topography map around the depression of Feature 368.

A line of pits was also visible in Feature 368 magnetometry data. These may be related to Feature 368. This pattern is consistent with a similar perimeter of pits, thought to be post holes, found in House 17 and House 18.

A possible charcoal concentration was also identified in the magnetometry data of Feature 368. This was identified based on a comparison with House 10 magnetometry data.

The magnetometry surveys of both House 10 and Feature 368 were both successful to varying degrees. Both were able to identify several anomalies related to archaeological features.

The GPR survey of House 10 was successful in identifying three anomalies correlating with archaeological features within the dwelling. These include the central depression, a post hole (Feature 100, the same post hole also identified in the magnetometry survey of House 10), and the rear platform, including its eastern extent.

The GPR survey of Feature 368 was successful in identifying nine anomalies possibly correlating to archaeological features. These include the central depression, a possible front perimeter berm, a possible western wall/bench/platform, a possible rear platform, and a possible eastern platform. These were identified based on comparisons with the 10 by 10 m topography map encompassing Feature 368.

A possible secondary entrance was also identified in Feature 368 GPR data. This was done based on size comparisons with previous excavated archaeological features. Two set of possible post holes (presumably abutting the axial feature) were also identified. This was possible due to the high frequency GPR antenna we used and the small increment (10 cm) surveying employed. The interpretation was done based on previous excavation data.

Ground penetrating radar surveys of both House 10 and Feature 368 were both successful, in varying degrees, in identifying several anomalies correlating with archaeological features. There is further discussed below.

6.3 Is there a difference between surveying excavated versus unexcavated dwellings?

Based on the research results, there is a difference between surveying excavated versus unexcavated dwellings using both magnetometry and GPR. Difficulties in magnetometry surveying were encountered in both excavated and unexcavated dwellings. Difficulties in GPR surveying were found in excavated dwellings.

Previously excavated dwellings, especially Harp's (who did not back fill his excavations) are difficult to survey using magnetometry due to excavation debris (such as nails or trash left behind) and the magnetic signature of back dirt. Highly magnetic materials, such as pop cans, nails, and cigarette foil disrupt magnetic surveying by creating highly magnetic anomalies. These obscure subtler anomalies which may be associated with archaeological features. Harp's piles of back dirt also hinder magnetic surveying by creating a strong magnetic signature. They also obscure any archaeological feature that may lie beneath them.

In unexcavated dwellings, soil and midden accumulation pose difficulties for magnetometry surveying as they can sometimes obscure archaeological features underneath them. Midden can sometimes be colonized by bacteria encouraging the accumulation of iron oxides, thus only the extent of the midden may show up on the magnetometry results. The anomaly created by this may also be strong enough to obscure archaeological features around the midden.

Magnetometry surveying of unexcavated dwellings is facilitated by the lack of back dirt and absence of metal associated with excavated dwellings; therefore, strong magnetic anomalies do not obscure archaeological features. However, these may be obscured by the midden covering them.

GPR surveying was hindered only in an excavated context. The outlines of Harp's (1964) previous excavation of House, and to extent, the outlines of Renouf's trench

(Renouf et al. 2005) were clearly visible on the GPR results. Harp's back dirt piles were also visible. These features were quite strong, dominating the GPR time slices, and obscuring (either partially or fully) other archaeological features. In the unexcavated context, GPR surveying was quite useful in identifying anomalies possibly correlating to archaeological features in both time slices and profiles. The most effective GPR surveying method is discussed below

6.4. What affect does surveying interval have on feature visibility in GPR data?

Feature 368 was surveyed using the GPR at both 10 cm and 25 cm increment between the transects. While the 25 cm increment survey was significantly faster, the quality of the results is not as good as in the 10 cm increment survey. The comparison focused on how well the central depression was defined in each survey.

In the 25 cm increment survey the central depression could be distinguished; however, the results were full of large anomalies and the depression was not very well defined. This is due to the creation of a time slice from GPR profiles as the computer interpolates the information between transects based on adjacent survey profiles. In this case, 25 cm of interpolated data is insufficient for high quality data.

In the 10 cm increment survey the central depression was better defined and there were fewer anomalies through the survey grid. This is due to only 10 cm of the data being interpolated based on information from two adjacent profiles, meaning that a clearer picture of the subsurface can be obtained. Thus, GPR surveying at 10 cm increments between transects, although more time consuming, provides a more accurate characterization of the subsurface. Based on this, I suggest that magnetometry surveying at 10 cm spacing between transects would also better characterize magnetic variations in the subsurface.

6.5 Conclusions

The overall purpose of this research was to expand on Eastaugh and Taylor's (2011) geophysical survey at Phillip's Garden. While their main exploration goal was to test whether magnetometry surveying would be useful in identifying possible buried dwellings at the site and therefore their survey was large scale, the purpose of this research is to test the efficacy and accuracy of smaller scale geophysical surveying at Phillips' Garden.

The 2011 and 2012 explorations at Phillip's Garden included magnetometery and GPR surveys, which were conducted on one excavated dwelling (House 10) and one unexcavated depression (Feature 368). Several archaeological features were identified in both the magnetometry and GPR surveys (such as platforms/walls/berms, entrances, axial feature post holes, and perimeter post holes – see this thesis, Chapters 4 and 5). As the GPR and magnetometer test different properties of the earth, they rendered different results; however, some features are visible on both the GPR and magnetometer results. This strongly supports the fact that the identified anomaly is not a product of the acquiring process.

Both surveys have opportunities and drawbacks. Magnetometry surveying had drawbacks in both the excavated dwellings and the unexcavated feature primarily due to debris associated with previous excavations and the possible accumulation of midden. The GPR survey had significant drawbacks in the excavated dwellings due to previous excavations (including excavated area and the back dirt surrounding them). Regardless of these drawbacks, both surveys were successful to some degree in both the excavated and unexcavated context.

This research established that archaeological features can be identified using small scale magneomtery and GPR surveying in both excavated dwellings and unexcavated features. This was supported by comparisons to the 2011 excavations, comparisons with the topography map, and comparisons with previous excavation data. This research also established that a smaller increment between survey lines is preferable in GPR surveying as it renders higher quality resolution results.

The geophysical investigations undertaken at Phillip's Garden (Eastaugh and Taylor 2011; Tudor this thesis) suggest that these methods can successfully be applied to hunter-gatherer sites, which are more ephemeral and subtler than historical sites. The current geophysical investigations at Phillip's Garden were useful in identifying buried anomalies correlating to dwelling depressions (Eastaugh and Taylor 2011) and anomalies correlating to features within dwellings and associated with them (Tudor, this thesis). Along with other geophysical research done on hunter-gatherer sites (Hodgetts et al. 2011; Wolff and Urban 2012); this provides the framework for a more holistic investigation of such sites. Phillip's Garden is a good example for this.

Many Phillip's Garden dwellings can be identified on the surface of the meadow (as depressions) (Renouf et al. 2013); however, some of them are buried. Using magnetometry we can identify anomalies, which, based on location, size, and shape, can correlate with dwelling depressions (Eastaugh and Taylor 2011). These can be targeted for further investigation – including excavation and smaller resolution magnetometry and GPR surveying, which when combined can better characterize dwellings at Phillip's Garden.

Phillip's Garden dwellings are large – some are as large as 121.5 m^2 (Wells et al. 2012:7). This means that excavation is time consuming; generally 8 field crew can excavate half of a large dwelling during one field season (Renouf, personal communication). Using geophysical methods in conjunction with excavation can aid in better characterizing the extent and shape of a dwelling. This can be seen in the investigations of House 10 (the excavated dwelling surveyed for this thesis).

The House 10 excavations did not encompass the eastern perimeter of the rear platform (Wells et al. 2012); however, both the magnetometry and GPR surveys of House 10 identified an anomaly correlating with the unexcavated portion of the rear platform. This suggests that geophysical surveying can be used on areas of the dwelling that we cannot excavate.

Geophysical surveying in conjunction with topographic mapping can also be used on unexcavated dwellings in order to characterize the dwelling's shape, size, and associated features. This can be seen in the magnetoemtry and GPR survey of Feature 368 (the unexcavated dwelling surveyed for this thesis); which identified a possible charcoal concentration, the front, western, rear, and eastern perimeters, the central depression, a possible entrance, and two sets of possible axial feature post holes. Geophysical surveying and topographic mapping may also be able to identify dwellings with several occupation/construction phases.

The GPR and topography results of Feature 368 suggest two possible entrances to the dwelling. The GPR results also suggest two possible sets of post holes which would abut the end of the axial feature. Interestingly, each possible set of post hole is aligned with each of the possible entrances. This suggests two phases of construction demarked by changing the location of the entrance to the dwelling and the alignment of the axial feature. Several phases of occupation demarked by a period of construction is not uncommon for Phillip's Garden dwellings. Renouf et al. (2005) distinguished two phases of construction in House 2. Cogswell et al. (2006) suggested more than one construction episode for House 18.

In conclusion, this thesis sought to answer three questions related to geophysical research at Phillip's Garden: *1) can features within dwellings be identified through small scale magnetometry and GPR surveying at Phillip's Garden?*, 2*) is there a difference between surveying excavated versus unexcavated dwellings?*, and 3) *what affect does surveying interval have on feature visibility in GPR data?.* This thesis demonstrated that some features (large and well defined) not visible on the surface can be identified through small scale (10 to 25 cm increments between surveying transects) magentometry and GPR surveying at Phillip's Garden. This study also demonstrated that surveying unexcavated dwellings is more appropriate at the site, and previously excavations and related debris hinder geophysical investigations. Additionally, a smaller surveying interval (10 cm between surveying transects) was established to be better suited for GPR surveying at Phillip's Garden and I suggest this to also be the case for magnetometry surveying. . Based on the second field season, in 2012, we realized that although smaller increments between surveying transects increased the time in the field; it rendered significantly better results. Additionally, we determined that GPR surveying was more suitable for dry days (as the subsoil water interferes with the transmission of electromagnetic waves) and cut down vegetation (so that the cart and antenna do not move too much thus cause fictitious anomalies).

This study suggests that integrating excavation with geophysical surveying at Phillip's Garden offers a more successful way of characterizing the dwellings at the site. Additionally, this study along with the few others (Anstey 2011; Eastaugh 2002; Hodgetts et al. 2011; Tudor 2010; Wolff and Urban 2012) suggests that magnetometry and GPR prospecting may be appropriate for other hunter-gatherer sites both in Newfoundland and the rest of Canada.

In order for such studies to be successful, I suggest that a strong contrast must exist between the investigated archaeological features and the surrounding matrix. Magnetometry surveys are appropriate for identifying hearths, charcoal concentrations, fire cracked rock and pottery, middens, and pits. Ground penetrating radar prospecting is appropriate for identifying large architectural features such as sleeping platforms, walls/berms, central depressions, large and deep pits/post holes, and entranceways.

The effectiveness of these methods also depends on the topography, soil moisture, vegetation, and anthropogenic effects of the studied site. For example, a varied topography with mounds and hills means that any GPR data would have to be corrected (GPR profiles are flattened in the data; therefore, mounds and hills may appear as anomalies). Soil moisture would also affect GPR prospecting, as water slows down the propagation of electromagnetic waves. Dense vegetation (such a grass) would affect GPR prospecting as the antenna would bounce around creating fictitious anomalies while trees would cause breaks in the GPR survey grid.

Vegetation and trees would also affect magnetometry surveying as the operator would have a hard time walking through and holding the instrument straight (bumping the magnetometer around would also cause fictitious anomalies). Lastly, anthropogenic effects such a refuse (nails, cigarette foils, and scrap metal) and as well cars, boats, houses, watches, iPods, cell phones, belt buckles etc. would also affect by magnetometer by creating anomalies.

Surveys where these factors are ideal; however, in certain instances I suggest one can control for these factors. For example, topographic maps for the whole site would help correct the GPR profiles and eliminate fictitious anomalies. GPR surveys can also be schedules during dry periods of the year. Vegetation (and even trees and braches) can be cut down to facilitation for GPR and magnetometry surveying or areas full of trees can be left out of the survey grid. Lastly, a metal detector survey can be conducted prior to magneometry surveying in order to remove any metal which may interfere with the reasons. Additionally, extreme caution should be practiced by the survey technician and assistant in removing all metal and electronic devices they may carry. Keeping in mind all these factors, I suggest that magnetometry and GPR surveying are appropriate for hunter-gatherer sites.

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